CRITICAL URBAN ECOLOGY: LINKS TO SOCIAL VULNERABILITY AND ENVIRONMENTAL JUSTICE IN THE AFTERMATH OF HURRICANES

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ABSTRACT

Diamond VE Holloman: Critical Urban Ecology: Links to Social Vulnerability and Environmental Justice in the Aftermath of Hurricanes
(Under the direction of Gabriela Valdivia)

Parallel to the world's rising urbanization trend, shifting patterns of large wet weather disturbances – more specifically, hurricanes – are raising concerns in coastal areas where many cities are located. A shift in studying these occurrences is paramount. This thesis addresses the following question: in what ways can the inclusion of social vulnerability studies and environmental justice, often developed outside of the field of urban ecology, contribute to a critical understanding of urban socioecological uncertainties following hurricanes? To answer this question, this thesis reviews the literature on urban ecology and examines how scholarship that emphasizes justice, vulnerabilities, and spatialities can expand the field's applicability to the study of natural disasters. In this thesis, I make claims for a critical urban ecology, which includes an integrated, holistic, and critical understanding of the social, economic, biogeophysical, and built parts of urban systems.

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CHAPTER 1

Introduction

The world is becoming increasingly urban. In 1950, 30% of the world's population resided in cities of over one million people or more, and seven megacities (cities with more than five million people) existed (PRB, 2016; UN, 2012). In 2008, for the first time, more than half of the world's population resided in urban areas, and by 2050, this trend is expected to increase to 70% (PRB, 2016). As of 2014, 82% of North America residents live in cities (UN, 2014). And, as of 2010, the number of megacities around the world has increased to 55; it is estimated that by 2025, the global total will increase to 87 megacities (UN, 2012). This significant increase has pushed urban problems and possibilities to the global forefront; issues like increased greenhouse gas emissions from cities as well as efforts at increasing sustainability in cities have led many cities to function as 'first responders' in climate change (Rosenzweig, 2010).

Parallel to this rising urbanization trend, shifting patterns of large wet weather disturbances (like hurricanes) are raising concerns in coastal areas, where many of these cities are located. The intensity and frequency of hurricanes along the Atlantic coast has increased in the past 50 years, although it is unclear if this can be entirely attributed to anthropogenic climate change. Nevertheless, the societal impact of these hurricanes has greatly increase, as rising concentrations of people live and build infrastructure in coastal cities (International Workshop on Tropical Cyclones, 2006).

For example, Hurricane Katrina in 2005 destroyed much of the Gulf coast of Mississippi, taking with it much of the historically rich African American neighborhoods in New Orleans

(Sherbinin et. al., 2007). While physical infrastructure was especially damaged by the saltwater, unforeseen impacts are still being felt 12 years later – and these occurrences are set to happen to coastal communities more often as global climate changes (Sherbinin et. al., 2007; Kraas & Mertins, 2014). Hurricane Sandy in 2012, the second largest Atlantic storm on record, ravaged the entire US east coast. Making landfall in New Jersey, Sandy destroyed hundreds of thousands of homes, killing at least 162 people, and leaving 8.5 million people without power or fuel (FEMA, 2013). Another recent example of a large hurricane impacting urban life is in eastern North Carolina following Hurricane Matthew. Flooding following the storm caused initial estimates of $1.5 billion dollars in damage to roughly 100,000 homes in half of the state, including the densely populated state capital, Raleigh. This cost does not yet take into account damages to roads and city infrastructure. Eight months after the storm made landfall in October 2016, residents are still struggling to recover. Individual and municipal-level claims are still being filed to FEMA (Figure 1). And while the geographical conditions of this storm and the two mentioned before differ, it is clear that hurricanes greatly impact coastal areas, and have ongoing, uneven effects on densely populated coastal cities.

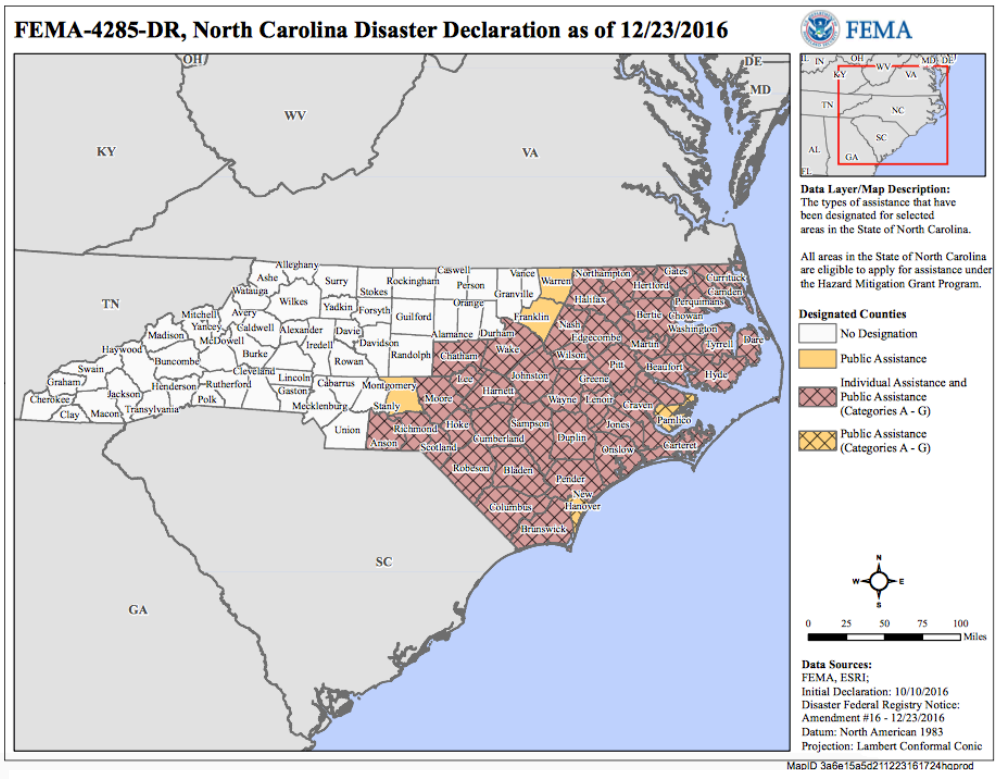

Figure 1.1. North Carolina Disaster Declaration as of 12/23/2016 (FEMA 2016)

My project takes an urban ecology approach that conceptualizes coastal cities as ecosystems in order to analyze the differential impacts of hurricanes and flooding on communities that vary by identity (race, gender, age demographics) and culture, as well as capacity markers (socioeconomic class, available resources, community networks). Conceptualizing coastal cities as ecosystems means acknowledging that there are ecological processes that are unique to urban areas, and that such processes engage with the built environment, humans, non-humans, and biotic factors into one interconnected system. Looking at the city as its own ecosystem with infinite feedbacks allows me to consider uncertainty as an inherent attribute of how cities operate and not something to be controlled or avoided. For instance, floods need to happen in urban areas as part of the circulation of water through the system after wet events. Rather than shielding communities from floods, we should embrace the

uncertainty of their exact effects (Liao 2012), acknowledging that there might be other impacts on humans – such as social, economic, or even political - that reach beyond the biogeophysical scope. Embracing uncertainty also means leaving room in our analysis of these events for reflection – in what other ways can we understand the aftermath of these events? Discussions in fields other than urban ecology on how to conceptualize cities further allow me to integrate a more critical examination of the human impacts of these storms into my urban ecology framework. **My project addresses the following question: in what ways can the inclusion of social vulnerability studies and environmental justice, often developed outside of the field of urban ecology, contribute to a critical understanding of urban socioecological uncertainties following hurricanes?**

To answer this question, this thesis reviews the literature on urban ecology and examines how scholarship that emphasizes justice, vulnerabilities, and spatialities can expand the field's applicability to the study of natural disasters. Urban ecology's broad definition allows for multiple theoretical frameworks to function under its umbrella; **in this thesis, I aim to make claims for building a "critical urban ecology," which includes an integrated, holistic, and critical understanding of the social, economic, biogeophysical, and built parts of urban systems**. Similar efforts have been made in physical geography to expand the lens of analysis in such a way; Rebecca Lave and others have pushed for critical physical geography to think about human-environment systems through a careful understanding of social dynamics and power *and* of the "deep knowledge of biophysical science or technology" in the environment (Lave et. al., 2014). Just as with critical physical geography, critical urban ecology will function to expand the scope of research and yet sharpen the analytical possibilities for the study of natural disasters. Critical analyses are not about critique; they are about addressing how some things become

"matters of concern" (Latour 2004), e.g., how some things or problems are treated as more pressing, immediate, important than others, and conversely, how other elements of the ecologies of urban spaces are neglected in the process. Engaging in this critical analysis process, I aim to contribute to the growth of the field of urban ecology.

The term "urban ecology" was first published by sociologists Robert Park and Ernest Burgess in 1922 (Gross, 2004). Since its inception in the early twentieth century, the language that urban ecology uses to describe urban phenomena has shifted. Urban ecology initially focused on succession and symbiosis –ecological principles observed in the non-human world – to describe human processes of migration from the city center to suburbs (Grimm et. al, 2008). In the last two decades, the field has expanded to include human interactions and feedbacks, as well as incorporated social and economic disparities (Grimm, 2008; Wu, 2014). Especially in regards to vulnerability assessments to changing weather patterns, urban ecology has looked to assess cities and their risks to floods and other biogeophysical disturbances. Much of this risk assessment is conducted through quantitative analysis (e.g., Cutter, 2003; Ebert et. al., 2009; El Raey, 1997; Hallegate, 2013); still, there is space for qualitative methodologies to expose other types of vulnerability and risk that don't have quantitative metrics. Urban ecology is now at a juncture where the incorporation of new language from different fields of study would further its growth and aid in conceptualizations of urban disaster management, and urban phenomena overall.

This project expands on potential directions for urban ecology that highlight a more humanistic approach to studying urban natural disasters. Borrowing themes from political ecology, I look to expand the field of urban ecology to include elements of social vulnerability and environmental justice. Political ecology encompasses a diverse field of research that takes

into account ecologically-oriented frameworks *and* political economy. Social vulnerability studies and environmental justice have well-developed frameworks for conceptualizing the human dimensions of the intersection of urban spaces and disasters; social vulnerability has explored the disparate effects of these hurricanes, and environmental justice emphasizes the importance of difference in lived experiences. While urban ecology has included some human dimensions already, social vulnerability studies and environmental justice possess the language to further this discussion at this intersection.

The paper aims to: a) reimagine urban ecology as a field that acknowledges the socio-ecological relations of "urban nature;" and b) trace ways of incorporating social vulnerability and environmental justice into urban ecology to explain urban phenomena, especially after large wet-weather disturbances. For this, I will use the examples of Hurricane Katrina over New Orleans, Louisiana in 2005 and Hurricane Matthew in Kinston, North Carolina in 2016 as key moments in recent U.S history where coastal cities were hit by hurricanes and urban ecology was presented with analyzing these moments through new lens. Because these case studies differ in urban form, storm intensity, and sociohistorical contexts, they support illustrating the diversity of experiences and situations that urban ecology must work with. My goal is to push for more transdisciplinary studies of urban systems, so that these can better incorporate the complex interactions of humans with urban environments, and their role as decision-makers in these systems. This reimagining aims to more accurately capture the conditions and impacts on urban human-dominated ecosystems following hurricanes.

This thesis is organized as follows: chapter 2 explores the intellectual trajectory of urban ecology. Chapter 3 elaborates a conceptual model that includes social vulnerability studies and environmental justice within urban ecology. Chapter 4 illustrates this conceptual model using

two case studies: Hurricanes Katrina and Matthew in New Orleans, LA and Kinston, NC respectively. Chapter 5 summarizes the main observations and synthesizes how I plan to expand this reconceptualization into further research.

CHAPTER 2

Urban Ecology: Ecosystem Approaches to Urban Space

Over the last century, human populations in cities have increased exponentially, giving rise to change in how scholars conceptualize urban phenomenon. To study these phenomena, multiple branches of research have sprouted – including city and regional planning and urban geography. In this context, urban ecology has provided a usefully broad and ambiguous connection between disparate fields of analysis and intervention in urban areas (Gandy, 2015). Because the field is not rigid, there is room for multiple interpretations, methodologies, and theories. This ambiguity and lack of restriction of what the field encompasses is a good place to begin reimagining the study of urban spaces. Creating transdisciplinary ways to address issues in urban areas is paramount to solving issues on a global scale. Urban ecology, its theoretical offshoots, and the potential evolution and transformation of the field provide the opportunities to study and create solutions to these issues.

Urban ecologists have conceptualized three similar, but distinct approaches to studying urban areas: Ecology IN cities, Ecology OF cities, and Ecology FOR cities (Figure 2.1). Ecology IN cities was the beginning of the jump to study urban areas; it focused on applying ecological principles and concepts used most widely in wild and rural areas to "green," or undisturbed, patches in the city. An underlying assumption of this approach's epistemology was that "ecosystem" inherently meant the absence of human; the focus was on the biogeophysical processes and land use change. As urban areas expanded to a point where the absence of humans and their influence was impossible to imagine, urban ecology grew to encompass human

influence (Gandy, 2015). The field adapted its conceptualization of ecosystems to include more than just non-human-dominated systems; human-dominated systems were now at the forefront. From this new conceptualization, the Ecology OF cities (also known as the ecosystems approach) was born, illuminating urban areas as distinct ecosystems in themselves. A more recent evolution of this is the Ecology FOR cities approach, aimed at holistically assessing human-dominated ecosystems and bettering their quality.

This chapter provides an overview of these last two operating concepts and a critical analysis of what each offers the contemporary study of urban vulnerability in coastal cities, and expands on more transdisciplinary framework in urban ecology to improve analyses of urban ecosystems. Then, this chapter discusses two major limitations in urban ecology literature: how space is conceptualized and the human-nature epistemological divide. These limitations are important to discuss because urban ecology engages with both of these concepts without explicitly delineating their meaning and impact. Examining these concepts critically and pointing to their limits creates the opportunity for frameworks from other fields to be integrated into a more holistic urban ecology.

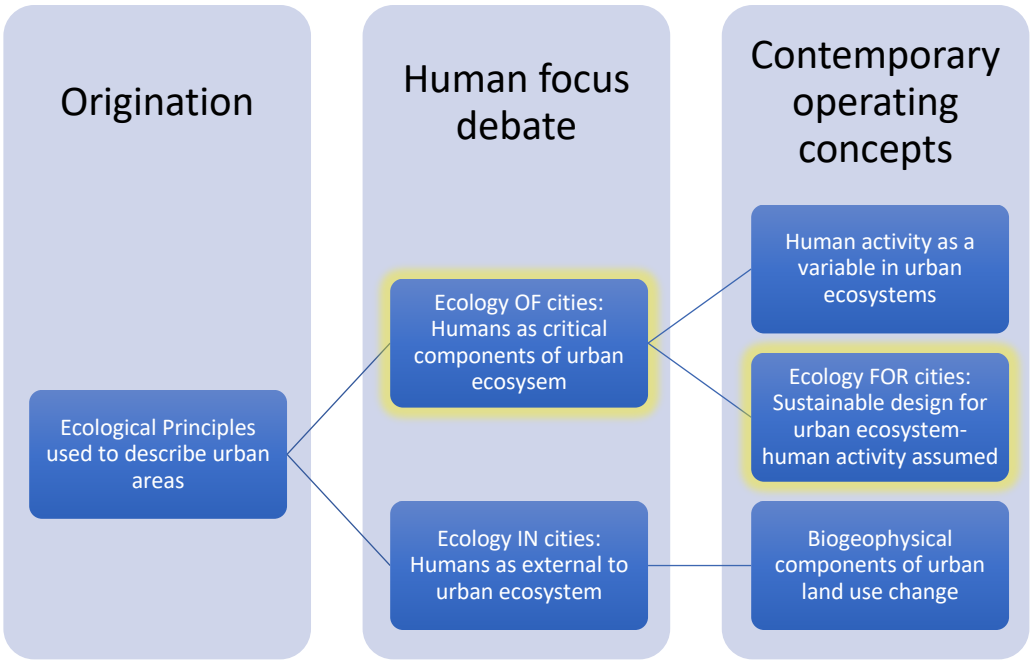

Figure 2.1. The intellectual trajectory of urban ecology. Highlighted boxes signify areas of focus.

Ecology OF Cities

Unlike it's antecedent (the Ecology IN cities approach), the Ecology OF Cities approach conceptualizes urban areas as complex ecosystems, with humans as drivers of, and responders to change (Ramalho & Hobbs, 2012; Cadenasso & Pickett, 2008; Pickett et al., 2001; Pickett et al., 2011; Wu, 2014). This includes built infrastructure (McPhearson et al., 2016). Though oftentimes housed in the natural sciences under ecology or biology programs, the goals of this approach are to more accurately represent the iterative processes that characterize complex and variable urban systems (Wu, 2014), as well as to capture the moments of possible intervention in systems that arguably already have global implications (Alberti et. al., 2003; Grimm et al., 2008).

Conceptualizing the city as an ecosystem allows researchers to analyze the complex differential impacts of natural disturbances on communities that vary by biogeophysical characteristics (such as in the natural sciences); identity (race, gender, and age demographics);

and capacity markers (socioeconomic class, available resources, community networks). Here, any social or economic capital is considered part of an individual's or community's capacity markers. Capital that has the potential to change also fits into this capacity marker category. Identity has been reserved for factors of a person that cannot be changed by will or work. It has been shown that increased social or economic capital leads to increased resilience in communities following natural disasters. This capital encompasses contextual and cultural factors that impact the disaster recovery process (Cox & Perry, 2011).

The Ecology OF cities approach has two major strengths: it creates an extremely valuable conceptualization of the complex and reiterative feedbacks that were previously ignored and/or drastically simplified before, as well as brings attention to the issues of scale and magnitude. By acknowledging the complex feedbacks that affect (and are affected by) humans in this system, researchers more accurately reflect urban life, and can, with greater detail, analyze it. Collins' et al. (2010), for example, describe one type of analysis anchored in the Ecology OF cities approach that better captures the complexity of the urban ecosystem (Figure 2.2). This analysis is named Press-Pulse Dynamics, or PPD. The Press-Pulse Dynamics (PPD) conceptual framework is a widely-used framework for studying the interchange between human-dominated ecosystems. This conceptual framework is utilized in many long-term socio-ecological research (LTER) sites across the globe to understand the impacts and feedbacks associated with systems that are human-dominated, but have deeply entangled environmental issues. This framework represents the current thinking amongst many urban ecologists:

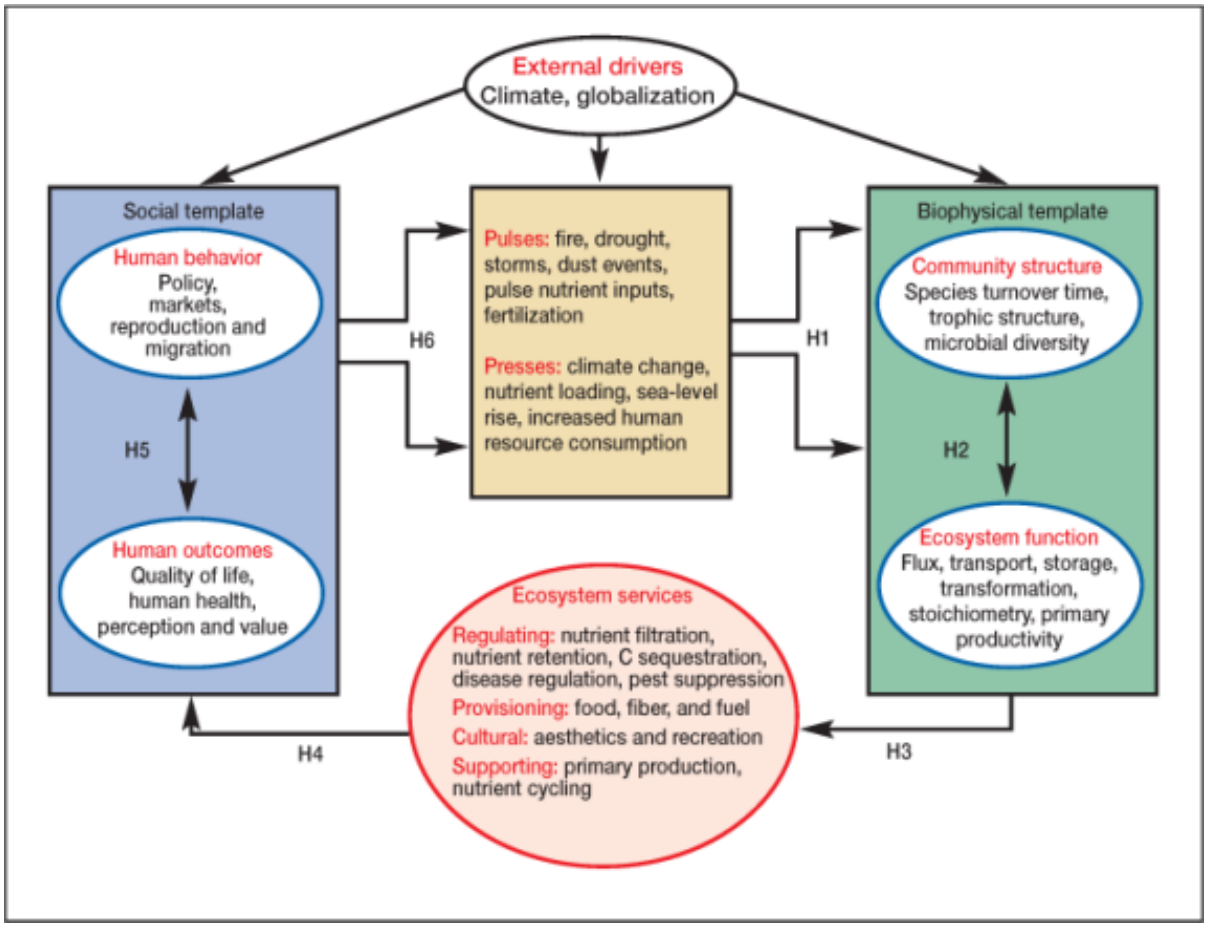

Figure 2.2. An integrated framework for long-term socio-ecological research (Collins et. al., 2010)

The Press dynamics of PPD are the extensive, pervasive, and subtle changes happening in a city, while the sudden events, such as natural disturbances, are represented by the Pulse Dynamics. The authors argue that the PPD framework can form the necessary linkage between social and biophysical research domains and serve as the "foundation for long-term, integrated, social-ecological research across scales" (Collins et al., 2010). Scale and magnitude are inherent in the framework's Pulse and Press concepts; the definition of these dynamics depend on the temporal as well as spatial scale and magnitude of each event.

While this framework is useful for conceptualizing the relationship between biophysical and social sciences, it does little to note the complexity of the feedbacks in the human-dominated realm. Some of the elements under the "Social Template" could be further expanded and more embedded into the feedbacks of the "Biophysical template." This separation also highlights the human-nature epistemological divide, which will be discussed further later.

The Ecology OF Cities approach has weaknesses: it is inherently retrospective. Perhaps this is a symptom of the field's relative youth, or because of the high variability and emergence of cities (Alberti et al., 2003), but the processes within a city cannot accurately (and in any great detail) be predicted using this conceptualization. Although several scholars have called for a conceptual homogenization of urban ecology in order to better predict urban outcomes (e.g., Muller, 2014), others argue that the only way to ensure an outcome is to study it in hindsight. This, however, is problematic because many problems originating in cities have global impacts (Grimm et al., 2008) and many global problems have unique impacts on cities. This temporal limitation also does not account for accumulation processes over time. For instance, because so many people live in cities, the energy they consume, and the greenhouse gases emitted on their behalf can account for up to 80% of all anthropogenic greenhouse gases emitted (Satterthwaite, 2008).

Typically, urban ecology studied from this approach is housed in the natural sciences, emphasizing biophysical processes and feedback loops that are adjusted to urban design. Using this approach, researchers (usually biologists or ecologists) study landscape changes, nutrient cycling, and species composition as it changes through time in these altered terrains (Pickett et. al, 2012). In order to study other interactions, such as socio-economic feedbacks, these researchers typically form research teams with other researchers from different disciplines. These

multidisciplinary research teams contain researchers from biology, ecology, urban planning, sociology, geography, or anthropology. These disciplines, though with overlapping interests, have different methodological, epistemological, and ontological traditions that call for different approaches to the problem the team is responding to. For example, the Baltimore Ecosystem Study is one of the largest long-term socio-ecological research sites in the U.S. This study examines (among other things) biodiversity and composition of soil, trees, birds and aquatic animals in Baltimore, Maryland (Pickett et. al 2012). This multidisciplinarity has its advantages (the problem is examined from multiple vantage points, for instance) but a major disadvantage is that the research can be disjointed – with each researcher following the tradition of their discipline and only communicating results to one another.

The Ecology FOR Cities approach, examined next, forces researchers to acknowledge that we actually understand relatively little of the spatial, temporal, socio-economic, and cultural dynamic feedbacks of events in urban areas.

Ecology FOR Cities

Urban ecology has shifted toward a more transdisciplinary focus. Instead of combining multiple disciplines (multi-/interdisciplinarity) in order to study urban areas, this approach suggests that urban ecology should be, from the start, a mix of multiple methodologies that are defined by their focus on the urban space and not by disciplinary home.

The Ecology FOR cities approach carries a landscape perspective increasingly focused on the future of cities, along with the planning and design of these urban areas (Ahern, 2013; McDonald et al., 2014; Wu, 2014). This approach is more holistic with a focus on ecosystem

services and human well-being (McPhearson et al., 2016). This approach aims to incorporate the biophysical, social, planning, and design elements to create a more equitable and livable city (McPhearson et. al., 2016). This approach emphasizes that the transdisciplinary processes of reiteration, feedbacks, deliberation, and debate between the non-human and social systems needs to be understood (Childers et. al., 2014), and emphasizes the pursuit of equilibrium. As opposed to the ecology OF cities approach, the ecology FOR cities approach is purposefully non-linear and encourages "critical feedbacks throughout the process among key stakeholders, urban ecological research, and knowledge derived from previous projects" (Childers et. al., 2014).

A direct answer to the weakness of the Ecology OF cities approach is the biggest strength of this approach: the Ecology FOR cities approach is forward-thinking. It aims to learn from the commensurable lessons from cities around the globe in order to build better-suited cities for the future. Childers et al. (2015) offer a useful framework under this approach: the urban design-ecology nexus. This nexus is an anticipatory, action-based, future-oriented approach that works on multiple scales; most prominent in this approach is the use of design to not only foresee what urban uses are necessary, but also to physical produce the space by which to perpetuate these uses (Childers et al., 2014).

Another example of this approach's forward-thinking is the focus on ecosystem services for future cities. McDonald et al. (2014) posed that treating natural resources as commodities (ecosystem services) and introducing them into the markets would allow for a more just valuation of these services, therefore creating even a cultural valuation for them similar to the one we have on human health. This approach now speaks to the political economy of urban ecology, entering a dialogue of power and value claims that the previous approach did not.

A flaw of this approach is that, in trying to analyze a city holistically *and* in detail, one is forced to do study only a few sites in depth, highlighting that the nuances of each site might make noticeable patterns in that site incommensurable with others. Analyzing issues of power, justice, and value claims, along with environmental, economic, technological, social, and individual risk factors (Douglas, 2012) in any place will make it seem impossible to compare one place to another. The contexts will always be different. This lack of generalizability from site to site is often seen negatively in traditional academic discourse. At the same time, this type of approach opens the possibility for rethinking how urban ecology research is conducted and how it could accommodate these different issues.

Room for Improvement

The Ecology OF cities approach, or the ecosystem approach, offers generalizability that is vital to addressing global issues in urban areas. However, this approach is more useful as a broad conceptualization, than a detailed model. It allows for more flexibility in place-based conditions, causal links, and feedback processes, while a model delineates clear directionality in the feedbacks over time and connotes that most (if not all) of the factors to consider are within the modeled framework already. In both the Ecology OF and FOR cities conceptualizations, green spaces within cities and the ecosystem services they provide (clean air, clean water, countering the heat island effect, etc.) are public health issues considered around the globe. However, the detailed impacts, magnitudes, and the dispersal of outcomes vary from city to city and are thus incommensurable. The approaches are not fatally flawed for this; if we only analyze the incommensurable features and ignore the commensurable patterns and directionalities of feedbacks, we lose a very large piece of the puzzle. There are researchers who study the specific physical and social conditions of urban areas, and that is necessary; but by focusing only on the

differing details across cities, research may lose the lessons learned from noticing the patterns, reiterative processes, and common challenges that accompany an urbanizing globe. The ecosystem approach, or Ecology OF cities, along with the Ecology FOR cities approach are useful in giving researchers this first step—a broad schematic for research.

Conclusions

As cities have expanded across global landscapes, so must urban ecology expand its conceptualization of how these spaces operate. Urban ecology has undergone some of these necessary shifts in conceptualizing urban spaces: the Ecology OF cities and Ecology FOR cities approaches both offer unique ways to study urban phenomena and provide the theoretical lineage to studying coastal cities and their vulnerability to disaster in the future. However, as new understandings of what constitutes "the urban" expand, we need the language and concepts to be able to recognize these and include them in models. By naming these concepts, it allows them greater visibility, especially as it concerns vulnerable and marginalized populations after natural disturbances. The following chapter will detail the concepts that need to be added to urban ecology, making it a more holistic, critical study of urban spaces.

CHAPTER 3

Critical Urban Ecology: Social Vulnerability and Environmental Justice

In this chapter, I provide an overview of the epistemological lineages of both social vulnerability and environmental justice, the dominant methods of each, and explain their roles in expanding and reimagining the contemporary study of urban spaces, especially following natural disasters. By highlighting the language, methods, and commitments of social vulnerability and environmental justice into urban ecology, my goal is expose areas where integration of these key points into urban ecology would make a more critical, and therefore analytically useful, study of urban spaces following natural disturbances. I will further outline a set of principles that expand urban ecology into this critical urban ecology.

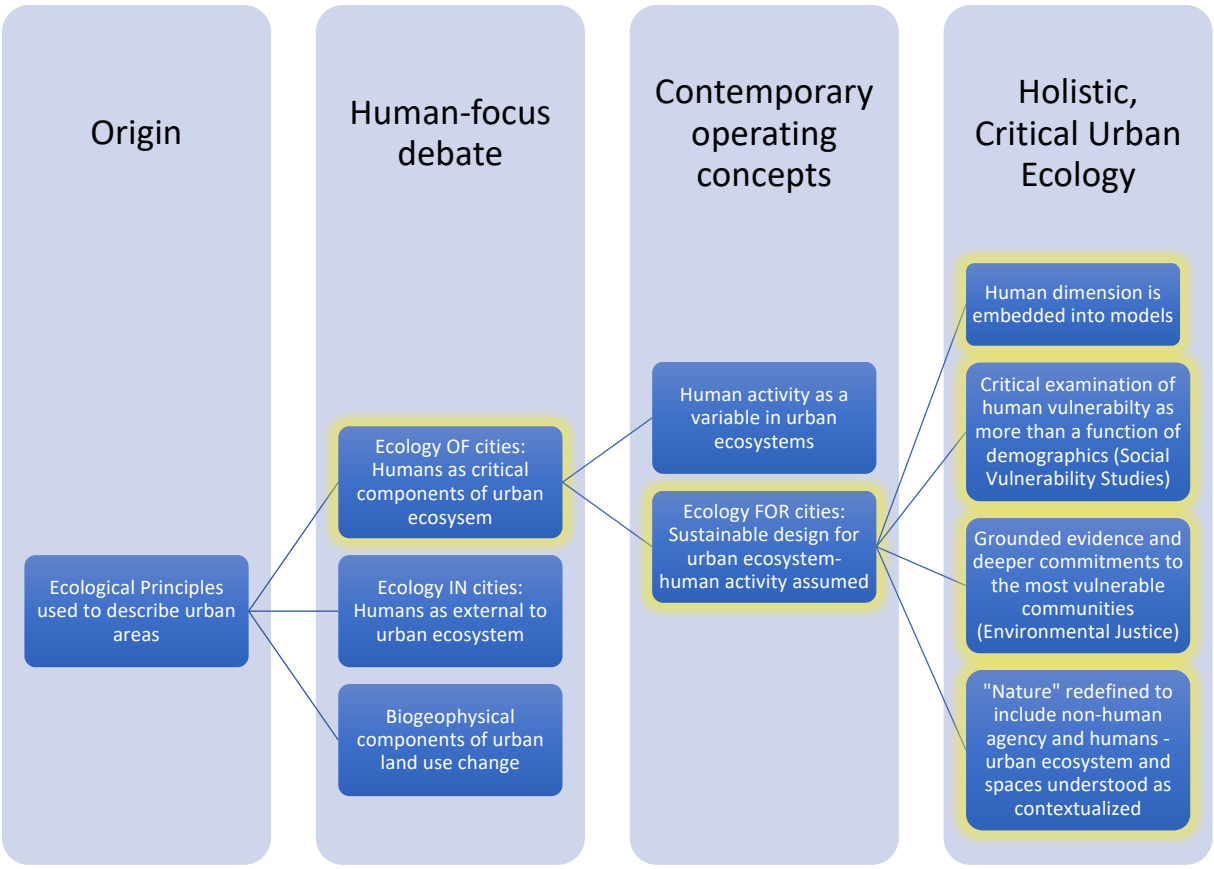

Figure 3.1. The intellectual trajectory of urban ecology. The last column are the four principles of critical urban ecology.

Figure 3.1 below shows the intellectual trajectory of urban ecology thus far (as discussed in the previous chapter) along with the potential for the fields expansion into what I call a critical urban ecology, utilizing a set of four principles garnered from the purposeful entanglement of social vulnerability studies, environmental justice scholarship, and urban ecology.

Social Vulnerability

Three conceptual areas characterize the study of social vulnerability: risk/hazards; resilience; and political ecology. Next, I provide a brief overview and analysis of each, a description of dominant methodological approaches, and show how I use them to expand and reimagine urban ecology of disaster.

Overview

Risks/Hazards

Researchers have looked to understand social vulnerability by emphasizing a people's risk to, or exposure to, a number of non-human disturbances, or hazards. This is used in natural hazards research in Geography and research on risk threshold and "adjustment to environmental risk" (Eakin & Luers, 2006), where researchers examine the socioeconomic determinants that lead to increased susceptibility to the harmful aftermath of natural hazards. This approach looks to answer three main questions: what are we vulnerable to; what consequences might be expected; and where and when might these impacts occur (Eakin & Luers, 2006; Adger, 2006)?

The risks/hazard approach emphasizes the biophysical characteristics of a community and the potential for loss. It equates loss after an event to the vulnerability of the community. Therefore, the community is not deemed vulnerable until it has suffered negatively after an event and the conditions continue to favor these potential negative outcomes for future events. In this approach, the biophysical is the central point and the social factors are only important insofar as they relate to, make cause for, or provide an explanation for, a people's susceptibility to these biophysical hazards (like earthquakes, hurricanes, or floods).

One of the fundamental assumptions of the risks/hazards approach is that the combination of particular factors (risks) and the introduction of a type of hazard will produce results that are more or less generalizable. This understanding necessarily involves typologies and widens the potential for overgeneralizations of communities and conditions associated with vulnerability. This lack of specificity and contextualization can also lead to problematic research methods and results

Many times, the risk/analysis conceptual lineage uses quantified variables based solely on biophysical characteristics. However, there has been a shift in this approach from a focus only on biophysical factors of risk analysis to a focus on the various degrees to which biophysical and socioeconomic factors impact one another. For instance, in studying mountain hazards in Austria, Fuchs (2009) utilizes the axiom (and key assumption of this approach) that "natural hazard risk is a function of hazard and consequence" (337). But while utilizing this axiom, Fuchs (2009) also addresses the institutional and social factors that could be producing disparate vulnerabilities. Here, Fuchs draws on the general consensus within the social science community about some of the major factors that influence social vulnerability. Some of the factors are the **lack of access to resources, such as information, knowledge, and technology; limited access to political power and representation; age; traditions and beliefs; and type and density of physical infrastructure** (Cutter, 2003; Blaikie et al., 1994).

Resilience

Related to the risk/hazards approach, but with slightly different ideological assumptions is the resilience approach. Most notably used in Ecology and ecologically-based Disaster Studies, ecological resilience is known as "the ability to absorb change and disturbance and still maintain the same relationships that control a system's behavior" (Hollings, 1973). This understanding of resilience is not to be confused with engineering resilience, which states that systems should be able to return to some pre-disturbed state after a disturbance. The ecological resilience approach recognizes that vulnerability and the interactions between humans and the biophysical environment are always in flux. There may not be a point of equilibrium; there may be multiple points of equilibrium.

The resilience approach emphasizes a set of biophysical processes alongside (and in conversation with) human processes that should be able to absorb the effects of natural disasters, and then return to similar processes, both non-human and human, that maintained the system before. In resilience studies, the social (or human) and ecological (or non-human) are represented as separate entities whose processes are intertwined and in some cases, causally linked.

In resilience studies, social vulnerability is understood in terms of limits and thresholds. Adger defines resilience as "the magnitude of disturbance that can be absorbed before a system changes to a radically different state, as well as the capacity to self-organize and the capacity for adaptation to emerging circumstances" (2006). This emphasis on processes of change, adaptation and thresholds forms the basis for this approach (Eakin & Luers, 2006; Gallopin, 2006).

Social vulnerability is often conceptualized as constituted by components that include exposure and sensitivity to perturbations or external stresses, and the capacity to adapt. Exposure is the nature and degree to which a system experiences environmental or socio-political stress. The characteristics of these stresses include their magnitude, frequency, duration and extent of the hazard. Sensitivity is the "degree to which a system is modified or affected by perturbations" (Eakin & Luers, 2006, p. 368). Adaptive capacity is the ability of a system to evolve in order to accommodate environmental hazards or to expand the range of variability with which it can cope. Social vulnerability, in this approach, can also be worded as the **"absence of capacity to adapt"** (Adger, 2006, p. 272). Therefore, capacity – both of the individual and the community – play an integral part in social vulnerability. Sen (2001) argues that vulnerability is characterized by the lack of freedoms that then create a depravation of capability, leading to a further marginalization of already socially marginalized groups. In this approach, with increased

(adaptive) capacity comes increased resilience, leading to a decrease in vulnerability (Adger, 2006; Eakins & Luers, 2006; Fussel, 2006; Gallopin, 2006).

Political Ecology

This approach formed as a critical response to risk-hazard assessments of vulnerability, emphasizing the need to examine the differential power dynamics that contribute to the vulnerability of a community or group. Much of the literature on socio-ecological systems and environmental change cedes that there cannot be an accurate account of the socio-ecological system without an examination of the political economy of resource use. This critique was in direct contrast to the fundamental assumption in the risk/hazard model that the biophysical is one of, if not *the* most important contributor to vulnerability.

In Political Ecology, social vulnerability is the product of social stratification and inequalities—it is not only a function of the demographics of the population but also of more complex constructs such as health care, social capital, and access to lifelines including emergency response (Finch et. al., 2010). Vulnerability is driven by inadvertent or deliberate human action that reinforces self-interest and the distribution of power in addition to interacting with physical and ecological systems. Political Ecology frames social vulnerability to disasters and their impacts within broader social contexts and processes.

Developing from roots in neo-Marxist thought, contemporary vulnerability research in a Political Ecology framework is characterized by analyses of social and economic processes, with interacting scales of causation and of social difference. This approach asks the questions: "why are particular populations vulnerable? How are they vulnerable? And, importantly, who precisely is vulnerable?" (Adger, 2006, p. 268). In this literature, **vulnerability is not an outcome but**

rather a state or condition of being—and a very dynamic one at that —moderated by existing inequities in resource distribution and access, the control individuals can exert over choices and opportunities, and historical patterns of social domination and marginalization (Eakin & Luers, 2006).

Methodological Approaches for Examining and Assessing Social Vulnerability

Some researchers seek to understand social vulnerability in quantitative ways. However, they disagree in the selection of specific variables within quantified models. Among the generally accepted variables are race, age, and socioeconomic status (which is also defined in a myriad of ways, but mostly uses income as a proxy). Other characteristics identify special needs populations or those that lack the normal social safety nets necessary in disaster recovery, such as the physically or mentally challenged, non-English- speaking immigrants, and the homeless. The "quality of human settlements (housing type and construction, infrastructure, and lifelines) and the built environment" are also important in understanding social vulnerability, which is why they are also taken into account (Cutter et al 2003).

The Social Vulnerability Index (SoVI), one of the most widely-used metrics for measuring social vulnerability, was created using statistical methods that parse through large data sets and pick out the variables that best explain a latent variable (like social vulnerability), ranking them in order of their explanation of the variance. The index's key variables include socioeconomic status, race, age, and gender. Note here that space is geographically defined. This model can be recreated at different scales, depending on the level of measurement given in the dataset.

Since its debut, the SoVI has been replicated in a number of different contexts, including an "analysis of historic spatial trends in social vulnerability for U.S. counties and an assessment

of the Gulf Coast counties affected by Hurricane Katrina" (Cutter et. al., 2003). The SoVI has been utilized to understand hurricane wind risk in Miami-Dade county and is used in multiple state- and county-level analyses (e.g. California, Colorado, and South Carolina as part of the mandatory FEMA hazard mitigation planning process) (Cutter et. al., 2003). The SoVI has also been applied internationally, as in the mountain hazard case mentioned beforehand in Austria (Fuchs, 2009). In this work, Fuchs analyzes how mountain hazards are being predicated by particular social factors, and explores how these factors work hand in hand with the structural factors (here, meaning the particular makeup of nearby rock formations) that cause mountain hazards (Fuchs, 2009). This index has been cited and discussed in more than 70 peer-reviewed journal articles, including many related to Hurricane Katrina and specifically discussing the New Orleans area (Cutter et al., 2003).

Critiques of Quantitative Measures

The SoVI, and other indices that try to capture social vulnerability, have been challenged in their attention to quantified predictors such as income, educational attainment, and rate of unemployment (Cutter et. al, 2003); it has been argued that they center on these quantifiable variables and pay little attention to actual lived experiences or contextual nuance (Schmidtlein, 2008). Yet they have answered many of these challenges by examining areas at different scales and utilizing local knowledge for validation (Schmidtlein 2008). Cutter and Finch (2008) have recognized that vulnerability also changes over time and space, as the formation of identities and their relations with the dominant power entity change.

Eric Tate (2013) also has critiqued the subjectivity of the Social Vulnerability Index, asserting that an epistemic uncertainty is involved in all of these quantified assessments and that researchers should more readily acknowledge this uncertainty. As a part of the team that created

the index, in other papers, Cutter (Cutter et al., 2008; Cutter & Finch, 2008; Finch et al., 2010; Tate et al., 2010) has attested to the need to examine "antecedent conditions" that might influence this quantified, static measure of vulnerability; several examples include existing inequities in resource distribution and access, the control individuals can exert over choices and opportunities, and historical patterns of social domination and marginalization (Eakin & Luers, 2006).

Quantified metrics assume that there are certain human factors that can be quantified, and that these are the most important factors in the quest to understanding social vulnerability. Because vulnerability is dynamic, measurement of vulnerability must therefore reflect social processes as well as material outcomes within systems that appear complicated and with many linkages that are difficult to pin down. Vulnerability is, therefore, not easily reduced to a single metric and is not *easily* quantifiable. This is shown by the need of a member of the local community to validate the relative accuracy of the SoVI measured for their area (Schmidtlein et. al., 2008). Best said by Adger:

> "While it is easy to recognize personally the feeling of vulnerability and perhaps to grasp the outcome of vulnerability in others in a similar situation, the translation of this complex set of parameters into a quantitative metric in many ways reduces its impact and hides its complexity" (2006, p. 274).

Environmental Justice

Separate from (though co-evolving with) social vulnerability, environmental justice (EJ) is a humanistic field of study that explores the ways in which different communities are disparately affected by environmental problems – many times associated with low-income, rural areas. The beginning of the environmental justice movement in itself mirrors the dichotomous conceptualization of nature urban ecology presented earlier; the tension between the mainstream

environmentalist movement, and the environmental justice movement. EJ calls for a more human focus to environmentalism, pointing out that much of the mainstream environmentalist movement not only ignored social issues – many of which affected people of color particularly – but also ignored other vulnerable groups such as those in poverty, women, the homeless etc. (Buckingham & Kulcur 2011; Dooling, 2009). **Environmental justice centers on the experiences of these groups; the analytic commitment in this field is to the lived/grounded experiences of the most vulnerable or disadvantaged groups.**

One of the pivotal moments in Environmental Justice took place in the early 1990s, when grassroots organizations wrote to the Great Ten (the top ten federal and non-governmental organizations at the time) about the lack of attention they paid to social issues that highly correlated and were interconnected with environmental issues (Pezullo & Sandler, 2007). Ignoring these groups, argued these activists, inherently silenced their problems, leaving them without representation. However well-intentioned these governmental organizations were in their belief that protectionism and environmentalism do not necessarily harm vulnerable groups (Wenz 2007), they gave no voice to these underrepresented groups, which is a major tenet of environmental justice (Principles of Environmental Justice 1991).

Overview

Distributive Justice and Equality

EJ initially focused on the intersection of race and class with observed ecological and environmental inequalities, such as improper toxic chemical plant siting (Pellow, 2016). The early environmental injustice claimed that certain citizens were denied the same protection from environmental hazards that other groups received (Pezullo & Sandler, 2007). This led to the most

vulnerable groups creating a list of principles that environmental justice activists and researchers should be committed to (Principles of Environmental Justice, 1991; furthered by Bali Principles of Climate Justice, 2002). Their protection from these hazards were not distributed evenly across racial and class lines. This conceptualization of in/justice is called distributive in/justice, where the contested resources (here, the protection from environmental threats) are/are not spread evenly amongst the stakeholders (Holifield, 2001; Schlosberg 2013). Distributive justice focuses heavily on the outcome of the justice-attaining process; it is based on the assumption that all of the relevant stakeholders are present and able to receive the right or resource that is being evenly allocated (Davoudi & Brooks 2014).

A major critique of distributive justice is this very assumption that all the stakeholders are being represented in the claim-making process, and that each stakeholder is due the same as another. Here, the difference between equality and equity plays a major role in evaluating and understanding EJ claims. Equality is defined as the state of being equal, especially in status, rights, and opportunities. But this notion of equality ignores the dynamics of power that are heavily embedded in environmental injustice claims. Systemic injustices and systems of power are ignored, or at best briefly mentioned, when conceptualizing justice as distributive in EJ research. While there are researchers who are attempting to do this work, to ascribe a broader sense of justice to EJ scholarship, their work is few and far between. However, a new wave of EJ research is beginning to acknowledge and interrogate multi-scalar and multi-dimensional understandings of environmental injustice claims (Pellow, 2016).

Critical Environmental Justice (CEJ), Procedural Justice, and Equity

More recently, there has been an ideological shift to the concept of procedural justice in EJ efforts (Holifield, 2011) that directly reflects the weaknesses of conceptualizing justice as

distributive. Procedural justice illuminates the complexity of "justice" by maintaining a larger focus on the process by which claims are made, addresses, and the multiple parties' relative power. This iteration of justice is most closely associated with equity, defined as justice free from bias or favoritism. This shift has come along with the "second wave" of Environmental Justice research, Critical Environmental Justice (CEJ).

This "second wave" of EJ research more heavily critiques older models of justice and interrogates our very understanding of what can be considered just. CEJ is rooted in the critique and expansion of EJ to consider factors that it had not before. Some of the factors are issues of scale, space, gender, and a more intense interrogation of the meanings of justice. CEJ focuses on the need to pluralize and contextualize justice; there are multiple meanings of justice that change based upon the cultural context in which the environmental justice claims are operating. In contrast to EJ, CEJ

> "brings greater attention to how multiple social categories of difference are entangled in the production of environmental injustice, from race, gender, sexuality, ability, and class to species, which would attend to the ways that both the human and the more-than-human world are impacted by and respond to environmental justice" (Pellow, 2016).

In this vein, CEJ studies gives urban ecology the language to explore urban environmental inequities across multiple scales and categorizations, such as gender, age, and other iterations of (in)justice. It also furthers the point that nature is more than a non-human – or as Pellow stated "more-than-human" – realm (2016). Nature is constituted by non-human and human spaces, both producing and reproducing each other.

Using this analysis, we can still acknowledge that humans do – as the most impactful decision-makers in this ecosystem – have a responsibility to the non-human aspects of "nature." This responsibility then "binds together social justice and environmental sustainability" by embedding them within each other (Davoudi & Brooks 2014).

Even though EJ may seem anthropocentric, it does not alleviate humans of the reverence many human cultures have had for "Mother Earth" for millennia (Principles of Environmental Justice 1991). And the more recent transformation into the field of Critical Environmental Justice highlights that this anthropocentrism may be faltering; in CEJ studies, more attention is paid to "more-than-human" species (Pellow, 2016) and more agency is conceptualized within this non-human world. While all species may not function socially or politically as we humans do, that does not negate their ability to exert force upon the human realm.

Methodological Approaches for Examining and Assessing Environmental Injustices

Environmental justice, as a movement, found legal credibility in being able to prove that the siting of toxic chemicals disproportionately affected communities of color. Using statistics and Geographic Information System (GIS)-based data, environmental justice activists were able to convince federal agencies to adopt environmental justice agendas (Holifield, 2001). These methods were established to prove the existence of environmental injustice along with the legitimacy of environmental justice claims. This quantified way of assessing environmental justice generally utilized variables such as race, ethnicity, age, and proximity to toxin to draw correlations in support of, or against, claims of disproportionate exposure. Researchers utilized census data, especially datasets provided by the Environmental Protection Agency (EPA), for their analyses. These methods still remain prominent in environmental justice research, especially in discussions of distributive (in)justice.

For example, a study conducted in Charleston, South Carolina that aimed to find the relationship between the distribution of Toxic Release Inventory (TRI) facilities and race or socioeconomic status (Wilson et. al., 2012) found that there were indeed burden disparities in the siting of these TRI facilities. They were more likely to be near non-white communities (or

communities of color), and those that were of lower socioeconomic status (Wilson et. al., 2012). These results are in line with many other environmental justice studies that have been conducted.

Critiques of Quantitative Measures

However, Holifield (2001) notes that methods used to establish environmental justice might no longer be the best methods to answer contemporary environmental justice questions. Traditional environmental equity analyses may no longer be appropriate now that federal agencies have "established policies, built bureaucracies, and earmarked funds devoted to environmental justice" (Holifield, 2001) – in essence legitimizing environmental injustice as a valid claim. Holifield contends that instead of asking if there are communities that have a disproportionate burden because of unjust siting practices, research should be asking in what ways are other environmental inequalities occurring and how to recognize and then aid these vulnerable communities. Here, the focus should be on the most vulnerable groups and their lived experiences. Environmental justice as a field has strong ethical commitments to the most vulnerable groups: those that are marginalized and are not only disproportionately denied access to the benefits of the products, but are also disproportionately exposed to their harm and toxins. It is reasonable then, that to capture the complex processes that perpetuate environmental inequalities, a qualitative methodology might be more useful. Stories of these groups should be told by these groups.

Space, Scale, and Time in Social Vulnerability Studies and Environmental Justice

The spatial scale at which vulnerability is identified affects the definition of the community affected, which then affects how one comes to understand and claim vulnerability

and environmental injustice (Schmidtlein et al., 2008). Scales range from the individual body, to group identity, to regional identity (Watts, 1993). Temporal variability also affects how people identify and assess vulnerability in political ecology. In assessing silenced or forgotten voices, the length of time—whether years or decades—can provide drastically different results. For example, in the aftermath of major environmental disasters or wars, the number of immediate casualties provides the magnitude of the event in collective memory (Nixon, 2011). However, the vulnerable are not just the immediate casualties, but those that remain marginalized in terms of visibility and official memory—many times, the illiterate poor (Farmer, 2009; Nixon, 2011).

Temporal aspects in the study of social vulnerability are crucial to the understanding of each the three conceptual linkages above. The temporal quality in the risk/hazards approach is in the assessment of vulnerability. A place or people are recognized as vulnerable by their municipal, state, or federal government system only after they have suffered from a natural disaster of some sort, or suffer from similar conditions to other communities that have suffered from a natural disaster. In this way, the assessment of vulnerability is not necessarily deterministic, but dependent upon a consideration of time. In the resilience approach, the importance of time is inherent in the study of vulnerability; a researcher must be able to identify conditions leading to, during, and going beyond the natural disturbance itself in order to more effectively garner an understanding of the social vulnerability of the community. For example, after Hurricane Katrina, to see how many people returned to their homes in the Ninth Ward, mail addressed to those homes were used as data (Finch et. al., 2010). This proxy was to determine if the homes were being used in the same capacity they were before the storm. If so, the same processes that functioned before were beginning to function again

Closely linked to social vulnerability are the frameworks provided by environmental justice scholars. **These frameworks give us the language to further explore the distributions of hazard/risk, and to more closely examine procedures that may lead to unjust exposure to risk.** Environmental justice also provides depth into the questions we might ask following a hurricane in vulnerable coastal cities, like how we understand, conceptualize, and analyze space. Next, I provide an overview of how space is treated in other disciplines and discuss what critical urban ecology could gain from these treatments of space.

"Making" Space and Nature

Urban ecology has had an inherent engagement with the concept of space in its discussion of nature and urban areas. Physical space and populations density within urban space designates the type of urban area it is. The distance to the city center, ability to walk to key areas, and the places where different demographics flock to, for example, engage with concepts of defining and understanding space. However, urban ecology does little to explicitly discuss the process of making space; the field treats space as something fixed and measurable through quantitative units.

Urban ecology similarly relies on an ontological divide between nature and society that fixes the object of study. On the one hand is the focus on human environmental concerns such as human vulnerability, resource allocation, and distributions of environmental costs and benefits. On the other, are the "natural" (non-human) concerns, such as water quality, air quality (as these relate to animal or plant health), and endangered species, for example. The latter approach is the more traditional, borne out of urban ecology's push to become a more objective science. By concentrating solely on the human *or* the non-human in nature researchers ignore the benefits of

analyzing the globe (and on a smaller scale, urban environments) as a web of human-dominated ecosystems. By positioning nature as a web of human-dominated ecosystems, we acknowledge that humans – as the most impactful decision-makers in this ecosystem – have a responsibility to the non-human aspects of nature. Nature's problems – namely, those of environmental sustainability – include human processes and issues, such as social justice.

Attention to how urban space is produced is necessary. Space is more than the Cartesian model of geographic location; space is recognized by the multiple spatialities (physical space and the meanings imparted on it) that can exist in the process of identifying and assessing vulnerability, as well as the processes of producing these spatialities. In much of the urban ecology literature, the biogeophysical spaces of a natural disturbance site are either explicitly discussed, or implicitly form an integral part in the analysis of these ecosystems. Here, I am defining biogeophysical characteristics as the non-human, biotic and abiotic factors that can affect the impact of a natural disturbance. For example, in examining mountain hazards, Fuchs takes into account the type and shape of the rock formations (2009). But the term "space" also goes beyond accounting for the biogeophysical characteristics and the meanings attached to them; space is not merely a static entity, bounded by geographical or ecological barriers.

> The production of space examines how new systems (actual or imagined) of land use, transport and communications, territorial organization, etc. are produced and how new modes of representation (e.g. information technology, computerized mapping, or design) arise (Harvey, 1990).

Social theorist Henri Lefebvre argues that once a space is produced, it

> serves as a tool of thought and of action; that in addition to being a means of production it is also a means of control, and hence domination, of power, yet that, as such, it escapes in part from those who would make use of it (1991).

So once the product is not there, it becomes something that works to produce more space, place, people, society, environment, and so on; it comes to take part in the process of production

(West, 2006). For example, in the book, Fields and Streams: Stream Restoration, Neoliberalism, and the Future of Environmental Science, Rebecca Lave details how streams are recognized by form and function, ignoring that as spatial features, they have been actually been produced to have features that count them as "streams" with those forms and features. Once produced, they produce the spaces around them, so that even when the stream is no longer functioning as a stream, the act of "restoring" it to some pristine condition reinforces what a "stream" should look like and do, thereby further producing more space.

Conventional approaches assume space as a static field in which activities take place and actors exist but is not itself made or altered by social action. Lefebvre (1991), and others demonstrate that the nature of space itself is constitutive of those actors and actions. In understanding space as a process, we must take into account that it is constituted within the same processes that shape and define "the environment" and "nature" (Harvey, 1996). Thus, nature is produced with space (Smith, 1990). In his *production of nature* thesis, Neil Smith (1996) moves away from nature as "fetishized or as seen as dominated by humans", to focus on the social relationships "producing nature and the social relationships we have with nature" (Smith, 1990) The key to the production of nature argument is that it brings together sociocultural constructions of nature with material productions of nature (West, 2006). This sort of analysis allows for a political theory of nature that expresses "the inevitability and creativity of the social relations" (Smith 1996) and how these social relations impact interaction with "nature."

I agree with Paige West, in her book Conservation is Our Government Now: The Politics of Ecology in Papua New Guinea, that thinking about space, and "nature" in these ways opens doors for us to understand and think about our relationships with each other, how we make ourselves, and our own space:

> "Thinking about the environment, which Smith calls nature, and the relationships between the environment and society as a process of production, allow us to think about the relationship between how we make ourselves and how we make our world (Harvey, 1996). It allows us to see the shared mechanisms of the production of environment, selves, society, and space." (West, 2006)

Smith argues that "nature," or the non-human environment, is being socially produced and reproduced (Smith, 1996); this focuses almost solely on the agency of the human in iterating what nature is and is not. But we can then reckon with and theorize how nature is an agent in these space-making processes as well, and come closer to a discussion of how non-human nature also produces and reproduces in the same ways that humans do, even in urban areas. Taking non-human agency into account in space-making allows us to consider how the natural disasters themselves make and remake space.

Conclusions: Principles of critical urban ecology

This chapter reviewed the conceptual lineages of social vulnerability and environmental justice, along with their dominant methodological approaches and critiques of these. By reviewing both of these fields, I expose areas where integration of their key points into urban ecology can expand urban ecology into a more holistic and critical study of urban ecosystems – namely critical urban ecology - especially in response to vulnerability following disasters, such as hurricanes.

In critical urban ecology, I will be taking the language and commitments that both social vulnerability and environmental justice have contributed to studying vulnerability after disaster. Each iteration of social vulnerability contributes language to critically examine vulnerability as more than a function of demographics, and names these concepts as legitimate ways to assess or characterize social vulnerability. In the risk/hazards approach, social vulnerability encompasses many factors, such as the lack of access to information, knowledge or technology. In the

resilience approach, vulnerability is characterized by an **"absence of capacity to adapt"** (Adger, 2006). The political ecology approach emphasizes **vulnerability as a state-of-being** rather than an outcome. Vulnerability is here conceptualized as an ongoing lived experience that is moderated by existing inequities and historical patterns of social domination and marginalization (Eakin & Luers, 2006). Environmental justice validates this language and the concepts named by **emphasizing deeper commitments to the lived experiences** of these marginalized and vulnerable groups. Space in both of these fields are constituted by processes that takes into account scale and time.

Critical urban ecology encompasses four major principles. First, humans and processes unique to them need to be embedded into disaster management models. By deeply embedding humans and their constructs into these models, we have a starting point from which to holistically examine a city pre-and post-disaster. Second, "vulnerability" must be situated and contextualized. We must ask "who is vulnerable? How are they vulnerable? In what ways were they made vulnerable? And what other vulnerabilities might then exist?" Third, there must be a commitment to understanding the lived experiences of the most vulnerable communities in the city. The city is only as secure as its most vulnerable populations, so a commitment to understanding their vulnerability and their grounded experience would shed light on how to critically examine a city. Fourth, space is not just biophysical. Although there are material processes that characterize a space, there are also sociohistorical processes that contribute to how a space works and what it means for people who interact with it. This element of space-making is crucial to understanding cities and their impacts on people, as well as people's impacts on them before and after a hurricane.

Alongside biogeophysical modeling, these principles contribute to more accurately capturing the aftermath of natural disturbances. Reimagining and expanding urban ecology to include these principles gives urban ecologists a wider, and more transdisciplinary framework with which to analyze urban natural disasters.

CHAPTER 4

Case Studies: Hurricanes Katrina and Matthew

In this chapter, I illustrate how critical urban ecology can move towards addressing the complex issues and impacts of large wet-weather disturbances on urban ecosystems. One of the best examples of significant challenges faced by vulnerable communities is the wake of natural disturbances such as major hurricanes. In such cases, "marginalized populations are most vulnerable to the negative consequences of a disaster and face significant challenges in recovery" (Reid, 2013). Non-human, weather disturbances are not only moments of physical change, but they also provide the potential for social change. These disturbances bring human social problems to light. Along with these physical manifestations, the time and the degree to which a community can return back to its normal state, or sustain the social and economic functions it once did (its resilience) also play a role in focusing social change. This chapter applies the critical urban ecology principles to two brief case studies: Hurricane Katrina in New Orleans, Lousiana and Hurricane Matthew in Kinston, North Carolina. I examine how critical urban ecology can aid in analyzing hurricane impact and perhaps help policy-makers and researchers predict how best to handle future disasters.

Hurricane Katrina, 2005, New Orleans, Louisiana

Hurricane Katrina was one of the biggest hurricanes to hit New Orleans. 80% of the city flooded after levees failed. The population of New Orleans fell from 484,674 in April 2000 to 230,172 in July 2006, a decrease of over 50%. By 2014, the population had increased to an

estimated 384,320, according to the US Census Bureau, putting New Orleans back on the list of the 50 most-populous cities that year. 70% of New Orleans' occupied housing, or about 134,000 units, was damaged in the storm (US Census Bureau). Using the critical urban ecology model outlined in the previous chapter, I analyze this disaster, and pose questions that, although eventually researched, might have proven more beneficial if examined sooner.

Principle 1: Human dimensions are embedded into models

In predicting Hurricane Katrina, many models showcased the severity of the storm in as far as wind speeds, flooding and category. To be effective however, these models must also include a strong focus on the communities at risk and include factors from both the "natural hazard" (biogeophysical conditions) as well as social vulnerabilities (Basher, 2006). In the case of Hurricane Katrina, one hurricane expert attempted to do just that. Ten months before Hurricane Katrina, Iver Van Heerden, a hurricane researcher at Louisiana State University, didn't just predict the biogeophysical characteristics of the storm, but also the potential dangers to the people in New Orleans (PBS.org). He noted that, at the time, about 57,000 families did not have a car in order to evacuate before the storm and that there were homeless people, as well as disabled and bedridden people who would be unable to escape the high flood waters that would take months to recede (PBS.org). These types of considerations are crucial in order to effectively prepare for disaster. Unfortunately, his warnings were not taken into account by public officials.

Principle 2: A critical understanding of vulnerability

As noted in the previous chapter, the definition of vulnerability is nuanced and multiple; different approaches have defined vulnerability in a number of ways, all of which hold a facet of

reality. A critical urban ecology approach would take this into account in order to more effectively predict and respond to natural disasters. As was seen in New Orleans, differential vulnerabilities can lead to catastrophic results (Cutter & Emrich, 2006). In the wake of Hurricane Katrina, numerous articles and books examined different types of vulnerability, and how these vulnerabilities changed forms throughout the recovery process. For example, scholarship on vulnerability examines groups that are vulnerable because of where they live (Boruff et. al, 2005; Crosett et. al, 2004); race, class and income differences (Cutter et.al, 2006); gender; and access to outside resources (Hawkins & Maurer, 2009), as well as the ways in which these vulnerabilities intersect. Some groups are living in a state of vulnerability because of factors that are less readily examined, such as: women with small children or infants (Callaghan et. al., 2007); those that are disabled; those that are homeless; and those that have close-knit and closed neighborhood networks. Examining these factors following hurricane Katrina has opened the recovery and vulnerability narratives to a myriad of ways that people are differentially affected by natural disturbances, and how their differing vulnerabilities manifest and explain their recovery trajectories.

Principle 3: A deeper commitment to the most vulnerable groups

Following Hurricane Katrina, an influx of research came out of interviewing and attempting to understand the recovery experiences of the most vulnerable groups. Emphasis on lived experience alleviates universal narratives of experience following hurricanes. As time progressed after Hurricane Katrina, research highlighted the nuance of lived experience through survivorship stories (Lindahl, 2012), narratives of the effects displacement (Cox & Perry, 2011), research about the psychological stress due to the effects of the storm and the recovery process

(Chen et. al, 2007; Goodman & West-Olatunji, 2008), and other perspectives that complicated the traditional recovery narrative (e.g Luft, 2009: Luft, 2016), as opposed to just theoretical or abstract ideas. This focus on grounded scholarship not only elevates the experience of the everyday, but also allows for more realistic understandings of the impacts of hurricanes on (coastal) cities.

Principle 4: Space as contextualized

Contextualizing space means examining the sociohistorical elements that contribute to the making of biogeophysical spaces as well as the social relations humans have with this iteration of nature. In this case, this entails interrogating why Hurricane Katrina – a natural disturbance – became an unnatural disaster. Understanding the sociohistorical creation of spaces also helps us interrogate why some groups in this disaster experienced either more substantial damage than others, longer recovery times, or both.

"Unnatural disaster" is a term used to describe natural disturbances whose effects are made more significant due to human actions (Abramovitz, 2001). These actions can include the proliferation of human populations along coasts – which makes these populations more susceptible to risks of natural disturbances – as well as the location of the most socioeconomically vulnerable populations in ecologically vulnerable areas. Not every natural disturbance is a disaster, and not every disaster is completely natural (Abramovitz, 2001). For example, following Hurricane Katrina (and subsequently Hurricane Rita) in New Orleans, national attention was soon brought to the demographic patterns of most displaced residents: they were predominantly African-American and poor (Elliot & Pais, 2006). The storms disproportionately affected these groups because of structural inequalities that resulted in these

groups living in low-lying areas with little drainage. Inequities based on race, socioeconomic status and other social markers are not only made more visible by natural disturbances, but are exacerbated, making the disturbance a disaster. Contextualizing these spaces gives rise to historical analyses of patterns of vulnerability. These patterns can then be interrogated, deconstructed, and then changed in order to prevent damage and further vulnerability following the more frequent and stronger natural disturbances that are sure to come.

If urban ecology can utilize the critical urban ecology framework proposed, perhaps researchers can aid policy makers in being able to name these concepts earlier and act in ways that decrease the vulnerability of coastal cities, and cities overall.

Hurricane Matthew, 2016, North Carolina

Hurricane Matthew brought devastating flooding, strong winds, and moderate to major storm surge to the coast of Eastern North Carolina on October 8, 2016. There was catastrophic flooding in the Coastal plains, reaching as far west as Fayetteville. River flood levels not seen since Hurricane Floyd (1999) caused millions of dollars of damage and multiple deaths across the eastern third of North Carolina. The Neuse River at Kinston recorded a record crest of 28.6 feet. Sound-side storm surge levels were observed at 3.5 to 4.5 feet above ground in Hatteras, and 2 to 3 feet above ground in Ocracoke. Kinston, North Carolina is not always considered an urban space based off of population and population density. However, its peri-urban nature makes it a prime example to illustrate the usefulness of a more holistic, critical urban ecology across different types of urban spaces. The city holds North Carolina's top disadvantaged census tract (High & Owen, 2014). Because Hurricane Matthew just occurred last year, there is far less published research on the storm's impacts in Kinston. However, there is room to explore some of

the lessons that have been explored following Hurricane Katrina.

Principle 1: Human dimensions are embedded into models

Utilizing the first principle, we can examine the ways that the absence of human experience from many models proved detrimental following the storm. Hurricane Matthew was projected to make landfall October of 2016, and while the focus of the warnings was on wind speed and rainfall, much of the modeling failed to plan for the displacement of residents and recovery of affected residents. Just as Heerden predicted the impact that Hurricane Katrina would have on residents in New Orleans, so must researchers make similar calculations in order to best aid in evacuating and/or safeguarding residents before and during a storm. Economically and politically, these predictions have the potential to aid federal agencies in budgeting recovery and relief funds for multiple sites as well as lowering costs of damaged goods.

Principle 2: A critical understanding of vulnerability

Examining vulnerability not only accounts for the impact of the social markers of vulnerability on people or groups' recovery, but also the ways in which people lived in vulnerability before the storm, and whose vulnerable state was exacerbated by the storm. Not only were these groups more susceptible to harm in the first place, but their experiences in the aftermath of these disasters are colored by these same vulnerabilities and may have subsequently introduced more. A critical examination of the unequal distribution of risk, inequity in procedure, along with multiscalar analyses (city-level, block-level, gendered etc.) would allow for a clearer understanding of the ways in which different groups in Kinston were vulnerable and continue to live in vulnerability following the storm.

Interestingly enough, a prominent narrative of Hurricane Matthew in that region is one of success: FEMA emphasizes the lessons that were learned and applied in order to lessen the impact of Hurricane Matthew on Kinston residents (FEMA, 2016). According to FEMA, property acquisition and demolition in the city drastically decreased the potential damage of the storm. But this type of narrative is dangerous; it ignores the ways in which so many residents are still impacted by this storm even now. And while there *may* have been some potential successes in avoiding harm to vulnerable groups that would have been more directly in the storm's path, I would argue it merely changed the circumstances by which already vulnerable people experienced their vulnerability during and after the storm. Instead of emphasizing the harm that was avoided, I would argue it is even more important to pay closer attention to the ways in which already vulnerable groups and their concerns can be addressed.

Principle 3: A deeper commitment to the most vulnerable groups

Using a critical urban ecology, researchers should focus on grounded scholarship that more deeply explores the intersections of unequal distribution of risk and a decreased capacity to adapt (or resilience). As was shown in the aftermath of Hurricane Katrina, already vulnerable groups experience natural disturbances and their effects differently. A focus on grounded scholarship would prove to expose the contextualized and specific ways in which Kinston residents who are already vulnerable experience their vulnerability. This type of scholarship also serves to give the microphone to those who typically aren't even asked on stage; their telling of their experiences are amplified, and they are able to ask (or demand) for what they, in actuality, need most.

Principle 4: Space as contextualized

Again, contextualizing space in this case means situating biogeophysical spaces within historical trajectories in order to better explain how people come to understand and make meaning of that space. Because of Kinston's peri-urban context, geographical location within North Carolina, and political location in a southern conservative state, researchers can triangulate and further interrogate the spatialities that Kinston is comprised of, along with the meanings that people ascribe to the spaces within this city. Doing this allows for a deeper understanding of the ways in which different groups live in their reality; this allows researchers and policy experts to better adapt policies, research agendas, and intellectual frameworks to the ways that prove most useful for the very people that are most impacted by these storms. As learned with Hurricane Katrina, there are narratives that have yet to be explored by researchers, ontologies that have yet to be understood by a larger audience. By analytically contextualizing spaces following hurricanes, critical urban ecologists will be creating room for rich truths to be told and potentially life-saving interventions to be had.

These inquiries, of course, are still in progress. As urban ecology engages with the study of natural disasters, it has already begun small shifts toward transdisciplinary approaches to inherently transdisciplinary questions. Answering these questions earlier in the recovery process is critical in holistically capturing the urban ecosystem following hurricanes. However, there is still room for future research. Specifically, this critical urban ecological model calls for in-depth examinations of the lived experiences of those displaced.

Broader Impacts

When we do not consider the ways in which we can critically examine hurricane preparedness, experience, and recovery, we lose a large part of the picture and are unable to notice patterns. Failing to notice these patterns has more than theoretical ramifications. Noticing patterns like the aforementioned can aid societies in enhancing the resilience of its most vulnerable citizens, thereby enhancing the resilience of the city overall. Accurately conceptualizing vulnerability, the effects of these storms, and community resilience are key factors in protecting urban communities from exacerbated negative effects following large, wet-weather events. Critical urban ecology calls for this analysis.

CHAPTER 5

Conclusion

This literature review aimed to create the case for a critical urban ecology, using the language of environmental justice and social vulnerability studies. Chapter 2 discussed the theoretical frameworks leading to the contemporary use of urban ecology. The Ecology IN cities approach was a starting point for urban ecology, and has since evolved into the Ecology OF cities approach and Ecology FOR cities framework. The latter two both conceptualize the city as an ecosystem, with interconnected feedbacks that take into account the human, non-human, biotic, abiotic, and built dimensions of urban space. Urban ecology, as represented by the Press-Pulse dynamics framework, has room for improvement in conceptualizing urban spaces. At the end of this chapter, I highlighted two themes inherent in studying cities that for some reason, are never explicitly tackled within urban ecology: the human-nature divide and space. These gaps are crucial to a more holistic urban ecology.

Chapter 3 expands on critical urban ecology as an approach that more deeply and explicitly incorporates social vulnerability studies and environmental justice into urban ecology. This holistic model uses the language and commitments of these two fields to expand urban ecology to a more holistic study of cities, especially following major disasters. Social vulnerability studies, especially through a political ecology lens, demonstrate that vulnerability is not only a function of the demographics of the population but also of more complex constructs such as health care, social capital, and access to lifelines including emergency response (Finch et. al., 2010). Environmental justice furthers this language by presenting grounded evidence and

deeper commitments to the most vulnerable communities in the city. Chapter 4 then applies this conceptual model to two case studies: Hurricane Katrina in New Orleans, Louisiana and Hurricane Matthew in Kinston, North Carolina. These cases differ in the urban form of the city, the demographics, and the biophysical terrain and climate. However, the principles of critical urban ecology can be applied to both, insisting upon deeper commitments to understanding the most vulnerable populations in a city and their lived experiences. Applying the principles to these case studies shows the gaps in where policy-makers and researchers alike could have decreased the vulnerability of already vulnerable groups or could have foreseen how these storms might impact these groups. This framework provides but one avenue that urban ecology can pursue in order to more holistically and accurately capture the effects of hurricanes on coastal city residents. As we've seen this past September, hurricanes in the Atlantic are happening more frequently, and with increased magnitude; this work is necessary. The world is ever-urbanizing, and as more cities are located on or near the coastline, and changes in climate make wet-weather disturbances along these coasts more prevalent and stronger, the urgency of accurately predicting and understanding the impacts of these events is growing.

Future Directions

Using this conceptual model, researchers can predict the impacts of large wet-weather events on the human dimensions of the urban ecosystem. Coupled with other models that predict the biogeophysical extent of the disturbance, more provisions can be made to secure the resiliency of vulnerable populations. Critical urban ecology provides the framework by which to engage in transdisciplinary, qualitative, long-term research following large wet-weather disturbances. I envision critical ethnography and participant observation as key methods in

producing the kinds of knowledge that are insisted upon in the proposed framework, although other methods may be just as useful. Many types of scholarship across disciplines, including environmental justice and political ecology, have provided templates for building meaningful and respectful relationships with vulnerable communities that are actively decolonial and attentive to positionality, so as to create the space for the most impactful co-production of knowledge. In using urban ecology as the general framework, our analysis of the data collected would include a systems way of thinking – paying close attention to linkages, relationships, and feedback loops in the urban ecosystem. In critical urban ecology, these feedback loops now pay greater attention to the human dimensions of this ecosystem, and critically examine how humans and non-humans interact, the effects of their interactions, and potential moments of intervention. In this way, transdisciplinary approaches to studying urban areas expose and address the ways strictly disciplinary approaches might fail to answer some of the most important questions.

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