The British Journal of Criminology, 2024, **XX**, 1–16
https://doi.org/10.1093/bjc/azae047
Original Manuscript

OXFORD

Incorporating a One Health Approach Into the Study of Environmental Crimes and Harms: Towards a 'One Health Green Criminology'

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Amid increasingly intense and frequent Emerging Infectious Disease events, such as COVID-19, it is evident that the current global ecological crisis poses a threat to the health and well-being of humans, non-human animals and ecosystems. This paper aims to expand existing green criminological scholarship by arguing for the incorporation of a 'One Health' perspective. This would (1) enable the integration of scientific knowledge to better address threats, harms and crimes to health and well-being; and (2) contribute to the advance of Eco-justice. The study identifies four areas where a One Health perspective within green criminology may reveal overlooked harms and threats to health and well-being. Conversely, integrating green criminology would benefit the One Health scientific community and specific programs.

KEY WORDS: One Health, green criminology, Emerging Infectious Diseases, COVID-19, Eco-justice, zoonosis

INTRODUCTION

Through the 20th and into the current century, threats and harms to the planet and other species, largely resulting from human activity, have increased in scale, complexity, frequency and intensity (Lynch and Stretesky 2014; Brisman and South 2020a). However, environmental degradation, climate change and the biodiversity crisis are not only making our world 'less verdant, less wondrous, less biologically rich', but also expose the intricate connections and vulnerabilities that link the health and well-being of humans, non-human animals and ecosystems (Brisman and South 2020b: 3). This has been particularly evidenced in relation to the growing

frequency of intense Emerging Infectious Disease (EID) events of wildlife origin (Jones *et al.* 2008; Allen *et al.* 2017)—most recently and obviously the COVID-19 pandemic.

Globally, approximately one-quarter of all human deaths are caused by EIDs (WHO 2000; Taylor *et al.* 2001). EIDs are defined as diseases originating from newly discovered or evolved infectious pathogens that have recently been introduced or reintroduced into a host population with an increased incidence or geographic range (Daszak *et al.* 2001; Morse 2001; Jones *et al.* 2008). This definition includes pandemic diseases causing highly severe symptoms or mortality, such as acquired immunodeficiency syndrome (AIDS) or COVID-19; diseases caused by pathogens that have evolved drug resistance (e.g. tuberculosis and malaria); and pathogens that have caused local outbreaks (e.g. Ebola or Hendra viruses) (Daszak *et al.* 2001). These EID events are largely dominated by zoonoses[1] (i.e. pathogens transmissible from non-human animals to humans—and then onward, human to human), and the majority of these, and almost all recent pandemics (>70 per cent), are caused by pathogens originating in wildlife, such as the coronaviruses SARS-CoV-1 and SARS-CoV-2 that cause Severe Acute Respiratory Syndrome (SARS) and Nipah virus (Taylor *et al.* 2001; Wolfe *et al.* 2007; Jones *et al.* 2008; Allen *et al.* 2017; Keusch *et al.* 2022; Leal Filho *et al.* 2022).

Anthropogenic drivers are crucial for the emergence of zoonotic EIDs (Patz *et al.* 2004; Brierley *et al.* 2016), including environmental and land-use changes, human population and livestock density, global trade and human mobility, and wildlife trade and trafficking (e.g. Daszak *et al.* 2000; Taylor *et al.* 2001; Jones *et al.* 2008; Morse *et al.* 2012; Allen *et al.* 2017; Rush *et al.* 2021; Carlson *et al.* 2022; Keusch *et al.* 2022).

In numerous instances, detrimental effects on human health represent merely the visible portion of a larger issue. Wildlife populations are being globally impacted by epizootic events—diseases spreading among non-human animals—leading to complex and often 'silent' processes of mass extinction. For example, colonies of great apes were decimated in Gabon due to epizootic outbreaks of the Ebola virus, possibly from bats that were likely disturbed by anthropogenic activities (Leroy *et al.* 2004; Quammen 2012). More recently, wild populations of birds and some mammals, such as sea lions, have suffered high mortality due to the virulent spread of Highly Pathogenic Avian Influenza (HPAI) H5N1 across the globe, including remote areas of South America and Antarctica (Plaza *et al.* 2024).

To understand these issues, several holistic approaches to health have been developed (i.e. Ecohealth,[2] One Health and Planetary Health[3]), each with a slightly differing focus, but all acknowledging the links between the health of humans, non-human animals and ecosystems. They have been widely applied within the scientific community to address global challenges beyond the study of zoonotic EIDs, such as climate change and pollutants (Wilcox *et al.* 2004; Zinsstag *et al.* 2011; Nguyen-Viet *et al.* 2015; Lerner and Berg 2017). In particular, following the COVID-19 pandemic, a broad conceptualization of One Health has attracted the attention of health policy analysts, social scientists and humanities scholars (Gibbs 2014; Adisasmito *et al.* 2022).

1 Apart from zoonosis, the term 'zooanthroponosis' or 'reverse zoonoses' refers to diseases that are spread from humans to animals (Beirne 2022). In addition, amphixenosis is the term for diseases that can spread from animals to people or vice versa (Leal Filho *et al.* 2022).

2 The ecosystem approach to health, or Ecohealth, emphasizes the dependence of health upon ecosystem services and the close interdependence of humans and animals in their social and ecological context (Zinsstag *et al.* 2011; Lerner and Berg 2015, 2017).

3 Planetary Health refers to the 'achievement of the highest attainable standard of health, well-being and equity worldwide through judicious attention to the human systems—political, economic and social—that shape the future of humanity and the Earth's natural systems that define the safe environmental limits within which humanity can flourish' (Whitmee *et al.* 2015: 1978).

Links between the health of humans, non-human animals and ecosystems should also, of course, be of central interest to a 'green criminology' which, as Lynch and Stretesky (2014: 177) note, has developed in recent decades and begun to break down the 'intellectual wall that has, for the most part, prevented criminology and criminologists from recognizing and discussing green harms'. However, green criminology currently lacks a comprehensive, interdisciplinary framework to examine the environmental threats, harms and crimes impacting upon health and well-being, and specifically as related to zoonotic EIDs. This could build upon existing green criminology work which has already pioneered the use of epidemiological evidence in relation to the 'toxic' crimes committed by corporate bodies (e.g. Lynch 2020: 51; Lynch and Stretesky 2001).

In this paper, we aim to address the lack of a holistic, overarching perspective within green criminology to comprehend the multifaceted harms and threats to health and well-being stemming from zoonotic EIDs by incorporating a One Health approach. We therefore outline the themes and parameters of green criminology and One Health, before discussing the benefits of an integration of the two, which would include: (1) improving the application of cross-disciplinary learning to threats, harms and crimes to the health and well-being of humans, non-humans and environments; (2) further advancing Eco-justice by drawing together One Health and Eco-justice approaches. In addition, we contend that the One Health scientific community and specific programs would benefit from such integration. Finally, based on a literature review of key publications on zoonotic EIDs, we outline promising potential applications in which a proposed One Health/Green Criminology framework can be useful.

OVERVIEW OF GREEN CRIMINOLOGY

Traditionally, the central concerns of criminological inquiry have been street, property or violent crimes, which overemphasizes a notion of 'crime' as defined in terms of criminal law. This focus fails to acknowledge the significantly higher amounts of harm, damage and victimization produced by environmental offenses, regulatory breaches and acts of omission (Lynch *et al.* 2013; Lynch and Stretesky 2014). This exemplifies how criminology can over-include certain subjects of investigation, while excluding or neglecting others. Young (2011: 189) highlights this issue, noting that the 'lens of orthodox criminology' is a viewpoint that 'not only distorts' but also omits 'all those acts and activities which suggest that wider structural forces generate social harms' (see also Currie 2014; Rock 2014). The potential contribution of criminology to engage with a wider range of crimes, harms and threats is, however, now unquestionable, as evident in the growth of a 'green field' for criminology since the 1990s (Lynch 1990; South 1998) and over recent decades (Brisman and South 2020a).

Green criminology most clearly emerges from within the tradition(s) of critical criminology (Brisman and South 2013), while expanding central conceptions for the discipline such as 'crime', 'harm', culpability or victimhood (Lynch and Stretesky 2014). The perspective has been applied broadly, to cover illegal acts and omissions as proscribed by law (e.g. the illegal taking and trade of flora and fauna), and 'taken for granted' legal (but harmful) activities (e.g. harms derived from climate change, biodiversity loss, animal abuse or waste and pollution) (White 2011). Thus, a distinction can be drawn between 'wrongdoing' activities that are illegal—*malum prohibitum*—which may be less harmful and limited to anthropocentric harms, and more serious harms excluded from the legal scope—*malum in se*—with disastrous consequences for non-human animals and ecosystems (White and Heckenberg 2014).

Much work in green criminology is captured by an expanded notion of harm, which serves as a starting point for a move beyond legal definitions of environmental crime to make many serious harms and injuries more visible (Wyatt 2013). To address environmental harm, green

criminology rejects philosophical underpinnings largely embedded in our current legal systems, such as utilitarianism, the commodification of nature or speciesism, and may draw upon three different eco-philosophical perspectives: anthropocentrism, ecocentrism and biocentrism (Halsey and White 1998; White 2011). Each corresponds to a particular conception of 'justice', namely environmental, ecological and species justice, respectively (White 2008, 2013b).

There is no claim that 'green criminology' is a unitary enterprise and the term broadly describes the study of ecological, environmental or green crimes or harms, their associated impacts on human and non-human life (e.g. victimization and regulation), and issues of speciesism and environmental justice (Beirne 1994; Lynch and Stretesky 2003, 2014; Beirne and South 2007, 2013; Brisman and South 2014, 2020a; Sollund 2019). There is a wide consensus that rather than being seen as a theory, green criminology should be understood as a broad and evolving *perspective* (Lynch and Stretesky 2014; South 1998: 212–213; White 2013a), providing 'a *unifying* theme and *rallying point* for … disparate work', adding 'power to its accumulation as a concretely identifiable field … within criminology' (South 1998: 220), but also serving as a *bridge* to other social scientific disciplines, humanities, natural and biomedical sciences (South 1998; Lynch and Stretesky 2011, 2014: 29–49).

The need for a holistic approach to the study of crimes, harms and threats to health and well-being

Given that a significant proportion of green criminological scholarship emphasizes that environmental harms are detrimental to the *health* and well-being of humans, non-human animals and ecosystems, it is perhaps overdue to argue for the integration of a comprehensive understanding of 'health' into the green criminological framework (South forthcoming). This is a recognition that, to date, there have been few contributions focused on the environmental threats, harms and crimes related to zoonotic diseases (see e.g. Beirne 2021; Gore *et al.* 2021; Spapens 2021; Van Uhm and Zaitch 2021; Luong and Thomson 2022), although some notable exceptions have examined attitudes towards zoonotic risk (Gore *et al.* 2021; Rizzolo *et al.* 2023), while Beirne (2021, 2022) has employed a non-speciesist criminology approach to zoonosis and anthroponosis. Most importantly, a comprehensive, interdisciplinary framework for the examination of environmental threats, harms and crimes related to zoonotic EIDs is missing.

One recurrent criticism of green criminology is that each philosophical stance embedded in each perspective (i.e. anthropocentrism, biocentrism and ecocentrism) narrows the focus to certain causes of crime and harm and promotes a particular solution while ignoring others (White 2003; Halsey 2004; Gibbs *et al.* 2010). Likewise, tensions exist both within and between the three approaches to justice (White 2013b). Specifically, tensions relate to the difficulties of dealing in practice with certain aspects of justice. Some green criminology scholars solve this issue through the notion of Eco-justice as a holistic approach that contends that human fate is inexorably linked to that of ecosystems and the many species that configure them (White 2013b). However, the notion of Eco-justice is not implicitly operationalized and is subject to different interpretations (see e.g. Walters 2019). Specifically, there is a need to further develop the paradigm by incorporating a new approach that aligns our interests and futures with that of ecosystems and the rest of the non-human beings that share our planet (Brisman and South 2020b). This approach should propel the notion of Eco-justice as a tool that can help to optimize the shared interests of humans, non-human animals and ecosystems in terms of 'environmental justice (humans and equity), ecological justice (intrinsic value of ecosystems) and species justice (rights and needs of animals)' (White and Heckenberg 2014: 17–18).

To address these limitations and possibilities, the concept of health in relation to harm and the One Health approach will be discussed, with the aim of aligning the One Health framework with green criminology.

DEFINING 'HEALTH' IN RELATION TO HARM

Harms do not occur in isolation and require a clear delineation of 'what' is being harmed in relation to specific entities and causes (Greenfield and Paoli 2022). Through a green criminological lens, we identify humans, non-human animals and ecosystems as the primary subjects of harm. We can also examine the dimensions of the concept of health to define 'what' is being harmed.

The World Health Organization (WHO) defines health as not merely the absence of disease or infirmity but also as a state of complete physical, mental and social well-being (WHO 1948). The term 'well-being' is used to refer to the broad conception of human health, aspiration and capacity to achieve goals (Charron 2011). The focus of such terminology is on human health, but without entering into ethical and philosophical discussions (Lerner 2008), we must also consider broad definitions of animal health and animal welfare, which are particularly relevant to harmful acts found in the trading and farming of non-human animals that play a role in the transmission of infectious diseases, such as overcrowding, poor living, storage and transport conditions, stress and poor nutrition (Huong *et al.* 2020), as well as habitat alteration.

The concept of health can be applied at the levels of individuals (i.e. animal, human and even plant health), populations and ecosystems (Lerner and Berg 2015; Destoumieux-Garzón *et al.* 2018). The consideration of ecosystems as 'healthy' is mostly inferred and assessed in relation to certain indicators such as biodiversity or 'ecosystem services', implying a desired 'equilibrium' (Destoumieux-Garzón *et al.* 2018). However, health terminology can also be used normatively when referring to 'healthy' environments (Charron 2011). This paper uses a broad conception of human, non-human animal and ecosystem health that encompasses not only physiological interpretations but also other holistic and normative aspects of well-being and welfare (Charron 2011; Lerner and Berg 2015). In line with Greenfield and Paoli (2022), defining health implies that the concept can be used as a proxy to encompass the physiological, psychological and functional integrity of humans, non-human animals and ecosystems. Harms and threats to human health are interconnected with those of non-human animals and ecosystems, and green criminology could benefit from the incorporation of an approach that not only acknowledges these interdependencies but also strives to achieve balanced and optimized 'health' among different individual bearers and entities (i.e. One Health).

ENTER THE ONE HEALTH APPROACH

Originating in the concept of 'One Medicine' (Schwabe 1984), the broader approach, termed 'One World—One Health', was initially focused on a combined biomedical approach to human and animal health (Zinsstag *et al.* 2012; Roger *et al.* 2016; Keune *et al.* 2017; Destoumieux-Garzón *et al.* 2018). Some scholars still consider the One Health perspective a narrow approach that combines public health and veterinary medicine, focusing on animal and human health (Keune *et al.* 2017). However, the approach is also conceived in a wide sense, often depicted as an 'umbrella' term. As it has developed, it has been widening out in terms of scope, focus and contributing sciences to also incorporate the social, cultural and ecological dimensions of health (Zinsstag *et al.* 2011, 2012; Gibbs 2014; Keune *et al.* 2017). As an 'umbrella' approach, a strategy and a forum, it offers conceptual elasticity and can encompass the biomedical, socioeconomic, cultural, and political factors that lead to the transmission of zoonotic diseases (Gibbs 2014; Cunningham *et al.* 2017).

One Health has gained momentum since the Covid-19 pandemic (Adisasmito *et al.* 2022), with stronger support for adopting a broader interpretation. Evidence for this can be found in the consensus on the definition reached by the One Health High Level Expert Panel (OHHLEP), which is comprised by members of the Food and Agriculture Organization (FAO), the WHO,

the United Nations Environment Program (UNEP) and the World Organization for Animal Health (OIE/WOAH). The OHHLEP defines One Health (2022: 2) as:

> an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes the health of humans, domestic and wild animals, plants and the wider environment (including ecosystems) are closely linked and interdependent. The approach mobilizes multiple sectors, disciplines, and communities at varying levels of society to work together to foster well-being and tackle *threats* to health and ecosystems, while addressing the collective need for healthy food, water, energy and air, taking action on climate change and contributing to sustainable development.

The OHHLEP identifies several key underlying principles of the approach: equity among sectors and relevant disciplines; sociopolitical and multicultural parity, including the inclusion of communities and marginalized voices; socioecological equilibrium that seeks a harmonious balance acknowledging also ecocentric and biocentric views (i.e. recognition of the intrinsic value of all beings and the importance of animal welfare, and the integrity of the whole ecosystem); stewardship and the responsibility of humans to change behaviour and adopt sustainable solutions accordingly; and transdisciplinarity and multisectoral collaboration, which includes both modern and traditional forms of knowledge (Adisasmito *et al.* 2022).

The implications of the current working definition and principles are two-fold in relation to other holistic approaches. On the one hand, One Health reinvigorates the aims of Ecohealth by adopting ecocentric views, and Planetary Health by explicitly acknowledging the importance of environmental health (Adisasmito *et al.* 2022). On the other hand, the definition implies a convergence, or at least an overlap, between One Health and Ecohealth in relation to its scope and focus (Zinsstag *et al.* 2012; Gibbs 2014; Lerner and Berg 2017; Adisasmito *et al.* 2022). For instance, both approaches are concerned with the health of humans, non-human animals (e.g. ecosystem changes affecting wildlife health through the spread of diseases among wildlife species) and ecosystems (including biodiversity as an indicator of ecosystem health) (Zinsstag 2012).

TOWARDS A HEALTHY AND SUSTAINABLE PLANET: INTEGRATING GREEN CRIMINOLOGY AND ONE HEALTH

Integrating the comprehensive approach of One Health within green criminology presents an opportunity to enhance the understanding of environmental crimes, harms and threats to health. There are compelling reasons for such alignment, and even though our aim is to highlight the potential benefits of incorporating a One Health approach into green criminology, we also sketch several arguments for including green criminology within the One Health umbrella.

Importantly, the frameworks are complementary: they are open and interdisciplinary *perspectives* (see e.g. South 1998; Zinsstag *et al.* 2011; Gibbs 2014; Adisasmito *et al.* 2022). Whereas One Health seeks to establish connections with social sciences (Keune *et al.* 2017), green criminology frequently draws upon evidence provided by the natural sciences (Lynch and Stretesky 2014) and a variety of research designs (Brisman and South 2017). The One Health approach, which inherently spans the domains of human, animal and ecosystem health, aligns seamlessly with the mission of green criminology to explore the intricate connections between the environment, society, ecosystems and non-human beings. This connection provides a unique opportunity for cross-fertilization between green criminology and disciplines, such as epidemiology, biology, veterinary science, virology, genetics and ecology. In doing so, the lexicon, theories, approaches, practices, methods, data sources and empirical insights can be incorporated to

enhance the understanding of issues that transcend single-discipline boundaries. For example, as Stretesky and Lynch (2001) argued, green criminology research could leverage scientific evidence to better comprehend, address and expose threats, harms and crimes to the health and well-being of humans, non-human animals and ecosystems.

This complementarity also includes the alignment of efforts to secure justice. One Health is compatible and synergistic with Eco-justice, which is understood as an optimizing tool in its mission to balance the interests of all beings and ecosystems (see Figure 1). Adopting the One Health definition and principles, which recognizes the health and well-being interests shared among humans, non-human beings and ecosystems, results in clear implications for their corresponding justice perspectives (i.e. ecological justice, species justice and environmental justice). For example, a health policy that aims to improve the health and welfare conditions of non-human animals on farms to prevent the spread of zoonotic diseases simultaneously considers the rights and needs of both animals and humans.

Conversely, this integration could be mutually beneficial, as green criminology scholarship is also well positioned to contribute to relevant One Health programs in the iterative process of engaging with policy, science and practice (Beirne 2021). Green criminologists in an interdisciplinary One Health team could also contribute to pandemic prevention, preparedness and zoonotic disease surveillance, helping to elucidate the behavioural, cultural, social, political and economic determinants of human behaviour that facilitate the emergence and spread of zoonotic EIDs at the micro, meso and macro levels. For example, for many years, zoonotic disease surveillance teams have not been aware of the role of trafficked animals in pathogen spillover. Recently, evidence from confiscated pangolins in China and Vietnam (Lam *et al.* 2020; Nga *et al.* 2022) suggested that wildlife trafficking may play a crucial role in zoonotic EID emergence. Green criminologists can provide insights (e.g. mapping out trafficking nodes and illegal activities) that will inform the sampling strategies of these teams. The inclusion of green criminology could also play a key role in discerning responsibility in relation to the role of legal actors (Keune *et al.* 2017), including corporate and state actors, and in determining legal or socio-legal responses (Cunningham *et al.* 2017; Keune *et al.* 2017). One-dimensional policy recommendations need contextualization. For example, consideration of a ban on wildlife trade and markets also needs reflection on potential consequences for local livelihoods, the likelihood of displacement effects and even the emergence of organized crime groups.

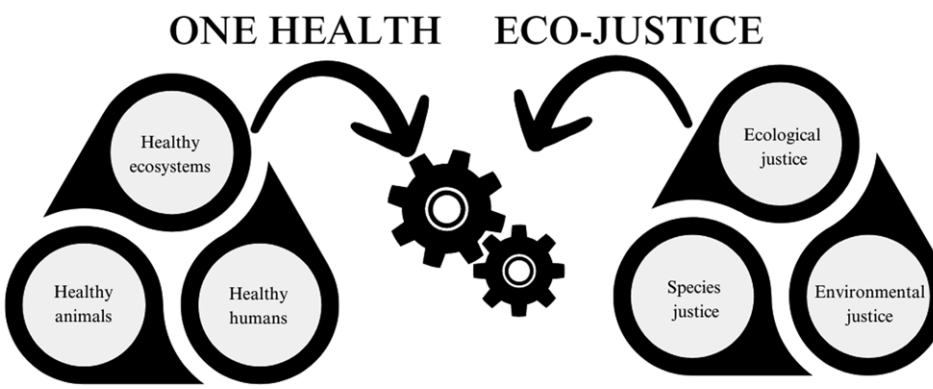

Fig. 1 Concept map illustrating One Health and Eco-justice approaches as compatible approaches set to work together as optimizing tools.

POTENTIAL APPLICATIONS OF A 'ONE HEALTH GREEN CRIMINOLOGY' AND THEIR MECHANISMS IN RELATION TO ZOONOTIC DISEASES

Adopting One Health has certain implications for the study of environmental crimes and harms. In practice, applying One Health primarily entails acknowledging the close links and interdependence of the health of humans, domestic and wild animals, plants and the wider environment (Adisasmito *et al.* 2022). Consequently, regarding zoonotic EIDs, a key implication is that anthropogenic activities—whether criminalized or not—that harm or threaten the health and well-being of non-human beings are associated with a significant increase in the likelihood of pathogen spillover to humans or other non-human animals.

Given the post-pandemic context, there is an opportunity to adopt a green One Health perspective to explore topics ranging from the micro-level of human-animal interfaces to macroecological analysis of the impact of climate change on zoonotic EIDs. Based on a review of key scientific literature, we identified four analytical dimensions of relevance through which green criminologists could examine threats, harms and crimes affecting health and well-being. To illustrate the interconnected nature of these crimes, harms and threats, we discuss the relevant mechanisms by which zoonotic EIDs may emerge within each analytical dimension.

Environmental and land-use change

Human-induced changes in the biophysical environment (e.g. drought and desertification) have transformed ecosystems (Vitousek *et al.* 1997). While economic growth and increased food production are cited as justifications (Patz *et al.* 2004; Murray and Daszak 2013; Loh *et al.* 2016), these changes are significant drivers of the transmission of EIDs affecting wildlife, domestic animals and humans (Daszak *et al.* 2001; Loh *et al.* 2015). Various activities, both criminalized and non-criminalized—such as deforestation, expansion of agricultural lands and extractive activities—contribute to the emergence of zoonotic diseases in myriad ways.

First, deforestation (legal or illegal) plays a key role in the emergence of novel pathogens via habitat alteration (Bernstein *et al.* 2022). This is especially relevant to the human-induced reduction of tropical forests with high biodiversity (Murray and Daszak 2013), which has led to further opportunities for the spread of novel pathogens as it forces the migration of wildlife, increasing contact with other wildlife species, livestock and humans (Wolfe *et al.* 2000; Patz *et al.* 2004; Fang and Song 2021; Bernstein *et al.* 2022; Keusch *et al.* 2022). Habitat fragmentation is the process through which previously intact habitats result in spatially separate smaller patches, thus altering ecosystems (Didham 2010). This can induce even more contact between pathogens, vectors and hosts (Patz *et al.* 2004), a process that is well-documented (Jones *et al.* 2008). For example, the Nipah virus emerged from flying foxes because of a combination of factors related to human-induced changes in the environment, including deforestation (Chua *et al.* 1999; Chua 2003).

Second, the most significant form of land-use change is the rapid expansion of crop and pastoral lands, which comes at the expense of pristine forests (Loh *et al.* 2016; Bernstein *et al.* 2022). Currently, agriculture uses almost half of the terrestrial surface on Earth, and more than two-thirds of the world's freshwater, and agricultural practices, such as irrigation, create new breeding sites for disease vectors (Patz *et al.* 2004). Finally, extractive operations, such as mining, logging, oil and gas extraction (Loh *et al.* 2016), infrastructure development (e.g. road or dam building) and other activities, including sites of illegal drug cultivation and processing, also facilitate the displacement of populations, wildlife and disease transmission (Lebel *et al.* 1998; Silbergeld *et al.* 2002; Patz *et al.* 2004; South 2023).

Climate change

There is consensus that human-induced global climate change is ongoing and significantly impacts physical and biological systems at an unprecedented rate (Oreskes 2004; Joos and Spahni 2008; Rosenzweig *et al.* 2008). Climate change, like deforestation, alters species' geographic ranges, and is likely to be introducing diseases to new hosts, especially in hotspots such as tropical Africa and Southeast Asia. This unnoticed epizootic (i.e. wildlife-to-wildlife) transmission could have catastrophic consequences for global biodiversity. Climate change is expected to foster and intensify pathogen adaptability (Carlson *et al.* 2022), while also affecting the reproductive rates and incubation periods of arthropod populations, influencing the spread of vector-borne diseases such as Murray Valley encephalitis and Zika viruses. Finally, changes in weather patterns, such as floods and rising sea temperatures, correlate with the emergence of diseases like haemorrhagic fevers, malaria and cholera (Daszak *et al.* 2000; Loh *et al.* 2015).

Human and population stressors

Human population density in and around 'hotspot regions' is strongly correlated with the emergence and spread of zoonotic diseases (Jones *et al.* 2008; Morse *et al.* 2012; Allen *et al.* 2017). The primary mechanism for the emergence of zoonotic EIDs involves urban expansion into wildlife habitats. This encroachment forces animals to adapt to human-modified environments, raising the potential for zoonotic transmission within expanding and densely connected urban populations (Wu *et al.* 2017; Andersen *et al.* 2020). Additionally, livestock density growth, especially in Asia, has increased the opportunities for zoonotic transmission, particularly in areas where high human and livestock densities have grown alongside high biodiversity. For example, the emergence of the Highly Pathogenic Avian Influenza H5N1 was first detected in an outdoor goose-rearing farm in Guangdong Province (Guan *et al.* 2002).

Global trade and human mobility also facilitate the spread of EIDs and 'pathogen pollution' occurs when travellers introduce pathogens into new locations (Daszak *et al.* 2001). The most vulnerable travellers, such as migrants, refugees and internally displaced persons, face heightened health risks (Patz *et al.* 2004) and even semi-isolated Indigenous communities are at risk (Goyes *et al.* 2022). None of this is entirely new of course—throughout history, trade and travel have been instrumental in disease dissemination, exemplified by events like the 'Black Plague', and the introduction of diseases to the Americas during colonization (McNeill 1977)—but it is intensifying.

Wildlife trade and trafficking

The global wildlife trade, a vast commercial exchange involving billions of live animals, plants and derivatives for different purposes (Smith *et al.* 2017; van Uhm 2018; Daszak *et al.* 2020), poses a threat not only to biodiversity, but also to health. This is due to the frequency and intensity of human–wildlife interactions (Chomel *et al.* 2007; Smith *et al.* 2009; Karesh *et al.* 2012). By increasing contact rates between wildlife, domestic animals and humans, pathogen prevalence rises after every stage of the supply chain, in a sort of 'snowball effect' (Huong *et al.* 2020). Additionally, recombination and spillover events can occur at any point, from original habitats to end consumers (Leroy *et al.* 2004; Johnson *et al.* 2015; Bernstein *et al.* 2022). For example, the international pet trade involving the sourcing of wildlife from hotspot regions, and their export into new environments, fosters potential spillover events such as monkeypox outbreaks (Patz *et al.* 2004). The risk of epizootic and zoonotic disease transmission is further increased through wildlife farms and markets that often include wild-caught animals, and where sanitation is not always optimal (Parrish *et al.* 2008; Aguirre *et al.* 2020; Broad 2020; Huong *et al.* 2020).

Unsurprisingly therefore, the illegal wildlife trade is also a catalyst for zoonotic EIDs (Karesh *et al.* 2005), due to its cross-border and global nature, and often weak 'quality', hygiene and sanitary controls (Bezerra-Santos *et al.* 2021). Here, both illegalities within legitimate wildlife supply chains (e.g. mislabelling wild-caught species as captive-bred) and activities related to wildlife trafficking (e.g. occurring during the period of abduction, transportation, smuggling or storage in overcrowded and closed-space transportation) are included as not only harmful for non-human animal health but also as potentially harmful to human health (Smith *et al.* 2017; Aguirre *et al.* 2020; Alonso and van Uhm 2023). Additionally, risky but legal practices can represent a potential threat to the health of humans and non-human animals. For example, the lack of use of Personal Protective Equipment (PPE) and the mix of different wildlife and domestic species within the same facility have been evidenced in wildlife farms in Dong Nai province (Vietnam) (USAID 2023).

We suggest that 'One Health Green Criminology' will be better placed to highlight all the harms and threats to human and animal health that occur within illegal, semi-illegal and legal markets. A further major implication could be to shift the criminological focus to the trade-in, and trafficking of, other wildlife species that have received less academic and policy attention, such as bats, rodents and non-human primates, which host the highest proportion of zoonotic viruses (Olival *et al.* 2017).

CONCLUSION AND DISCUSSION

This paper has presented an argument for strengthening the power and potential of the green criminology perspective to engage in discussions surrounding zoonotic EIDs by introducing and adding elements of the One Health approach. A major limitation, however, is that One Health can be viewed in very broad terms potentially posing challenges regarding operationalization within green criminology. The aim of this study, however, has been to highlight the synergies between green criminology and One Health rather than providing a detailed roadmap for implementation.

Adopting a One Health approach has several implications for green criminology, and vice versa. We have delineated the concept of 'health' as the object of harm and presented the definition and principles of One Health. Specifically, adopting One Health involves the acknowledgement of the links between, and the interdependence of, the health and well-being of humans, domestic and wild animals, plants and the wider environment. By synthesizing current scientific knowledge, this approach can more effectively address the multifaceted threats, harms and crimes impacting the health and well-being of humans, non-human animals and the environment. The adoption of the One Health definition and principles has clear justice implications, particularly in advancing Eco-justice. Conversely, incorporating a green criminological perspective into the One Health scientific community can significantly enhance efforts in pandemic prevention, preparedness and zoonotic disease surveillance.

This exploratory study has identified four key areas—environmental and land-use change; climate change; human and population stressors; and wildlife trade and trafficking—where a One Health perspective within green criminology can illuminate often overlooked harms and threats to the health and well-being of humans, non-human beings and ecosystems. This can include, for instance, non-human animal deaths through epizootic events. However, a One Health lens will also reinvigorate the criminological attention to these issues by expanding it to neglected activities and animals. The trade-in, and trafficking of, bats, rodents and non-human primates is an example. Beyond consideration of zoonotic EIDs, the potential applications of a 'One Health Green Criminology' framework can also include other, unrelated, threats and harms stemming from climate change or from toxins and contaminants. For example, non-infectious

diseases such as heat-related illnesses, anxiety or depression, ultimately pose a threat to human life through dehydration or exhaustion. Other interconnected health processes, such as ocean acidification, affect marine life and ecosystems, especially organisms such as corals and shellfish (Kleypas *et al.* 2005; WHO 2019).

Ultimately, the potential of a 'One Health Green Criminology' framework seems promising both for academic endeavours and for leveraging effective strategies to safeguard global health. In the aftermath of the COVID-19 pandemic, the link between green criminology and public health has become even more pertinent. As Macdonald (2021) notes, the time may be right for nations to sign up for proposals such as a 'global pandemic treaty', linking prevention and preparedness, animal welfare, environmental protection, health care systems, justice and equity. The proposal for a 'new, rights based relationship with the non-human world' (Macdonald 2021) could build upon foundations already laid by green criminology and One Health approaches that acknowledge the intricate relationships between human, animal and environmental health.[4]

FUNDING

This work was supported by the Research Foundation Flanders (FWO), PhD fellow fundamental research grant [application number: 11C2623N to A.I.A.].

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