



How deep does justice go? Addressing ecological, indigenous, and infrastructural justice through nature-based solutions in New York City

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ABSTRACT

Scholarship on Nature-based Solutions (NbS) primarily focuses on the potential for NbS to deliver multiple benefits to humans and biodiversity from networked natural systems. These approaches, if enacted without sensitivity to local contexts and histories, can deepen long standing injustices resulting from the destruction of complex self-organizing ecological systems, the usurpation of Indigenous governance and knowledge, and the prioritization of technical managerial approaches transforming nature into infrastructure. Here we review, synthesize, and critically reflect on existing scholarship on the rise of NbS in New York City, USA, to inform environmental policy in support of just transformations of complex urban systems. To do so, we examine NbS within the context of the social-ecological-technological system (SETS) of NYC. We organize our review and synthesis around three interrelated concepts of justice: Ecological, Indigenous Environmental, and Infrastructural Justice. Ecological Justice entails addressing the harms, needs, and desired futures of ecological actors while identifying synergies with human focused environmental justice concerns and movements. Indigenous Environmental Justice requires restoring Indigenous systems of governance and knowledge while making space for a diversity of social-ecological practices of marginalized communities. Infrastructural Justice addresses the historical and ongoing injustices perpetuated through mainstream infrastructure policy and design practice – including Environmental Justice concerns – which have increasingly turned towards NbS. Without embedding these principles within emergent NbS focused environmental policy agendas seeking just transformations, they will likely recreate utilitarian, anthropocentric, and colonial modes of managing nature as infrastructure. We conclude with a research-to-action agenda for meeting the interdependent needs of urban ecosystems and humans.

1. Elements of justice in nature based solutions: The case of NYC

In the United States, Nature-based Solutions (NbS) for climate adaptation have often been implemented as green infrastructure (GI) (Frantzeskaki et al., 2019), ranging from bioswales to green roofs and constructed wetlands. An amorphous concept (Matsler et al., 2021). In the context of US urban planning GI can be defined as “...a system of interconnected ecosystems, ecological-technological hybrids, and built

infrastructures providing contextual social, environmental, and technological functions and benefits. As a planning concept, GI brings attention to how diverse types of urban ecosystems and built infrastructures function in relation to one another to meet socially negotiated goals” (Grabowski et al., 2022). The justness of GI and NbS must therefore consider *whose* goals are met through NbS (Wijsman et al., 2021) and whose knowledge and power shapes NbS policies and programs (Wijsman and Berbés-Blázquez, 2022 – this issue). Justice is an

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inherently normative and subjective goal, purposefully constructed by humans to achieve specific ends, including, as Wijsman and Berbés-Blázquez (2022) discuss, the quality of human relationships with land, and improving wellbeing, dignity, and community membership, alongside redress for harms. Building on this plurality of goals and emphasizing the embeddedness of NBS in longer historical trajectories, here we argue that, at a minimum, justice in the context of NBS should consider three related concepts of Ecological justice, Indigenous Environmental Justice, and Infrastructural Justice. Each of these ideas of justice incorporates existing justice theory including distribution of goods and hazards, recognition of prior harms and the value of different cultural identities (Fraser 2009), and transformation of the underlying systems causing harm (Greedy et al., 2010).

Given that NBS functions in relation to complex and contested urban infrastructure systems, we examine how these three domains of justice function in the context of the ongoing transformation of the social-ecological-and-technological system (SETS) of NYC (Frantzeskaki et al., 2019; Grabowski et al., 2017; Markolf et al., 2018; McPhearson et al., 2022). Examining NBS as a SETS allows us to examine how its evolution is explicitly shaped by power within the social negotiation of setting goals, framing current conditions and problems that infrastructure is meant to address (Grabowski et al., 2017). In this sense, SETS serves as a heuristic for understanding how irreducibly complex reality becomes known as a series of components, processes, and relations amenable to formal modeling, analysis, and management, including some perspectives while excluding others (Manuel-Navarrete, 2015). Pluralism in framing goals and means in sustainability transitions (Grabowski et al., 2019), is therefore required to create social processes capable of handling ontological difference while aiming to create common knowledge (De la Cadena, 2017).

Viewing the evolution of NBS in New York City, USA, through a SETS lens we examine (1) how a concept of Ecological Justice could be operationalized to allow for ecological agency within current NBS approaches (2) approaches for restoring Indigenous ecological governance and other self-determined modes of social-ecological governance, and (3) the tradeoffs within current NBS efforts turning urban nature into infrastructure. Through the examination of Ecological, Indigenous Environmental, and Infrastructural Justice in NYC we identify blind spots in current NBS policy and practice in New York City, USA. For each concept, we also identify how it can inform transformations of current policy and practice.

2. Ecological justice in NBS

2.1. Centering ecological agency

The idea of ecological justice highlights the harms visited upon the living beings composing ecosystems caused by the development of cities, some of which can be addressed through NBS (Pineda-Pinto et al., 2021a). In a literature review of existing NBS and justice research, Pineda-Pinto et al. (2021a) found that Anthropocentric, utilitarian, and economic notions of justice dominate thinking on the relationship between justice and NBS, presenting a significant blind spot in NBS research and policy. To address this blind spot, Pineda-Pinto et al. recommend the integration of ecological agency within urban SETS research and policy, which requires humans to work with rather than against ecological agents to shape the structure and function of urban ecosystems for mutual wellbeing. These approaches are not exactly novel - but reflect a widespread understanding held by many different Indigenous peoples worldwide (Berkes, 2008), and are employed in the UK through official policies making space for nature (Lawton, 2011). Such an approach goes beyond other frameworks for considering the needs of other organisms exist, such as weak anthropocentrism (Norton, 2017) and the rights of nature (Callicott et al., 2020). Working with the agency of more than humans allows us to examine how the self-organizing aspects of urban ecological systems function in relation

to the social norms, knowledge, and built infrastructures shaping urban SETS.

Ecological justice in this context entails recognizing the agency of the Earth, or a recognition of the actions of the earth system increasingly occupying the political sphere independently of human discourse (Latour, 2018). The living world has (political) effects. Political discourse and ethical philosophy respond to the reality that the earth and its diverse inhabitants are unruly, and not willing to fit within existing social schemas for how they should behave (Alaimo 2016). Practically speaking, it is the agency of ecological actors – through growing roots systems, transporting seeds, extending bodies, and myriad ecological interactions of microbes, fungi, plants, invertebrates, and vertebrates – that shape the ecosystems constituting NBS, and provide ecological services. Emphasizing agency avoids ‘mechanizing’ complex species behaviors, instead focusing on the ways in which diverse species interact with and make up the environment and each other based on their affordances and capacities (Andersson and McPhearson 2018) including their sociality and culture (Youatt, 2020). These capacities include organismal roles as ecological engineers (Jones et al., 1994), such as salt-marsh grasses trapping coastal sediments and building extensive habitat for other species. From this perspective, humans serve as one of many ecological agents, who may exert an outsized influence on some ecological and environmental processes while being potentially overwhelmed by others (e.g., viruses, hurricanes). In both cases, the environment and ecosystems are entities live in relation with, rather than as an abstract construct to be ‘managed.’⁴

Ecological justice can be compatible with social justice. Both require recognizing harms and transforming the systems perpetuating those harms as a fundamental step towards repair (Pineda-Pinto et al., 2021a). The notion of ecological justice is fast becoming international law, which now recognizes ecological destruction as a form of genocide through the concept of ecocide (Higgins et al., 2013; Dunlap, 2021). Eco-feminist scholarship has also argued that ecological justice is inclusive of social justice – as it entails a fundamental respect for life and self-determination regardless of gender, racial, or species identity (Haraway, 2015; Bell et al., 2019). Including ecological justice in NBS research and policy allows for thinking through fundamental ontological and practical issues when defining the need for and designing interventions on urban ecological systems. Ecological agency complicates research and practice by making it clear that ecological systems are not simply domesticated esthetic or infrastructural components of the urban landscape, instead they are alive and struggling for their own self-determination (Pineda-Pinto et al., 2021a). Current thinking in environmental justice also seeks intersectional and transformational approaches towards repairing environmental harms (Pellow 2016). Indigenous scholarship is at the forefront of this integration of social and ecological justice concerns by focusing our attention on dismantling the systems of power degrading human-land relations rather than seeking an extension of ‘rights’ by those same systems (Gilio-Whitaker, 2019; Corn tassel, 2012; Weaver, 1996). In contrast to ‘rights’ based approaches, scholars like Coulthard and Simpson (2016) offer a concept of grounded normativity which centers the need for explicitly ethical and multi-generational relationships with place in order to enact positive forms of ecological transformation. Given that over 80 % of global biodiversity occurs within Indigenous territories beleaguered by state and corporate development projects, maintaining ecological resilience within cities and globally requires sustaining and defending Indigenous

⁴ The term ‘management’ stems from the French *managere*, which literally means to ‘put under the hand’ and originally referred to the breaking of a horse. Management thus refers to the ‘putting nature under the hand’ in order to achieve some desired schema or purpose, and even if extended through technologies, still critically depends upon the skill, knowledge, and capacities of the manager, which includes recognizing the behaviors, desires, and capacities of the lives they seek to manage.

systems of customary land conservation exhibiting grounded normativity (Carriño and Ferrari, 2021). Grounded normativity recognizes the reciprocity required for healthy human-ecosystem relations; caring for the land requires acknowledging that the land cares for us. Reciprocity in turn requires accepting and interacting with Land as a living entity and helps us address the relationship between social and ecological justice, a primary gap in scholarship on justice in NbS (Pineda-Pinto et al., 2021a).

2.2. Environmental and ecological agency in NYC

In New York City, existing work has applied the concept of ecological justice to investigate current gaps in the design and implementation of NbS. By considering ecosystem needs, NbS can restore key ecological functions and structures while addressing long standing disparities in environmental hazards in society (Pineda-Pinto et al., 2021b). Here, we expand on this work to explore the trajectory of urban ecological change that can be addressed through justice oriented NbS.

NYC occupies the ecologically rich estuary of the Hudson River which drains most of upstate NY, along with parts of Vermont, Massachusetts, and Connecticut, meaning that the green infrastructure supporting the city extends far beyond its formal boundaries. The city's temperate climate contains diverse ecosystem types dominated by temperate mixed and broadleaf forests and has been found to be a regional biodiversity hotspot despite intensive built development (McPhearson and Wijsman, 2017). The city itself sits on a post-glacial granitic and metamorphic geology, with extensive soft shoreline deposits of glacial till left behind during the last glacial maximum circa ~18,000 ago. Its location exposes the city to both the circumpolar jet stream and warm Atlantic-Gulf Stream, and subsequent climatic extremes of both tropical and winter storms. Notably, hurricanes such as Sandy in 2012, will likely increase in frequency and severity under future climates (Lin et al., 2016), as will heat waves (Ortiz et al., 2019), both with highly uneven social impacts. The city has also experienced major blizzards with recent storms depositing ~ 1 m of snow in a single event. Additionally, ice storms, which can have severe impacts on the electrical distribution system and topple trees, are likely becoming more frequent in future winters (Klima and Morgan 2015). All of these extreme weather phenomena are shaped by both multi-decadal climatic variations, such as the North Atlantic Oscillation, as well as meso-scale processes such as sea breezes.

The climate challenges the city faces are exacerbated by its location in a sea level rise hotspot due to geological and oceanic factors, which are conservatively projected to increase mean sea level by 0.5 m by 2100 (Gornitz et al., 2019). Much of the city's coastline consists of anthropogenic fills on former marshlands and open estuary (Montalto and Steenhuis, 2004), which combined with ongoing floodplain development (Herrerros-Cantis et al., 2021), dramatically exacerbates coastal flooding risks.

This dynamic coastal environment is a home for diverse flora and fauna, with numerous migratory animals including intercontinentally traveling birds, sharks, and fishes using the estuary during part of their life cycles. The coastal mixing zone historically supported enormous shellfish reefs gradually extirpated by over-exploitation, habitat destruction, and water pollution, although are now the focus of major restoration efforts (Wakefield, 2019; New York City, 2018; 2013). While urbanization destroyed pre-colonial mast forests, recent efforts (like the million trees NYC initiative) have expanded city wide tree canopy alongside 4000 ha of spontaneously assembling forests (Pregitzer et al., 2018). This complex mosaic of self-assembling habitats also includes poorly studied ruderal plant communities unevenly distributed throughout the city (McPhearson and Wijsman, 2017). Vertebrates also form an important part of the overall ecological community, and yet are not discussed in the city's current official NbS policies and programs, representing another blind spot for NbS policy. These organisms, such as urban coyotes, racoons, white-tailed deer, opossums, birds, rats and

other rodents, among others, all participate in shaping the urban ecosystem in ways that remain poorly understood. Although most species are hypothesized to decline with increasing degrees of urbanization, persistent introduced and acculturated species have created a rich ecological mosaic including numerous rare and threatened species (McPhearson and Wijsman, 2017). Invertebrates likewise play important roles in structuring fundamental physical and chemical properties of urban soils, as in the case of invasive earthworms. Additionally, pathogens such as ticks serve as vectors of infectious diseases, including the regional epidemic of Lyme disease, an important disservice of urban ecosystems under active study (Van Acker et al., 2019). Thus, despite extensive urbanization, the city's ecosystems have continued to self-assemble in relation to dynamic environmental forces and human influence.

2.3. Incorporating ecological justice in NbS practice and research

Ecological justice highlights that current scientific knowledge of urban ecosystems is derivative of ecological processes that science seeks to understand. While just transitions scholars (Whyte 2017) explicitly call for procedural justice in sustainability transitions, this typically happens in an anthropocentric fashion. Instead, acknowledging the agency and stakes of non-humans, and how such a consideration would change processes of analysis, planning, design, implementation, and maintenance of NbS remains a blind spot for mainstream NbS research and practice (Pineda-Pinto et al., 2021a). By centering ecological spontaneity and self-assembly, the concept of ecological justice highlights the need to consider the numerous ways that ecosystems participate in the making of their own complexity and futures. In New York City, existing tree planting, green stormwater infrastructure, and coastal ecosystem restoration can all benefit from considering how they can support and are supported by ecological self-assembly and dynamic environmental processes.

Working with, rather than against, ecological processes and capacities allows for more robust and resilient urban ecologies within NbS strategies (Kennedy, 2022). However, current green infrastructure plans in NYC are silent on the rights and capacities of nature and have no avenues for including ecological agents within decision making processes. To take steps in this direction, we advocate for a normative framework that acknowledges the personhood and agency of ecological actors, similar but distinct from existing frameworks for the 'rights of nature' which are rapidly proliferating across the globe (Boyd, 2017; Nash, 1989). These can be augmented through an elaboration of a place based relational ethics that builds on Native ontologies and recognition of the spirit and agency of other organisms (Cajete 2004), which we elaborate on in the following section. In practice, existing scientific concepts of designed experiments (Felson and Pickett, 2005), can be expanded to investigate how ecological self-assembly occurs in different urban habitats and contexts. Heterogeneous ecological successional stages are an important component of maintaining regional biodiversity, especially in human modified landscapes (Teurlinx et al., 2018). Taken together, the agency of nature can be recognized through successional landscape design practices (e.g., Dagenais, 2008), which allow for self-assembly to occur in collaboration with human interventions.

Ecological Justice also aligns with existing concepts of making space for nature (Lawton, 2011), rivers (Warner et al., 2012), and water (Jones and MacDonald 2007). By 'making space' in both an ethical and physical sense, NbS policy can support ecological self-assembly through recognizing the inherently spatial dimensions of ecological processes such as dispersal, connectivity, patch quality, and heterogeneity, as articulated in early versions of the green infrastructure concept (Benedict and McMahon 2012). While radical on the surface, policy proposals that explicitly seek to support ecological self-assembly have been mainstream in the UK for over a decade (Lawton et al., 2010). Similarly, making space for water provides greater reliability in flood and storm-water management (Warner et al., 2012), and has been instituted as a

formal policy concept in The Netherlands (De Vries and Wolsink, 2009), and Germany (Hartmann, 2012). These approaches present an alternative design paradigm of safe-to-fail infrastructure which ultimately needs to incorporate dynamic environmental and ecological processes to improve infrastructural resilience (Kim et al., 2022). Design approaches for coastal flood hazards that focus on resisting environmental forces, for example through hard infrastructural features such as seawalls, have often accelerated the processes they were meant to control and contain. In NYC, significant tradeoffs exist in terms of the effectiveness, and cost-effectiveness, of coastal adaptation measures, and there remains a clear need to make space for coastal nature to attenuate increasing coastal hazards (Wijsman et al., 2021; Ceres et al., 2022). Designing effective and just NbS can use the concept of ecological justice to highlight environmental dynamism and ecological agency within the social process of designing social-ecological-technological infrastructure systems.

3. Indigenous environmental justice in NbS

3.1. Socio-ecological justice in NbS

Despite their reliance on human-land relations predating colonialism, mainstream Green Infrastructure and NbS discourse omits Indigenous land relations and infrastructural practices (Tomateo, 2021). In settler colonial states, such as the United States, these dynamics include the ongoing political marginalization of Indigenous peoples, as well as disregarding Indigenous Environmental Knowledge (IEK) in conservation interventions (Gilio-Whitaker, 2019). Advancing socio-ecological justice then requires understanding and conceivably reinstating Indigenous approaches to ecological governance and landscape care (Corntassel, 2012; Cajete 2004). Compared to Western (Euro-American) environmental governance approaches, which tend to emphasize utility and responsibility to country (Rose, 1994), IEK understands ecosystems as societies with ethical interspecies structures, Land as sentient, and natural elements as kin in reciprocal relationships (Dei et al., 2022), and centers the importance of positionality, situatedness, and responsibility for environmental knowledge (Wijsman and Feagan, 2019). Acknowledging the purposeful elimination of IEK and working towards its restoration serves as the focus for Indigenous Environmental Justice (IEJ) (Gilio-Whitaker, 2019; Weaver 1996), providing an important evolution of existing Environmental Justice scholarship shifting focus from understanding the patterns of uneven exposure to environmental hazards to their causal processes and how they can be reinforced, obscured, or addressed through research and policy formulation (Liboiron 2021; Pellow 2016). The point is not to romanticize Indigenous environmental governance or to dismiss Western (or scientific) approaches, but to recognize how historical legacies continue to shape the making of social decisions about the environment in ways that fundamentally impact what is deemed important, desirable, and just.

Critical EJ and IEJ share a focus on how current systems of governance cannot be relied on to extend ‘rights,’ appropriate reparations, or return land to those on the receiving end of environmental harm – shifting our attention to transforming the systems causing harm. IEJ focuses attention on the governance of land and how claims of ownership (e.g., settler colonial claims on Indigenous territories) set the stage for all subsequent political processes for deciding on permissible environmental and social harms (Coulthard and Simpson, 2016; Whyte, 2017). As such, just NbS can likely only occur through the restoration of displaced systems of Indigenous governance.

Practically, IEK is based on intergenerational observations on the effects of land care practices (Cajete, 2004; Berkes, 2008). Place based knowledge is often carried by specific individuals, which may or may not be reflected in institutions, necessitating an understanding of both formal and informal systems of managing and relating to the environment (Ernstson and Swyngedouw, 2018). For many Indigenous peoples,

identity, sacred responsibility and land cannot be separated, although territories can be shared with other groups and individuals who accept responsibilities of caring for it (Coulthard and Simpson, 2016). Thus, restoring Indigenous governance does not de-facto exclude other social groups, instead it predicates living with the land in Indigenous territory on the acceptance of specific place-based responsibilities. Such an approach goes beyond notions of cultural pluralism and epistemological equity (Miller et al., 2008) for enacting sustainability transitions, as it centers just governance and overall agreement on the centrality of protecting the quality of life for humans and other organisms alike.

In urban systems, the power to care for, or destroy, ecosystems often resides in formal institutions and associated budgets and expenditures, including the capacity to enact sanctioned forms of violence, and in the quality of built infrastructures and environmental amenities (Brenner, 2009). While wholesale restoration of Indigenous forms of governance in settler colonial states may not be seen as feasible by many, global movements of Indigenous resurgence continue to gain momentum (Dhillon, 2018). Here we re-examine the legacies affecting Indigenous and Environmental Justice in NYC to identify opportunities for NbS to contribute to transformative ecological governance as part of a larger just transition in the city.

3.2. Indigenous and environmental justice in NYC

The area currently known as New York City occupies the unceded lands of the Lenape people. Unceded Indigenous lands in settler colonial states present a particularly thorny legal and moral terrain within which to address social and ecological justice issues – as has been extensively documented in the province of British Columbia, where landmark court cases have found that occupation by settler colonial states does not extinguish Aboriginal title in the absence of treaty agreements (Sroka 2018). As such, addressing fundamental issues of Indigenous governance in settler colonial states represents a major gap in current NbS research. Of 16 plans implementing various forms of NbS within the city, only 2 even mentioned Native relationships with land (www.giequity.org/nyc). While others have extensively examined ecological (Pineda-Pinto et al., 2021b) and environmental justice (Sze, 2006) issues in NYC, we know of no peer reviewed literature to date that discusses Indigenous Environmental Justice in the context of NYC, which merits elaboration here. The lands and ecosystems of NYC were co-constituted through complex forms of land relations since time immemorial. These diverse cultural practices have been well documented in oral traditions, including coppicing, transplanting, selective harvests, targeted dispersal, and periodic burning. The landscape has been shaped by thousands of years of purposeful ecological interactions punctuated by significant climate changes (Lenape Center 2022; Deloria, 1997). Indigenous persistence and presence on the land continues to be contested by settler narratives of Indigenous ‘arrival’ in the Americas (Deloria, 1997). At the same time, the archeological and genetic evidence for timing of arrival remains rapidly evolving, and highly contested, including the evidence for human habitation of the Americas prior to the last glacial maximum (Willerslev and Meltzer, 2021). Contested histories aside, it is clear that Native peoples shaped regional ecosystems since the last glacial maximum which deposited Long Island as a terminal moraine (Lothrop et al., 2016).

It is therefore impossible to understand the current ecological conditions of New York City without understanding the role of Indigenous peoples in shaping both ecological communities and the settler imaginary. For example, the militarism of colonial land claims is reflected in the world famous ‘Wall Street,’ named after the wall built to fortify Dutch settlement on the island of Manhattan. Other marks of persistence include Shell Point, which is named after a site of shell middens marking a significant fishing and year-round habitation site. Despite their purposeful erasure, Lenape peoples have persisted and their ongoing cultural resurgence (Sanderson, 2013) forms part of a broader process calling for honoring Indigenous relations to land and meaningful

anti-colonial projects (Liboiron 2021). Many accounts of the history of New York City mention in passing the role of the Lenape in shaping the regional ecosystem, but quickly move on to the problematic mythology of rightful purchase of lands and colonial actors struggling epically against an untamed wilderness (Weaver et al., 1996). Such accounts of pre-European habitation romanticizes Indigenous peoples and their relation to land, and historicize narratives of settlement within a larger, and often racist, narrative of migration and cultural exchange, claiming Native history as a component of their settler colonial cultural lineage (Deloria, 1997). These attempts to appropriate history disregard that many treaty agreements allowing settler use of lands were agreements for joint use and occupation, not exclusive ownership (Gilio-Whitaker, 2019). It was in this context that the Dutch Colonial city of New Amsterdam began as a trading post that absorbed many refugees from Spanish and English wars throughout the Caribbean and served as the chief importation center for the Trans-Atlantic Slave trade of stolen Africans (Horne 2018).

Colonists of New York engaged in restructuring regional ecosystems with labor of enslaved Africans and in active confrontations of varying intensity with regional tribes. Large old growth mast forests of widely spaced mature trees, often approaching 100 m in height, were converted within several generations into pasture and croplands (Cronon, 2011). During this time settler colonialism slowly transformed from a milieu of relations with multiple overlapping frontiers into a hegemonic project of ethnic and ecological cleansing to make way for colonial settlement (Hixson, 2013). Since the revolutionary war, the United States of America systematically limited Native economic and political self-determination and ultimately pursued their total eradication and removal (Gilio-Whitaker, 2019), in spite of which they have persisted within the city limits (Connolly, 2018) and region.

Colonization and the intensification of settler agriculture quickly led to ecological issues, including poor sanitation and the spread of transmissible diseases (McNeur, 2014). Changes in the surrounding ecosystem were regulated by colonial and American governments to little avail, and as water quality deteriorated, regional economies shifted to further prioritize trade and importing food previously obtained through local aquaculture, agriculture, hunting, fishing, and gathering (Cronon, 2011). Large migratory fisheries – notably salmon, shad, sturgeon, eels, and alewives – were progressively stressed by land and wetland conversion, overfishing, and dams. These processes accelerated the collapse of aquatic ecosystems accompanying the international commodification of beavers, their subsequent extirpation, and the large-scale loss of aquatic habitat (Cronon, 2011).

These shifts in the underlying socio-ecology of NYC, foreground how *colonization* entails a shift from the relations between humans and other beings resulting in complex ecological mosaics, towards formal systems of resource extraction supported by the standardization and regulation of land ownership (Gilio-Whitaker, 2019; Scott, 1998). Ecological transformation in turn was shaped by the labor of enslaved Africans in building regional infrastructures (Horne 2018), speculation over the value of land (Stein, 2019), and the rise of industrial modes of production (McNeur, 2014). The project of slavery-based settler colonialism has been described as a transition from a settler society that contained racism to a settler society based on racism, or one whose material well-being fundamentally depended upon the expropriation of bodies and land justified by white supremacy (Horne, 2018).

The cultural tapestry of the city is likewise shaped by histories of migration and displacement. Along with being a major center of importation of enslaved Africans, the city was also the dominant port of entry for European laborers to meet growing demand in the cities' industries through the late 19th and early 20th century. These waves of migrations occurred before severe restrictions on immigration of Jewish and Eastern European peoples were imposed in 1924 through the Johnson-Reed Act, which were not lifted until *after* WWII despite knowledge of Nazi Germany's attempted systematic extermination of those same peoples (Okrent, 2020). These were but some of the more

extreme examples of racist immigration and domestic policies contributing to the ghettoization of many migrant communities (Ward, 1989). Clashes between immigrant communities, Blacks who had long resided in the city, and Southern Blacks that had emigrated during the Great Migration, were increasingly frequent in this period, and formed one of the little recognized drivers for reform planning and the creation of a city-wide network of green spaces (Cranz, 1982). The idea that different races and ethnicities had different requirements and should be granted differential access to park facilities was firmly ingrained in early park planning efforts (Cranz, 1982). Early parks planning also coincided with large scale programs of urban renewal and slum clearance (Gandy, 2003), as well as the significant restructuring of the coastline through fill, dredging, and armoring (Wakefield, 2019).

Immigration from the colonial territory of Puerto Rico also significantly impacted the social-ecological dynamics of the city. Increasing 'latinization' occurred with diasporic immigration caused by US backed coups in Central and South America (Grosfoguel and Georas, 2001). Together these forces resulted in a complex mosaic of social-ecological relations manifested in different uses of private green space, public parks, and access to green infrastructure, continuing to shape the perceived value and necessity of NbS today. Numerous 'vacant' lots throughout the city, stemming from cycles of disinvestment, have also contributed to the persistence and health of urban ecosystems (Kremer et al., 2013). It is no wonder then that even though NYC is now arguably one of the most culturally and racially diverse cities in the world, enormous inequalities and issues of environmental justice persist, including disparities based on race and ethnicity in life expectancy, occupational hazards, exposure to ambient pollution (Sze, 2006). These disparities include differences in access to green space and tree canopy and the environmental hazards explicitly managed by NbS such as urban heat (Hoffman et al., 2020) and exposure to flooding (Herrerros-Cantis et al., 2020; Maantay and Maroko, 2009).

Disparities in access to ecological amenities and exposure to hazards are inseparable from long standing racist patterns of real estate development and associated federal and local policies (Rothstein, 2017). These include the purposeful clearance of Black communities through urban renewal such as the displacement of the community of Seneca Village during the creation of the city's iconic Central Park (Gandy, 2003; Low, 2019). In this sense, urban greenery that would now be considered NbS has historically been weaponized against people of color and the poor, most recently through aggressive 'green' real estate development gentrifying portions of the city (Gould and Lewis, 2016). These profound inequalities are defining characteristics of the social-ecological arrangements of NYC and other cities in settler colonial states (Pulido, 2018). While long hidden in plain sight, they are now increasingly taken up in the discourse around sustainable design and environmental justice, as well as the acknowledgment of the need to recenter Indigenous relations with land and address the horrors of settler-colonialism and persistent racism (Low, 2020). Utilizing a just transition framework for NbS should explicitly consider the structural social injustices affecting uneven exposure to hazards managed by (Anon, 2022) NbS and inequalities in the amenity value of NbS. Thus, to prevent NbS projects simply extending existing dominant modes of assigning value to life and property, principles of IEJ and EJ should shape NbS policy and practice.

3.3. IEJ and EJ policies in support of just transformations of NbS

Addressing socio-ecological justice through NbS in NYC and beyond can begin with recognizing the reality of Indigenous erasure, displacement, dispossession, and persistence. Recognizing harm, however, is not the same as addressing harm. Other settler colonial states such as Canada, Australia, and New Zealand have previously established truth and reconciliation commissions, but only in New Zealand has formal recognition of violations of treaty rights led to the state accepting treaty responsibilities and recognizing the Indigenous right to self-

determination (Sullivan, 2016). Other states with more contested governance regimes, like Chile, have created parallel legal systems that recognize Indigenous law and relationships with land (Stavenhagen, 2006). Investing in processes of recognizing how treaty rights and the lack of treaty rights have affected Indigenous communities and the socio-ecological system of NYC remains a necessary step down the path towards justice. Given that place based Indigenous ecological knowledge and practices provide vital supports for biodiversity (Berkes, 2008), investing in restoring this knowledge will likely improve the efficacy of NbS programs in the city.

Addressing IEJ is complementary with – but distinct from – current policy initiatives around EJ. New York State’s Department of Environmental Conservation has programs dealing with Indian Nation Consultation and Green Infrastructure (Dei, 2022). This recognition of the need for government-to-government consultation with Indigenous peoples while simultaneously addressing EJ issues is therefore already modeled at the state level. In 2018 the City of New York established an advisory body on EJ issues, the *Environmental Justice Advisory Board*, with a goal of incorporating EJ concerns into all city agency decision making. However, the current scope of work is so far silent on Indigenous and Native issues and does not recognize the City’s treaty obligations to protect land relations of upstream Nations or any other historical harms visited upon Native Peoples (Environmental justice inter agency special working group, 2021). As such, IEJ forms a significant blind spot in current city policy on just NbS and climate adaptation.

Addressing Indigenous Environmental Justice can be done through supporting existing Indigenous led initiatives within the city, such as Justice Interagency Working Group EJ IWG, 2021. Previously, the Manahatta and Welikia projects set about to understand the pre-colonization ecology of the city (Anon, 2017), and these efforts can be expanded. Ultimately, IEJ cannot be addressed without creating processes for restoring Indigenous governance (Gilio-Whitaker, 2019), including significant land restoration, which has begun within the broader region, as in the example of the Papscaanee Island Return (Anon, 2021). The return of Papscaanee Island to the Stock-Bridge Munsee community illustrates how Native peoples maintain connections with land despite their forced removal and displacement from ancestral homelands. At the same time, the significant cultural features of the island remain threatened by energy infrastructure development (HMEAN 2022), indicating that restoring Indigenous governance remains more complex than simple land return within a colonial system. Broader issues of restorative justice that reinstates Indigenous governance regimes include the potential tokenization of Native stakeholders and a failure to enact meaningful participatory or transformative decision-making processes in both research (Klein et al., 2022), and practice. Klein et al. (2022) and others such as Liboiron (2021), point out that engaging in anti-colonial and justice-oriented research with Indigenous communities requires significant investments in participatory research methods, which remains a gap in NbS research in support of just transitions. This gap remains despite the rapid proliferation of research on how Indigenous led urban restoration projects, and the use of Indigenous ontologies and value systems to guide scientific research, improve environmental outcomes (Walker et al., 2019), build social capacity for environmental care (Hall et al., 2021), and are a key component of achieving social justice through ecological restoration (Constant and Taylor, 2020).

NbS research and practice seeking just transitions should actively explore restoring Indigenous governance arrangements and pursue Indigenous co-management of NbS projects, as has become commonplace in conservation practice and by extension, NbS, across the globe (Dhillon 2018). In addition to the global examples above, other examples can be found in the ongoing, and fraught, restoration work on the Duwamish river in Seattle (Klein et al., 2022), where restoration programs have struggled to build just processes for the federally unrecognized Duwamish tribe despite their ongoing organizing efforts. In Vancouver, British Columbia, the ongoing restoration of Sk̓wx̓wú7mesh

Úxwumixw/Squamish Seṇákw lands along False Creek returns land to First Nations that were illegally displaced from their homelands, and is allowing for significant economic benefits to the tribe while pursuing the largest First Nations economic development project in Canadian history. Similarly, the x̓m̓əθk̓w̓əy̓əm/Musqueam, Sk̓wx̓wú7mesh/Squamish, and səliw̓ətəṭ/Tsleil-Waututh (MST) joint redevelopment of the Jericho Lands provides an example of economic development projects being used as part of larger efforts of “reconciliation” between a settler state and First Nations. Notwithstanding the significant, and underexplored, complexities of merging the reconciliation imperative with speculative real estate capitalism (Whiteside 2020), these efforts point at both the possibility of the potential for Indigenous land return to provide some measure of economic justice and ecological restoration, while not escaping the larger questions over what constitutes acceptable urban-ecological form and Indigenous self-determined governance (Coulthard and Simpson, 2016). What these examples do point to is the ongoing struggle to make conceptual space for Indigenous planning and science as a legitimate spatial practice (Porter et al., 2017).

In the broader contest for social and environmental justice, community groups and urban planners alike continue to enact alternative forms of planning to challenge hegemonies around property ownership and land value (Stein, 2019). Although many practical initiatives within current planning practices exist to alleviate the forces driving dispossession and displacement, in NYC radical reformulations of property ownership, such as the creation of housing cooperatives, have been the most effective at maintaining housing affordability (Huron, 2015). Regardless, researcher on justice in NbS should consider the relationship between the distributional benefits of NbS and how it is situated within regimes of land ownership and governance.

Addressing the broader patterns of socio-ecological injustice, including environmental injustice, will require supporting community-based, cultural, and political institutions advocating for socio-ecological self-determination of diverse urban communities. This approach may significantly increase the diversity of land care and use practices considered NbS. Numerous community gardens and grassroots initiatives for example have improved access to food, medicine, and recreational opportunities for marginalized communities (Balick et al., 2000) and form a rich part of the overall *biocultural* diversity of NYC. Existing socio-ecological systems indicate that humans and ecological agents can form convivial and mutually beneficial relations based on principles of shared abundance and reciprocity (Hinchliffe and Whatmore, 2006), the question for NbS is how such relations are altered, for better or for worse, by turns towards systematizing the management of urban nature as infrastructures.

3.4. Infrastructural justice

In complex urban systems, social-ecological relationships and ecosystem services are structured and mediated by technological infrastructure systems (Frantzeskaki et al., 2016; McPhearson et al., 2022; Gilbert et al., 2022). Infrastructures in turn, are irreducibly complex social-ecological-technological systems whose forms are driven by social processes of goal setting, design, implementation, and maintenance (Grabowski et al., 2017). Mediating human-environmental relationships, infrastructures often create new forms of socio-environmental regulations and corresponding institutions (Carse, 2012). By restructuring physical environments, they critically constrain what environmental futures are possible based upon the obduracy of the past (Pritchard 2011). Historically, the creation of built infrastructures has been one of the primary stressors on ecological systems, often physically displacing ecological systems and fundamentally altering the material and energy flows underlying ecological quality. Additionally, many infrastructure systems have been purposefully used as tools of dispossession and extraction of Indigenous lands and the labor and resources of minoritized groups (Gilio-Whitaker, 2019).

Infrastructural Justice calls attention to the social and ecological

impacts and reconfigurations caused by the creation of built infrastructures, as has been detailed by STS scholars like Ashley Carse (2012), Sara Pritchard (2011), and Langdon Winner (2017). Formally managing NbS as hazard mitigation infrastructure calls attention to the uneven power relations shaping the social distributions of existing and future environmental risks and how they are communicated (Wynne, 1992). Infrastructural Justice thus intersects with EJ, as many of the harms facing environmental justice communities are hazards created by specific technological infrastructural practices such as resource extraction, manufacturing, transportation, and waste disposal, and are managed by specific classes of experts residing in institutions wielding state power. They share concerns around the politics of infrastructure decision making, and together offer a lens to examine the equity of defining hazards and acceptable exposure levels within regulating institutions and agencies. Additionally, as infrastructures provide specific social services and benefits, IJ requires consideration of the uneven distributions of benefits provided by NbS. As NbS goes ‘mainstream,’ the normative considerations of justice ask us to consider how infrastructure decision making occurs, what role it plays in social and ecological harm in the past and present, and how different forms of decision making can either perpetuate those harms or offer redress and restoration.

Socio-ecological systems approaches to understand the development and role of NbS in climate change adaptation – and the attendant impacts on justice issues – are incomplete because of the extensive relationships of ecosystems and built infrastructures. SETS approaches overcome this limitation by focusing on how ecological and engineered infrastructures are managed to perform similar types of infrastructural. Infrastructure in this sense refers to designed systems making contemporary life possible, including both physical systems providing biophysical functions, and social systems required to plan, design, implement, and maintain them. These notions of infrastructure are also culturally relevant, as many ancient systems of landscape care and alteration formed living infrastructure networks (e.g., Tomateo, 2021), in contrast to ‘modern’ ideals of networked technologically sophisticated systems (Graham and Marvin, 2002). NbS interact with these systems in many important ways. In NYC for example, stormwater and overflows from the city’s combined storm and sanitary sewer system are regulated through a system of rain gardens, bioswales, permeable pavers, green roofs, streetside stormwater, trees, and extensive systems of pipes, pumps, and wastewater treatment facilities (NYC DEP 2010, McPhearson et al., 2013b). While here we focus on within-city efforts, the larger SETS of NYC also includes the city’s extensive source water protection programs connecting reservoirs, aqueducts, and water treatment facilities with land acquisition, management, and diffuse forms of environmental regulation across the Hudson and Delaware basins (New York City 2013, 2018). In both cases, ecosystems and engineered systems are managed as cohesive wholes to deliver infrastructural services. Transforming ecosystems into infrastructure is inseparable from evolving forms of expertise and social organization that regulate *social* relationships with the *environment* through and for *technical* systems (Carse, 2012). Justice in NbS informed by infrastructure studies requires understanding both who benefits from the development of particular infrastructural regimes, and who bears their burdens, including the shifting of risks and displacement of populations.

3.5. Infrastructuralization of ecosystems in NYC

New York City serves as a long-term case study in the transformation of ecological systems into infrastructure via technical and bureaucratic forms of management with far reaching social and environmental consequences. As the city’s resource base was decoupled from its local social-ecological system and transformed by global commodity flows of sugar, cotton, rum, and enslaved peoples, the regulation of local waterways took on increased importance. In 1899, Congress authorized the Army Corps of Engineers to protect and enhance these coastal infrastructures. The regulation of waterways for the purposes of

navigation included restrictions on dumping and the creation of maritime structures. This regulatory framework remains the foundation of current efforts to manage waterways through dredging and using resultant spoils in ‘restoring’ and reshaping coastal ecosystems (Wakefield, 2019), which have been profoundly reshaped by numerous intersecting transportation, power generation, and maritime infrastructures. The rise of a regional commuting public further entrenched a new class of technical and corporate infrastructure ‘experts’ in guiding the growth of the metropolitan region (Revell 2003).

Other infrastructure agencies at this time also created the city’s water supply system, along with extensive coastal defenses, parks, stormwater and sanitary sewers. These different infrastructure systems were managed by city departments with little accountability to one another, and whose rational integration formed the basis for major reform efforts (Caro, 1974). The creation of physical infrastructures and the social infrastructures required to plan, design, and operate these complex infrastructure systems continue to profoundly shape the nature of NYC (Gandy, 2003). They do so through two primary means, 1) the purposeful structuring of urban habitats by human engineers and other actors, as well as introducing novel toxins into the urban environment and 2) the transformation of ecological elements into infrastructure, often through their incorporation into hybrid facilities such as green roofs, streetside planters, and larger hybrid engineered ecosystems like restored coastal wetlands and blue belts (New York City 2013, 2017).

Hybrid ecological-engineered facilities form the basis for NYC’s formal green infrastructure programs. Major conceptual and political struggles continue over how urban nature becomes circumscribed and delimited when it is referred to and managed as ‘infrastructure.’ In particular, the current city plans limit GI to engineered stormwater facilities (Grabowski et al., 2022), which has large consequences for what types of services can be provided by urban GI. It severely limits multi-functionality and benefits and becomes reflected in their limited siting criteria (Kremer et al., 2016) much to the detriment of multi-hazard management (Depietri et al., 2018). Such disjunct in the potential versus the planned purposes of GI is striking given long standing efforts to coordinate tree planting between the NYC Department of Parks and the Department of Environmental Protection (New York City, 2013). Currently, controlling combined sewers overflows are the highest priority for the city’s GI programs, though managing heat waves as well as local and coastal flooding are also serious concerns, albeit with less dedicated funding and planning (New York City, 2013, 2017). Attempts to deal with changing environmental conditions through infrastructuralization of urban nature makes it clear that complex interplays between environmental agencies and the social processes framing desirable and necessary relationships with them continue to drive the deployment of the GI concept in NYC.

The administrative roots of managing nature through technical projects run deep; managing storm and sewer water with GI is the result of attempts to comply with environmental regulations stretching back to 1899. The city’s experience with avoided filtration of drinking water through source water protection translates conceptually to a program of avoided treatment through diversion, infiltration, and vegetative filtration of storm runoff (New York City, 2015). However, Hurricane Sandy made clear that the accretionary fabric of technological infrastructures is vulnerable to environmental forces, spurring a large-scale regional effort to evaluate the feasibility of green and gray infrastructure systems to respond to sea level rise and increasing storm intensities through ‘nature and nature-based features +’ for coastal protection (Bridges et al., 2015). In recent decades, city government has reacted to increasing environmental extremes in haphazard ways that limit long range and inclusive planning efforts (Friedman et al., 2019). Major obstacles to a more robust and democratic notion of urban green infrastructure in the city include the fragmentation of sites of opportunity (McPhearson et al., 2013a), along with the fragmented governance structure of urban nature, which continues to privilege funding streams dedicated to single mission agencies (Meerow, 2020).

These politics in turn borrow their siloed structure from the current system of environmental regulation in the United States, which has generally failed to protect human and environmental health (Chiapella et al., 2019). Current green infrastructure efforts are largely silent on the legacy of contamination in the city, preferring to utilize the discourse of new urbanism and ecological securitization in promoting the benefits of livability and resilience. As the cities GI programs have matured, including its extensive urban forestry programs (Pregitzer et al., 2018), green roof mandates (Anon, 2019) and previously mentioned stormwater programs, the social, political, and ecological tensions around the process of implementing NbS and the resultant distributions of functions and benefits rise to the fore (Meerow, 2020).

A central paradox of the greening of New York City then results from its past and present inequalities in the distribution of environmental services and hazards. These cannot be separated from the governance of the city's infrastructure systems. In the case of flood risk, development and resilience policies have allowed for continued population increases within the flood prone zone, resulting in a complex arrangement of both vulnerable and affluent communities at risk of flooding (Herreros-Cantis et al., 2020). In urban greening, the use of tax-increment financing and other incentives spur new development in poorer neighborhoods, giving rise to the phenomenon of 'green gentrification' (Gould and Lewis, 2016). Given the potential for NbS to entrench risk in particular communities, and displace others, incorporating justice principles in NbS that are managed as infrastructure systems becomes increasingly important.

As the city struggles with aging infrastructures, changing environmental conditions (Revi et al., 2014), and the growth imperative that sought to maintain property values despite population declines, city agencies have become increasingly beholden to real estate speculation as a driver of urban economic growth (Stein, 2019). Taken together, these forces have structural consequences for city budgets, environmental quality, and the disruption of the balance of power that traditionally pitted industrialists against commercial and residential property developers (Stein, 2019).

3.6. Towards infrastructure justice in NbS

Planning for NbS in NYC as part of the city's complex infrastructure system highlights several key paths for addressing justice. The first involves strengthening democratic governance practices around infrastructure planning to address the needs of diverse communities. A careful examination of distributions of risk, costs, and provision of infrastructure services should be part of the larger calculus of justice in NbS planning, so as not to continue practices of extracting wealth from marginalized communities to pay for infrastructure improvements in wealthier ones (Trounstine 2018). One such avenue to do so involves expanding practices of participatory budgeting that appear promising for increasing investments in those infrastructures most needed by marginalized communities (Hagelskamp et al., 2020). Expanding these approaches to include regulatory green stormwater infrastructure along with diverse green elements, such as community farms, gardens, and forests supported by civil society stewardship (Campbell, 2017), can insure that NbS is not another externally prioritized infrastructure investment negatively impacting community well-being.

The second, critical to larger just transitions, involves intersectional efforts to accelerate the greening of existing gray infrastructure systems (New York City, 2019), and large-scale efforts to restore the urban ecosystem of NYC (New York City, 2018). Toxic chemical hazards and pollution more generally are some of the primary drivers of urban ecological decline. A just approach towards urban NbS would benefit from identifying synergies between gray infrastructure-oriented programs of eliminating pollution and those explicitly making space for nature. This also requires supporting social actors in restoring cultural practices of care for the urban ecosystem. Attention to infrastructure justice does not seek to exclude consideration of natural systems as an

integral part of the infrastructure systems of NYC, but rather, the way in which they are transformed into infrastructure requires acknowledging both their own explicit agency (i.e., Ecological Justice), as well as their varied, place based, and evolving socio-ecological relationships (i.e., Indigenous and Environmental Justice).

The central question becomes: can NYC adapt to a rapidly rising sea and changing climate while addressing long standing issues of social and environmental injustice? Previous work has identified that a novel and infrastructure-oriented research-to-action nexus in the city may hold the key towards unlocking new forms of urban ecological research and governance for enabling sustainability transitions (Depietri et al., 2018). How this will take shape in new forms of infrastructure and new social-ecological realities, remains a function of the combined skills and capacities of motivated and engaged actors operating in the context of global to local forces.

3.7. Towards just NbS in a green NYC?

By examining NbS practice in NYC through the lenses of ecological justice, Indigenous and Environmental Justice, and Infrastructure Justice we identified deep synergies in justice issues that can be addressed through NbS Policy and future research. Just transformations cannot occur without reframing human-nature relationships around the capacities of nature recognizing the inherent agency and self-assembling properties of ecological systems. These capacities in turn support the well-being of numerous human communities which have been historically oppressed and marginalized by present decision-making systems. Deeply restorative governance and democratization of decision-making processes therefore form a vital part of addressing justice through NbS.

How NYC today seeks to use NbS to provide a healthy urban environment for human and ecological health must directly confront how the city has been shaped by the forces of settler colonialism, racism, industrialization, speculative real estate, and ecological securitization. The last twenty years have increasingly seen deployment of hybrid NbS infrastructure technologies to manage stormwater and prevent combined sewer overflows while sparking fears of green gentrification. In the face of a rising sea, the city has been progressively armored through huge influxes of expertise and capital for gray infrastructure and NbS alike (USACE, 2022). Since the large-scale coastal protection projects overseen by the US Army Corps of Engineers cannot consider managed retreat, the scope and scale of NbS and its function in relation to projected sea level rise and resulting shifting of risks requires further study. The city has planted a million trees in response to the intersecting hazards of climate change, and yet did not prioritize underserved neighborhoods (Garrison, 2021), reinforcing longer running patterns of residential segregation and differential investment. Current legislation on green roofs mandates new construction to utilize NbS for climate mitigation, but it is too early to tell how this will shift the overall distributions of environmental amenities and hazards mitigated by NbS.

What is clear from present NbS planning efforts, is that impacted communities are typically not deeply involved in shaping either processes or outcomes (Grabowski et al., 2023), although working groups on addressing Environmental Justice may provide a window of opportunity to address these deeply embedded inequalities in the city (New York City, 2022). NYC remains a critical laboratory for understanding how to re-integrate ecological elements into an urban fabric to provide multiple functions and benefits. Justice is not only about doing what is fair for vulnerable communities now, but also compensating them for the consequences of colonial and racist practices in city planning throughout history and transforming the decision-making systems that created those harms. Recognizing treaty responsibilities, returning land to Indigenous governance, supporting community led greening efforts, eliminating toxic hazard and pollution from gray infrastructures, and explicitly democratizing infrastructure budgeting and decision making is crucial to the thriving of marginalized human and ecological communities in the city.

Given rates of sea level rise and climatic chaos, a key question pertains to the rates of transformation: can NYC adapt fast enough to the new environmental conditions that it, as a global center of finance and industry, has been a principal player in creating? Emergent participatory approaches show promise for community ownership of greening initiatives that can revitalize and stabilize neighborhoods, but the larger power dynamics and inequalities remain largely unaddressed. In this sense NYC serves as an illustrative case study of the embedded politics of addressing long standing social and ecological harms, often caused by built infrastructure systems, through NbS. At present intersecting crises of Covid-19, climate change, and systemic racism are shaking the social and economic foundations of the city - it appears impossible to disentangle the future of NbS from the ways in which these deep-seated social ills will be addressed.

There is a clear need to improve urban resilience to intersecting climate stressors with NbS (Pelling et al., 2021). To avoid replicating the inequalities caused by present decision-making systems around urban nature and hazards, NbS researchers and practitioners can build power with marginalized human and ecological communities. A green and just future is possible but impacts and costs will remain problematic and unequal until all those involved in its creation acknowledge and address the need for justice.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

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