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Social Ecology of Sustainability

Editors

Stephen Wheeler, Christina Rosan, Bjoern Hagen

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Table of Contents

COGITATIO

Urban Planning (ISSN: 2183–7635)
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Commentary

Biophilic Cities and Healthy Societies

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Abstract
Biophilia holds that as a species humans are innately drawn to nature and to living things. Mounting research confirms the many positive health benefits of contact with nature, and the need for daily (and hourly) contact with the natural environment in order to live happy, healthy, meaningful lives. A new vision of Biophilic Cities is put forward here: cities that are nature-abundant, that seek to protect and grow nature, and that foster deep connections with the natural world. This article describes the emergence of this global movement, the new and creative ways that cities are restoring, growing and connecting with nature, and the current status and trajectory of a new global Biophilic Cities Network, launched in 2013. There remain open questions, and significant challenges, to advancing the Biophilic Cities vision, but it also presents unusual opportunities to create healthier, livable cities and societies.

Keywords
biophilia; biophilic; nature in cities; resilience

Issue
This commentary is part of the issue "Social Ecology of Sustainability", edited by Stephen Wheeler (University of California, Davis, USA), Christina Rosan (Temple University, USA) and Bjoern Hagen (Arizona State University, USA).

The concept of Biophilic Cities, or Biophilic Urbanism, has emerged as a compelling vision for how cities of the future will be designed and organized. It builds on the essential insight of "biophilia": that we are drawn to nature, and that we have an innate connection or affiliation with the natural world (e.g., Beatley, 2011, 2017; Kellert & Wilson, 1995; Wilson, 1984).

Research shows the remarkable ways in which contact with nature can make us happier and healthier as well as contribute to meaningful urban lives. Findings from the work around Japanese "forest bathing" show that a walk through a forest or greenspace has discernible mental health benefits, for instance reducing stress hormone levels and boosting immune systems (e.g., Wang, Tsunetsugu, & Africa, 2016). Nature also enhances cognitive performance and mood (e.g., Berman, Jonides, & Kaplan, 2012; Bratman, Hamilton, Hahn, Daily, & Gross, 2015), and is a significant antidote to long-term chronic stress experienced by many urbanites (e.g., Roe et al., 2013). Studies show that in the presence of nature, humans are more likely to be generous and cooperative as well as to think longer term (Weinstein, Pryzybylski, & Ryan, 2009; Zelenski, Dopko, & Capaldi, 2015). The experience of nature helps people live in ways that recognize the claims of others and the larger world. In short, nature helps make us better human beings and fosters the qualities that will be essential to resilience, sustainability, and healthy social ecologies.

Biophilic cities are also profoundly resilient cities. Virtually every step or action taken to increase nature in the city will help to make it more resilient. Rising urban heat, for instance, is a growing problem, and many of the most effective planning responses, from urban forestry to ecological rooftops, will at once insert new nature and cool urban environments. In addition, the Nature Conservancy's recent global analysis of urban tree planting shows how effective such steps can be in addressing serious air quality problems experienced in cities in the Global South (The Nature Conservancy, 2016).

The vision of Biophilic Cities has been gaining traction recently. Colleagues and I launched the global Biophilic Cities Network in 2013, and there are now fifteen cities participating in this Network. Individuals and organizations can join the Network by simply signing an on-line

pledge[1], while new partner cities must, among other requirements, select and monitor over time a set of metrics and adopt a Biophilic Cities resolution or proclamation. In support of this Network we organize webinars, produce films about participating cities, collect and share model biophilic codes, and produce a new Biophilic Cities Journal[2].

Biophilic cities celebrate, protect, and restore flora, fauna, and fungi while taking every opportunity to integrate nature with built structures. The vision of Biophilic Cities is of a blended nature in which remnant natural species and habitats mix with more human-designed forms of nature such as living walls, green rooftops, and skyparks (e.g., Kellert, Heerwagen, & Mador, 2008). Each city must explore the most effective and appropriate ways to integrate nature given its own unique natural settings and qualities. Biophilic cities must also understand nature as an integrative land-sea notion, including a "blue urbanism" along with other forms of urban greening (Beatley, 2014).

Many urban areas worldwide are helping us reimagine urban environments as nature-immersive places. Singapore has recently changing its official motto from "Singapore, a Garden City," to "Singapore, a City IN a Garden." The city's Landscape Replacement Policy requires new buildings to include nature in the vertical realm to replace nature lost at ground level. This ordinance has resulted in new buildings, such as the Park Royal hotel, that contribute much to the sense of immersive green city. Milwaukee is creating new green pockets by consolidating vacant parcels through its GR/OWN Program. San Francisco has created a new Sidewalk Garden Permit that allows residents to take up some hard surfaces and plant flowers and shrubs, and its pioneering program for creating Parklets (from on-street parking spaces) has gone global. Portland has emphasized the installation of "green streets": portions of roadways and sidewalks that become stormwater collection facilities through the creation of bioswales. Pittsburgh has sought to make its riverfront accessible by investing in walking and biking trails, and even a "water trail," as well as new waterfront parks such as the South Shore Riverfront Park. A large number of other cities including Wellington, NZ, Rio de Janeiro, and Singapore have also been investing in urban trails that add mobility options while making access to nature easier (see Beatley, 2017).

Not only does a Biophilic City put nature at the center of its design and planning, it also creates programs, initiatives, and opportunities for residents to experience nature directly and to engage in citizen science. Whether through birding, participation in a BioBlitz, or serving as a volunteer nature guide, residents deepen connections to place and nature while forging friendships and social connections. Austin, Texas, for example, is famous for its efforts at protecting and celebrating the 1.5 million Mexican free-tailed bats that occupy the underside of the Congress Avenue Bridge in downtown Austin (believed to be the largest urban bat colony in the world). Biophobia and fear characterized the city's initial response to the bats, but thanks to the work of groups like Bat Conservation International (BCI) the bats were saved and their return each spring (and nightly emergence from the bridge) is celebrated, becoming the source of millions in tourism revenue. As BCI founder Merlin Tuttle says, Austin is now "a city that loves bats" (Tuttle, 2015). St Louis has exhibited a similar love affair with Monarch Butterflies. Setting an initial goal of planting 250 butterfly gardens, the city has now seen more than 370 installed.

Engaging residents with nature faces many challenges: a hurried and harried lifestyle, a growing dependence on electronic media which often distracts us from nature, the fact that natural elements are often small or hard to see, and the need for active coaching and mentoring. Residents often have the sense that nature is to be found only in certain places in the city. Educational efforts are needed to help us re-imagine a city as a nature-immersive place. Nature of course is also a culturally defined concept, and cities will need to be open to exploring the different forms it might take. Biophilic cities include both living nature (e.g., birds and wildlife) and many human-created shapes, forms, and images of nature (for instance, murals). Increasingly we are seeing nature "hybrids" which challenge our conventional ideas about what nature is. Singapore's SuperTrees are one example—large, visually dramatic metal structures that do in fact shade and cool urban spaces as well as serving as home to thousands of living plants. Urban nature in the future will likely entail the creative blending of real and artificial natural systems, requiring us to expand and grow beyond our conventional ideas of nature.

One continuing challenge is social justice and the need to ensure that access to natural assets and experiences within a biophilic city is fairly distributed. Greener, leafier neighborhoods tend to be higher-income and absent of minorities. In a recent interview in the *Biophilic Cities Journal*, Oakland Re-leaf founder and director Kemba Shakur tells how there were more trees and greenery in the Soledad Prison where she worked than in the predominantly African-American neighborhood in which she lived. To address such equity questions, cities such as Los Angeles and New York have taken steps to invest in parks and greenspaces in underserved neighborhoods (e.g., City of New York, 2014).

Another challenge is that markets often respond to the presence of nature by raising housing prices and displacing residents, a phenomenon that has been described as "ecological gentrification" (e.g., Dooling, 2009). Heralded projects like the High Line in New York have now become cautionary tales, as displacement and unaffordability have deepened as a result of investment in what all agree is a wonderful park. We need to develop and apply new mechanisms for spreading fairly the col-

[1] See http://www.BiophilicCities.org
[2] See http://biophiliccities.org/biophilic-cities-journal-volume-1-issue-1

lective benefits of urban nature, and dampening their unintended consequences, for example through new mechanisms aimed at value capture and planning tools such as neighborhood benefit agreements.

The vision of Biophilic Cities can and must be harnessed toward the joint goals of nature-connection and poverty-reduction. We can and must confront the paradox that many of our most *natureful* cities in the northern Hemisphere sustain themselves from global resource flows that inflict considerable damage on far-away nature. Urban areas of the future must care about and protect distant nature as well as nature within their borders. Likely actions could include support (financial and otherwise) for biophilic city planning in other parts of the world, and trade agreements and purchasing decisions that reflect biophilic ethics (another dimension of what we might call a "just biophilia").

There are few visions for future cities as compelling and as appealing as that of Biophilic Cities. Concepts such as sustainability and resilience are important, but we must also envision and dream of (to paraphrase Thomas Berry, 1990) the kinds of places we want to live in, raise children in, and grow old in. Nature in all its forms will be the centerpiece of a new global urbanism that leads to healthier people and healthier societies.

Conflict of Interests

The author declares no conflict of interests.

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Article

A Carbon-Neutral California: Social Ecology and Prospects for 2050 GHG Reduction

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Abstract
How might a large jurisdiction approach carbon neutrality by 2050, and what initiatives might increase the chances of success? This article explores these questions using California as a case study. Current trends as well as multiple modeling studies show that existing policy directions for the state will not be sufficient. Additional initiatives appear needed to accelerate adoption of electric vehicles, reduce driving, reach 100 percent renewable electricity, convert existing buildings to zero-net-carbon status, change diet, and reduce consumption. The state's social ecology does not currently support such changes. Consequently, planners and other professionals need to consider strategic actions to change social ecology as well as climate policy. Potential steps to do this include raising the price of carbon; revising the state's tax system so as to increase public sector capacity; developing a stronger framework of incentives, mandates, and technical support between levels of government; and expanding educational and social marketing programs aimed at behavior change. A main implication of this analysis is that in many contexts worldwide sustainability planners should consider action on both policy and social ecology levels to maximize chances of success.

Keywords
2050; California; carbon neutral; carbon neutrality; climate change; climate planning; GHG mitigation; global warming

Issue
This article is part of the issue "Social Ecology of Sustainability", edited by Stephen Wheeler (University of California, Davis, USA), Christina Rosan (Temple University, USA) and Bjoern Hagen (Arizona State University, USA).

1. Introduction

Jurisdictions worldwide face the challenge of moving towards carbon neutrality, among other sustainability needs. How can planners and other professionals best help them do this? This article explores this question, using California's climate mitigation planning as a case study. The argument developed here is that new, more explicit attention to shaping social ecologies in constructive directions is needed in order to enable stronger state climate planning as well as the regional, local, corporate, and individual actions that together will be required to reach carbon neutrality.

For an American state with annual greenhouse gas (GHG) emissions averaging 35 metric tons CO_2e[1] per household to reach carbon neutrality by mid-century would seem next-to-impossible. (By carbon neutrality I mean a condition of no net global warming emissions when life cycle impacts of production and consumption are considered.)[2] Capitalist economics, consumptive lifestyles, elite-driven politics, and institutional inadequacies are daunting obstacles to ending GHG emissions. Large petroleum exploration and refining industries would need to be shut down, motor vehicle use and air travel dramatically reduced, diets changed, and many other lifestyle changes brought about.

[1] CO_2-equivalent; i.e. all global warming emissions measured in terms of CO_2.
[2] Preferably emitters would not be allowed to purchase emissions offsets which promise to reduce GHGs emitted elsewhere. Major problems exist in verifying that such offsets really occur, that they wouldn't have been done anyway, that they are permanent, and that they didn't lead in turn to other emissions. However, offsets that produced verifiable carbon reduction within California might be desirable if used only to offset unavoidable emissions such as those embodied within otherwise zero-net-energy vehicles and buildings.

However, the State of California has already made substantial progress toward reducing its GHG emissions through actions starting in 2005. The state is likely to meet its initial target of reducing 2020 emissions to 1990 levels, approximately a 20 percent reduction from the peak in 2007 (California Air Resources Board [CARB], 2017). In 2016 the legislature and governor embraced a new goal of reducing emissions 40 percent below 1990 by 2030. The eventual aim is 80 percent below 1990 levels by 2050. So despite the difficulty of moving toward carbon neutrality, California has embarked upon an ambitious program to achieve it. With the sixth largest economy in the world, California's success or failure in this effort will have lessons for many other jurisdictions worldwide.

This article takes a unique perspective on climate mitigation planning by asking not only what additional policy initiatives might be needed for carbon neutrality, but what fundamental steps to shape the state's social ecology might maximize the chances of success. Such an analysis has not been attempted before and is admittedly exploratory and broad-brush. Many events over a 30-year period are unpredictable. However, other important trends can be foreseen with reasonable certainty. Future demographic changes in the state are relatively predictable, institutions of state government have well-known strengths and weaknesses, and many political forces, values, and lifestyles are relatively stable. We have more than a decade of data on the state's current climate policies, and several modeling groups agree on the necessity of new steps to reduce emissions (e.g. Yeh et al., 2016). So support can be found for this large scale of analysis, which on both climate policy and social ecology levels can suggest near-term steps to increase the likelihood of long-term climate planning success.

2. Social Ecology

A starting point here is the assumption that a jurisdiction's policy options and its social ecology evolve hand-in-hand. "Social ecology" as used here refers to interwoven human systems co-evolving under the influence of environmental, social, cultural, economic, technological, institutional, political, racial, gender, and cognitive factors. Over the past two centuries many social scientists have theorized various versions of social evolution, including Spencer (1864/2002), Marx (1867), the Chicago School of urban sociology in the early 20th century (e.g. McKenzie, Park, and Burgess, 1925/1967), Bookchin (1982), Bateson (1972), and Norgaard (1994). This sort of systemic, holistic analysis is particularly called for when contemplating strategies for sustainable development, which must cross disciplines and time scales while meeting environmental, economic, and social goals (Wheeler, 2013).

Another historical foundation for social ecology has been public health. Bronfenbrenner (1977) was among the first to emphasize that the individual should be seen as embedded within interpersonal influences (the family, peers, local networks), organizational influences (schools, churches, workplaces), broader community structures, and large-scale policy frameworks. Stokols (1992) emphasized the dynamic relations between elements of these systems, writing that "Social ecological analyses incorporate a variety of concepts derived from systems theory (e.g., interdependence, homeostasis, negative feedback, deviation amplification) to understand the dynamic relations between people and their environments."

Other contemporary disciplines such as political ecology, environmental history, natural resource management, and resilience theory take a similarly social ecological view, but unlike public health do not place the individual at the core. Ostrom, for example, comments that "All humanly used resources are embedded in complex, social-ecological systems (SESs)…composed of multiple subsystems and internal variables within these subsystems at multiple levels analogous to organisms composed of organs, organs of tissues, tissues of cells, cells of proteins, etc." (2009, p. 419). Writers such as Fabinyi, Evans and Foale (2014) within the growing field of resilience science emphasize factors of social diversity, institutions, power, and values within social-ecological systems.

Despite this widespread interest in "social ecology," there is still no well-accepted contemporary framework with which to employ it. Hence in this article I've tried to flesh out the concept. As illustrated by Ostrom's quote, social ecological systems can be very complex. A main question is how to conceptualize them simply so that multiple audiences can understand important elements of these systems. One graphic depiction of how socio-ecological factors interrelate from a social science point of view is shown in Figure 1. This graphic is intended to illustrate the dynamic nature of what Norgaard and others have termed "co-evolution." It is necessarily a simplification; in the text of his book Norgaard conducts a far more wide-ranging exploration of topics related to international development than represented by Figure 1 (Norgaard, 1994).

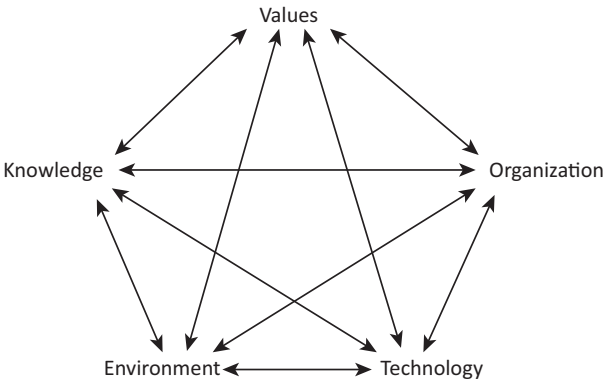

Figure 1. Norgaard's diagram of co-evolutionary factors.

To consider social ecological forces within a state such as California, I would like to cast a somewhat broader net as shown by Figure 2, adding several important dimensions while trying to keep the overall number of variables limited. In putting forth such a graphic as a basis for analysis, I don't want to imply that people haven't thought about how many of these dimensions, separately or in combination, relate to climate planning. Instead I want to suggest that a systematic approach to socio-ecological analysis can be useful, and that these are some of the most important dimensions to be considered.

We may define the components of Figure 2 in the following ways:

- *Ideology*: Any overarching belief system or worldview
- *Cognition*: An individual's mental processes of understanding
- *Behavior*: Individual or collective actions, including patterns of consumption and lifestyle
- *Politics*: Systems of power, in particular through elected office and political parties
- *Institutions*: Social structures including laws, organizations, and channels of communication
- *Economics*: Systems of production and exchange
- *Technology*: Techniques, skills, methods, and machines to achieve particular purposes
- *Environment*: The physical context, including ecological systems and human-created settings
- *Class*: Systems of inequality based on wealth
- *Race*: Systems of inequality based on physical traits and ancestry
- *Gender*: Characteristics related to masculinity and femininity
- *Values*: Individual or collective priorities whether based on belief or action

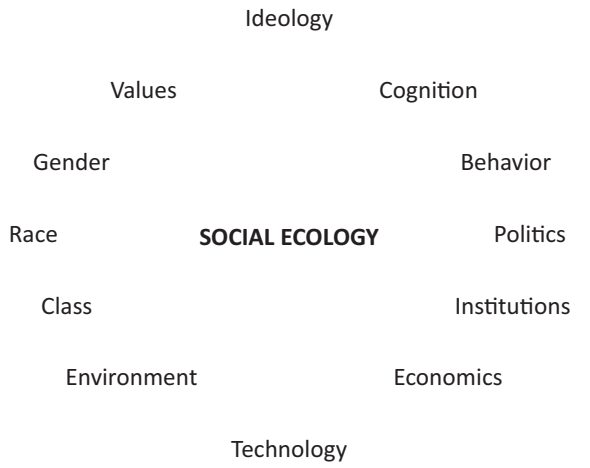

Figure 2. Socio-ecological factors affecting climate policy in California.

Within social ecologies, the relative influence and priority of these elements will be constantly changing and dependent on the particular times, scales, and places being analyzed. Race, for example, is a strong constituent of American social ecology that has been overlooked at times but has re-emerged time and again. Gender was considered relatively little as a dimension of analysis within most societies until social reform movements gave women the vote and advanced a variety of feminist histories and social critiques. Dimensions of social ecologies are often linked to one another. To take one example, the ideology (one dimension of Figure 2) of the Republican Party in the United States (an institution active in the political dimension of Figure 2) consists in part of denial of climate change (an environmental influence within Figure 2) through rhetoric derived from particular types of cognition and values (two further dimensions of Figure 2). To put it another way, the influences between elements of social ecology move in multiple directions, involve synergies, and are highly dynamic.

As California's social ecology evolves, its climate planning options will change as well. Conversely, successful policy innovations may change the state's social ecology so as to pave the way for additional breakthroughs. For example, a growing state identity as a global climate leader (a combination of "politics," "values," "ideology," and "cognition" in Figure 2) may inspire politicians to take additional steps. For climate mitigation, political support is perhaps the most relevant product of social ecology changes. If sufficient political support exists, far-reaching GHG reduction policies can be adopted. Conversely, if it doesn't exist, movement toward carbon neutrality is unlikely. But other variables are of course important as well, and many influence politics.

3. California's Climate Mitigation Planning

California has a long history of actions linked to reducing GHG emissions, enabled by a relatively favorable social ecology. The state adopted the first version of its best-in-nation building energy efficiency standards in 1977, and began studying global warming risks in the late 1980s. During the 1990s cities such as San Francisco, San Jose, and Santa Monica initiated sustainable city programs with a focus on energy conservation. Senate Bill (SB) 1771 (2000) established the California Climate Action Registry, a state-affiliated non-profit agency which pioneered emissions reporting protocols and allowed institutions to voluntarily record their emissions. Assembly Bill (AB) 1493 (2002) mandated that vehicles sold in the state have reduced CO_2 emissions, in an effort to get around the federal government's unwillingness at that time to raise fuel efficiency standards for cars and light trucks. Sixteen other states then adopted the California standard. This measure required a waiver from the U.S. Environmental Protection Agency; after the George W. Bush Administration denied this waiver, California sued

the federal government and eventually won the right to set such standards.

Although many of these early actions were significant in their own right, California's climate action planning entered a new, more comprehensive stage in the mid-2000s. In 2005 Governor Arnold Schwarzenegger signed Executive Order S-3-05 setting emissions reductions targets for several future dates, including 80 percent reductions below 1990 levels by 2050. The following year the legislature passed AB 32[3] directing the powerful CARB to lead planning efforts toward the goal of lowering GHGs to 1990 levels by 2020. CARB collaborated with other state agencies to form an interagency working group known as the Climate Action Team, and by 2008 had approved a list of 40 early action items. Of these, state officials expected by far the largest GHG reductions from GHG emissions standards for new vehicles, increased energy efficiency standards for new appliances and buildings, a renewable energy portfolio standard requiring utilities to produce 33 percent of electricity from renewable sources by 2020, reformulated motor vehicle fuels, and programs to reduce emissions of refrigerants and other non-CO2 GHGs.

To further reduce GHG emissions from motor vehicles, in 2008 the legislature passed and Schwarzenegger signed SB 375[4] requiring the Air Board to set vehicle miles traveled (VMT) reduction targets in each of the state's metropolitan regions. Metropolitan planning organizations (MPOs) were required to produce Sustainable Community Strategies (SCSs) with spatial development and land use policies that would achieve these reductions. By the early 2010s most had done so, though in practice these SCSs were simply rebranded Regional Transportation Plans with modest land development targets integrated. Local compliance is voluntary since the MPOs have no statutory authority over land use. One evaluation found that "very little progress has been made toward actually changing the regional transportation system and land use patterns" with the result that "total CO_2 emissions increase over time at historical rates" (Niemeier, Grattet, & Beamish, 2015, p. 1600). Another analysis concluded that "given MPOs' limited resources and authority, the state and federal government must take on larger roles if outcomes are to change substantially" (Barbour, 2016, p. 24).

A major strengthening of California's climate planning framework took place in 2016 as the AB 32 end-date of 2020 approached. The strongly Democratic legislature passed a new bill, SB 32, with a goal of 40 percent reductions below 1990 by 2030, even though the state's population was expected to increase about 10 percent between 2020 and 2030 and its economy was expected to grow by about 30 percent (Megerian & Dillion, 2016). CARB set to work in 2017 to develop a scoping plan of programs to reach the new target, but with the intent of relying only on existing policy directions.

To provide a broad economic mechanism for emissions reductions, leaders decided early on to adopt a cap-and-trade program in which a gradually lowering cap would be established on overall emissions and large emitters made to buy or trade for permits. Emitters would need to reduce cumulative 2013–2020 emissions at least 10 percent compared to business-as-usual projections. Permit auctions would establish a funding stream useful for other GHG mitigation purposes. Applied to 360 large institutions responsible for 85 percent of the state's emissions, this system went into effect in 2013, and annual auction proceeds rose to $1.8 billion in 2015–16. However, corporate interest declined due to a business lawsuit and uncertainties about whether the program would be continued beyond 2020. Proceeds fell and the allowance price hovered around the floor of $12/ton, a level unlikely to encourage large emissions reductions. Environmental justice advocates also criticized the program for allowing continued pollution of minority communities. However, in 2017 with strong support from Governor Jerry Brown the state legislature extended the cap-and-trade system through 2030 with a two-thirds vote.

4. California's Social Ecology

California has been able to take leadership on climate planning in large part because of the nature of its social ecology. Historians such as Starr (2004, 2005) and writers such as Didion (1968, 2003) and Davis (1990, 1998) have provided extensive background on the state's history and culture. Here I will focus on the main factors shaping the state's ability to initiate climate change planning, referring back to particular elements within Figure 2.

An initial set of socio-ecology factors relates to the state's geographic location and natural environment ("environment" variables in Figure 2). On the far western edge of the continent, California is spatially distant from many eastern and midwestern centers of population, separated from them by mountain ranges and deserts. From the beginning of European settlement it has been a place apart, a destination for those with independent spirits ranging from gold rush pioneers to aspiring filmmakers, dot-com entrepreneurs, and New Age seekers (thus developing a population with certain dominant values, ideologies, and forms of cognition and behavior according to the categories of Figure 2). The resulting diverse, dynamic political culture is more characterized by individualism and moralism than the traditionalism of many mid-Western and southern U.S. states (Elazar, 1966/1984).

California's landscapes are also well-known for their unique beauty and fragility, and have helped give the state its identity and environmental sensitivities (more influence of "environment" variables). Since the nineteenth century Californians have rallied to protect old-

[3] Global Warming Solutions Act of 2006.
[4] Sustainable Communities & Climate Protection Act of 2008.

growth redwoods from logging. In the middle of the twentieth century they voted to protect much of the state's stunning coast from development and oil drilling, and the legislature enacted environmental review processes for development and the nation's toughest air quality regulation (in response to Southern California's air pollution problems caused in part by geography). The state's mild, Mediterranean climate is quite different from that of most other U.S. regions, contributing to the state's identity as a balmy haven from cold and snows, and its ample sunshine and warm winters greatly facilitate prospects for carbon neutral buildings in the future. Since much of the state is arid or semi-arid, residents are also highly conscious of the scarcity of water and risk of drought.

Social factors further distinguish California from the rest of the U.S. It is the most urban state in the country (Cox, 2016), and in recent decades has become among the most diverse. Diversity can play out many different ways in politics. Much depends on which demographic groups are involved and what degree of mixing has occurred and for how long. However, a case can be made that within relatively well-mixed urban regions where different types of people live together on a daily basis, diversity leads to both tolerance and progressive politics. Hero (1998, p. 9) distinguishes between homogenous states, bifurcated states, and heterogenous states; the latter often verge on "an ethnic or racial polyglot" society without the extreme racial divisions of bifurcated states. He places California within this category. Intolerance and racism have often been present, certainly, and led to divisive politics through much of the twentieth century as the heavily white, Republican state experienced waves of immigration. However, many parts of the state, especially urban areas, have now been highly diverse for generations and have become more tolerant (e.g. Talbot, 2012). The state is also known globally for alternative lifestyles, and "live and let live" values which occasionally merge into libertarianism. Although a full discussion of this topic would require more space than we have here, a case can be made that Figure 2's dimensions of "race," "gender," "ideology," "behavior," and "values" in California have all provided support for tolerance and progressive politics in recent years.

Economically, California, like the rest of the United States is firmly wedded to laissez-faire capitalism (a combination of "economics," "politics," and "ideology" in Figure 2), and from the gold rush to the dot-com boom has exemplified the wealth-obsessed, speculative tendencies of that system (influencing "values," "cognition," and "behavior" within this social ecology model). Railroad, oil, real estate, agribusiness, and construction industries have produced deeply conservative elites ("class" and "politics" within Figure 2) who often oppose public sector efforts to plan and regulate for environmental protection (Davis, 1990; Starr, 2005; Walker, 2004). Not surprisingly given this background, the state's Chamber of Commerce has litigated the cap-and-trade program, and petrochemical interests including Koch Industries and Valero Energy, the nation's largest independent oil refiner, sponsored a 2010 Proposition 23 to suspend the entire AB 32 framework. However, these players are counterbalanced by film, finance, electronics, internet, media, and clean tech economic elites, which at times have spent freely to defend and expand the state's climate leadership. Billionaire Tom Steyer for example contributed $5 million to help defeat Proposition 23, which lost by a wide margin, 61–38 percent (Roosevelt, 2010). At the state level pro-GHG-reduction economic forces have helped support GHG reduction efforts so far; at the local and regional levels, especially concerning land development and motor vehicle infrastructure, business-as-usual interests more often hold sway.

In terms of "politics" in Figure 2, the state's history was conservative or middle-of-the-road for much of the twentieth century, with a long series of business-oriented governorships (Starr, 2005). Political reform movements had only limited success or, as in the case of the early-twentieth-century good government movement, resulted in reforms like the initiative and referendum process that have at times backfired, being abused by special interests. Late twentieth-century and early twenty-first century politics has become more progressive, aided by many strong organizations of civil society, but is far from radical. Unions, including ship workers, Pullman porters, farm workers, teachers, and prison guards, have at times played a significant role but have not had the same breadth and strength historically as in the Midwestern U.S.

Institutionally California is also similar to other parts of the U.S., but with some important differences. As elsewhere, local government exerts primary control over land use and economic development, and at least in terms of suburban expansion is easily captured by pro-development interests (e.g. Davis, 1990; Pincetl, 2003). Local capacity to undertake new programs is weak, in large part due to Proposition 13 in 1978, which reduced local property taxes by two-thirds and made local governments more dependent on development fees and state funding sources. Regional government is also relatively weak, as is the case in the U.S. generally, being mainly focused on distributing funds for transportation and governed by boards of local elected officials often dominated by conservative suburban and exurban jurisdictions (e.g. Bollens, 1997; Fulton & Shigley, 2012). State government in contrast has strength in areas such as environmental protection and transportation, with large, experienced regulatory agencies.

California has seen strong organizations of civil society from relatively early times ("institutions" in Figure 2, linked in turn to "politics" and "values"). The Sierra Club got its start in the Bay Area in 1892, and countless other environmental groups are active within the state. In the 1960s and 70s the human potential movement was particularly strong in California, with leaders such as psychologist Abraham Maslow and legislator John Vascon-

cellos. This movement touches upon social ecological dimensions of "cognition," "behavior," and "values," and is linked in turn to liberal politics. From early times social institutions ranging from the Bohemian Club to the Esalen Institute have promoted the spread of avant-guard ideas among a variety of networks. Although many of these networks have been liberal or progressive, the state has also been on the cutting edge of conservative ideology as well. The John Birch society was strong within it in the early twentieth century; Richard Nixon and Ronald Reagan got their starts in the state; and the modern anti-tax movement arose in southern California.

Technology (a major force within social ecology) has played a leading role in California's social evolution from the arrival of hydraulic mining and the railroad in the nineteenth century to the private motor vehicle in the twentieth and the internet in the twenty-first. Although aerospace, electronics, and semiconductor industries have transformed the state's economy in recent generations, perhaps the largest technological influence upon the state's social evolution has been communications media. Radio, television, movies, and the internet were to a large extent pioneered in California, and have helped shape both California and global society. A century before the rise of electronic media, William Randolph Hearst's "yellow journalism" was a precursor both of later tabloid journalism and of Fox News and Breitbart. The state's film, television, and advertising industries have also helped shape consumptive lifestyles worldwide.

Overall, California's values have dovetailed with other dimensions of its social ecology in recent years to support climate action planning. To be sure many of the state's social values are inconsistent and conflictual. Individualism and environmentalism, for example, conflict when environmental regulations impinge on individual property owners' desire to exploit natural resources. The state also has strong spatial political divisions that sometimes complicate decision-making. Difficult questions of behavior change and economic tradeoffs (for example more costly consumer goods with a high price on carbon) have yet to be tackled. But climate policy and the state's social ecology have worked relatively well together to date.

5. The Need to Go Beyond Current Policy Directions

With this background, we can turn to the future policy challenges California faces in reaching its 2030 and 2050 goals. In 2014 a team from the University of California, Davis, the University of California, Berkeley, Stanford, and other institutions reviewed nine models of deep emissions reductions for the state, and warned that "without new policies, emissions from non-energy sectors and from high-global-warming-potential gases may *alone* exceed California's 2050 GHG goal" (Morrison et al., 2015, p. 546; emphasis original). Yang, Yeh, Zakerinia, Ramea and McCollum (2015) found the 2050 goal potentially achievable, but only by assuming rapid adoption of questionable technologies including biofuels and carbon capture and sequestration (large-scale use of biofuels might interfere with food production; carbon capture and sequestration has not been shown to be technically or financially feasible). Greenblatt (2015) found that none of three modeled scenarios met the 2050 goal, and that only a very strong policy scenario going well beyond existing initiatives met the 2030 goal. Yeh et al. (2016) reviewed six leading models, finding that in order for the state's 2030 goal to be achieved new initiatives are needed related to energy efficiency, renewable electricity, use of biomass for liquid fuels, aggressive adoption of zero emissions vehicles, reduction in vehicle miles traveled (VMT), and reduction of non-energy-related GHGs. Although such steps would be difficult politically, the models showed that these strategies could bring potential net economic benefit to the state. Finally, Jones, Greenblatt, Wheeler and Kammen (2017) and Jones, Wheeler and Kammen (2017) argue that the state's existing sector-based GHG accounting leaves out emissions due to residents' consumption of goods and services produced outside the state.

These studies provide evidence that California's existing policy directions are inadequate to meet long-term goals. Several non-academic critiques make the same point, including Porter (2017), Saha and Muro (2016), and PricewaterhouseCoopers (2015). The latter study argues that a global decarbonization rate (decline in the carbon intensity of economies) of 6.3 percent annually is necessary to avoid dangerous climate change, and estimates California's decarbonization rate at only around 2 percent.

The targets set by state government, in other words, go far beyond what current policies can achieve. However, these policies appear to be at the limit of what the state's social ecology will support, as shown by the mid-2010s legislative struggles to establish 2030 policy and re-authorize the cap-and-trade system. The climate planning literature offers little guidance towards addressing this disconnect, which affects not just California but most societies worldwide. Authors such as Socolow and Pacala (2005), Brown (2015), and Hawken (2017) present lists of ambitious strategies that could dramatically reduce GHG emissions, but fail to address the underlying need for social ecological changes that could support such policies. Brinkley (2014) surveys policies in countries with proven track records of decreasing GHG emissions. However, none of these countries is anywhere near carbon neutrality. Others such as Bulkeley (2013), Boswell, Greve and Seale (2012), and the International Council for Local Environmental Initiatives (ICLEI, 2017) discuss more modest and achievable policies at the local government level to reach short-term goals. Yet these are unlikely to produce the necessary level of long-term change. In light of the fundamentally new challenges produced by climate change planning, Hill (2016) and Wheeler (2010) argue that new planning approaches are necessary.

6. A Potential Policy Path to Carbon Neutrality

To address this conundrum, I will first consider what expanded climate mitigation policies might be sufficient to make California carbon-neutral by mid-century, starting with the highest-emitting economic sectors. These are summarized in Table 1 below. Then we will turn to social ecology changes that might make such policies more feasible.

Transportation is the largest emissions contributor within California's existing GHG inventory framework, responsible for 37 percent of total emissions (CARB, 2017). Although past state policies requiring reformulated fuels and low-emission vehicles plus the post-2008 recession managed to lower transportation emissions 12 percent between 2000 and 2011, these then stabilized and edged back up 5 percent by 2017. So new steps are needed. Two strategies embraced by CARB in its draft 2030 scoping plan and endorsed by many researchers (e.g. Wei et al., 2013) are to move to an all-electric fleet with electricity generated from renewable sources and to adopt policies reducing driving in general. Even if both were successful, emissions embodied in vehicle components and production would remain (about 15 percent of the total according to Delucchi, 2005, p. 99). Carbon sequestration within forests and soils (discussed later) could help offset those. CARB's draft 2030 scoping plan has only modest ambitions for reducing transportation emissions, aiming for only a 15 percent reduction in light-duty VMT by 2050 and only 4.3 million electric vehicles by 2030 out of approximately 15 million. Much stronger policy seems needed. Experts have proposed steps such as a strong feebate system (which would levy steep fees on high GHG-emitting vehicles but provide rebates for those with few emissions), pay-as-you-drive insurance, buy-back programs for high-emitting older vehicles, and strong state mandates for better local land use planning that could reduce driving (e.g. Jones, Wheeler, & Kammen, 2017; Sperling & Eggert, 2014). Carbon fees applied to air tickets and rapid

Table 1. Carbon neutrality policy strategies and obstacles. Emission percentages retrieved from CARB, 2017.

Challenge	Potential Strategies	Potential Obstacles
Transportation (37% of sector-based emissions)	Vehicle electrification brought about through feebates, other incentives, strong carbon pricing, and/or regulation. Better alternative modes of transport; more compact, balanced land use; lifestyle change.	Opposition from motor vehicle, petrochemical, airline, and development interests; local government opposition to land use requirements; difficulty of raising funds for improved transit; difficulty of behavior change.
Industrial emissions (21%)	Regulation (e.g. building and process efficiency); strong carbon pricing through cap-and-trade or carbon tax.	Industrial and political opposition; social equity concerns over economic burden and allowing continued pollution of disadvantaged communities.
Electricity-related emissions (19%)	Increase renewable portfolio standards to 100%; community choice energy; incentives for renewables and battery storage within buildings.	Reluctance of investor-owned utilities to embrace decentralized renewable energy systems; developer opposition to ZNE home requirement.
Non-electric building emissions (11%)	Require all-electric buildings and ZNE construction; require and subsidize upgrades upon sale of existing buildings.	Building industry opposition; legal and code barriers; expense and political difficulty of retrofitting existing buildings.
Agriculture (8%)	Increased regulation of the dairy industry and agriculture; strong carbon pricing; lifestyle change around diet.	Political opposition from farmers; difficulty of changing behavior (diets).
High Global Warming Potential Gases (4%)	Phase-out following current regulatory trends.	
Landfills and recycling (2%)	Stronger programs to capture methane and reduce waste.	Funding; behavior change.
Consumption (out-of-state products not counted currently)	Behavior change campaigns; aggressive carbon pricing extended to consumer products; regulation to reduce energy use/carbon content of products.	Economic, political, and cultural opposition; difficulty of lifestyle change.
Carbon sequestration	Pursue maximum possible sequestration within farmland, grassland, and forests.	Farmer and landowner opposition to mandates; cost; difficulties of managing and verifying long-term sequestration.

development of biofuels for aircraft could help reduce emissions from air travel.

Industry represents California's second largest source of emissions, at 21 percent. While the carbon intensity of the state's economy (tons of CO_2e/million $ GDP) fell about 28 percent between 2000 and 2015, total industrial emissions declined only a few percent and plateaued after 2009 (CARB, 2017). Oil, gas, and hydrogen industries are by far the largest industrial sources, providing further argument for making both vehicles and buildings all-electric. Emissions for manufacturing fell in the 2000–2015 period but those for food services, rail transportation, aviation, petroleum refining, landfills, livestock operations, and commercial facilities rose significantly (CARB, 2017). Thus far the cap-and-trade system appears to have had only limited influence. The needed policy direction appears to be a much higher price on carbon, which could occur either under a strengthened cap-and-trade system or through a carbon tax. High minimum prices on carbon have been proposed by climate activists globally, and were in fact envisioned by a 2017 bill introduced into the state Senate, SB 775, which would have put a minimum price on carbon of $20/ton, rising by $5 plus inflation each year while disallowing offsets (Roberts, 2017). However, facing political opposition and desiring a two-thirds vote in order to avoid legal challenge under the state constitutional requirement for a 2/3 vote on taxes, Governor Brown and legislative leaders opted for the milder step of continuing the current cap-and-trade system with modest improvements.

Electricity generation is the third largest sector of emissions, comprising 19 percent, and represents the biggest success story in California's climate planning to date. Emissions declined 22 percent between 2000 and 2015 mainly as a result of increases in solar and wind energy due to renewable energy portfolio standards (CARB, 2017; California Public Utilities Commission, 2016). Renewably generated electricity reached 35 percent of the total in 2015, and the 2030 mandate for 50 percent should be easily made. The necessary goal would seem to be 100 percent renewable electricity, with appropriate storage systems to manage supply and demand. Bills requiring this have been introduced in the legislature but have failed to pass. The rapid spread of Community Choice Energy (CCE) programs across the state, through which cities and counties develop contracts with electricity generators directly on behalf of their residents rather than going through utilities, is another potential means to approach 100 percent renewable electricity, since usually these contracts emphasize renewable energy.

Building energy use—spread across several categories of the state's accounting system—is also a large source of emissions. Non-electricity-related emissions from commercial and residential buildings accounted for 11 percent of the state's emissions in 2015. With the state's building energy code being strengthened every three years, new buildings are approaching zero net energy (ZNE). However, two large barriers to carbon neutrality of buildings remain. First, most ZNE buildings use natural gas for heating, cooking, and/or hot water, with sufficient solar to offset the energy content of the gas with renewable power. Yet on a carbon basis the solar panels will progressively offset fewer emissions over time as the electric grid becomes lower carbon. Plus any use of natural gas produces direct emissions that are not in the spirit of carbon neutrality. So the real goal should be zero net carbon (ZNC), with 100% renewable energy and no gas. The second major challenge is how to retrofit the large stock of existing buildings. Past building retrofit programs have underperformed; a $98 million California Comprehensive Residential Retrofit program between 2009 and 2014 reached only 8,100 single-family homes and 5,700 multifamily units (out of 12 million housing units in the state) (Metoyer, Gaffney, Hoover, & Yang, 2014). Some jurisdictions have adopted Property Assessed Clean Energy (PACE) programs through which homeowners can pay for energy upgrades through property tax surcharges over time rather than upfront payments. However, residential PACE programs funded only 148,000 energy upgrades nationally in the 2009–2016 period (PACENation 2017), so in their current form these are not likely to be a solution either. Since voluntary retrofit programs seem not to be working, one potential policy direction would be to require and subsidize building energy efficiency upgrades at time of sale, or within a mandatory time frame. This would require major state investment and political support.

Agriculture generates 8 percent of California's emissions, mainly from methane and nitrous oxide. Dairies account for 60 percent of agricultural GHGs, an amount that increased by 23 percent between 2000 and 2015 as production rose (ARB, 2017). Strong regulation to control emissions from manure, feed supplements for ruminants, and other farm programs can help somewhat (Hristov et al., 2013). However, the state will probably need to mandate or incentivize dietary changes, perhaps through strong carbon pricing of dairy products and meat (Wirsenius, Hedenus, & Mohlin, 2011). Major resistance can be expected.

High Global Warming Potential gases (mainly HFCs used in air conditioners) account for 4.3 percent of California's emissions. These emissions declined about 44 percent between 2000 and 2015, and existing policy directions seem sufficient to meet long-term goals. Landfill (and to a much lesser extent recycling) operations account for an additional 2 percent of emissions, and stronger programs to cap landfills and retrieve methane may be needed. Finally, the state will need to reduce its residents' consumption of high-carbon goods and services produced elsewhere (including air travel). Very strong new educational and social marketing campaigns will probably be needed, along with high carbon pricing.

A wild card within California's carbon accounting is the potential for carbon sequestration. Programs to store carbon within soils, trees, or geology can potentially off-

set some of the state's emissions. Accelerated research into these strategies seems called for. However, sequestration is unlikely to reduce the need for carbon mitigation policies such as those above; rather, it may help offset unavoidable emissions, for example, those embodied in motor vehicles and buildings.

7. Future Prospects for the State's Social Ecology

What can trends in various dimensions of California's social ecology tell us about the prospects for such next-generation climate policies? In terms of the "politics" and "institutions" dimensions of Figure 2's model, prospects are mixed. Climate leaders have been able to keep the legislative and regulatory process moving forward to date, but with great effort and multiple setbacks. Fossil fuel industries successfully derailed a 2016 attempt by Governor Brown to secure a legislative mandate for a 50 percent reduction in motor vehicle emissions by 2030. They also forced a relatively weak compromise in terms of reauthorizing the cap-and-trade framework in 2017. Democratic leaders in the state Senate had developed the much stronger alternative mentioned above, SB 775. But hamstrung by the perceived need for a 2/3 vote (an institutional constraint put in place decades previously by conservative political forces), Brown and others decided to negotiate a much weaker bill and gave up many concessions in exchange for a few Republican votes.

In terms of the "institutions" dimension, other challenges face the state besides the 2/3 vote requirement. In California, as in most other parts of the U.S., electricity is generated and distributed by investor-owned utilities, which have primary responsibility to shareholders rather than the public. Regulation by the state's Public Utilities Commission has been weak, and utilities have built unnecessary fossil fuel-fired power plants and been slow to support decentralized renewable energy (Penn, 2017). So changes to energy-providing institutions are probably needed, either through stronger regulation or public sector take-over. Another set of institutions, the state's metropolitan planning organizations (MPOs), manage regional transportation systems and were directed by SB 375 to reduce motor vehicle-related emissions. However, these MPOs are frequently dominated by more conservative suburban and exurban jurisdictions and have been unable to implement strong policies for compact, mixed-use urban development that might reduce motor vehicle use. The board of the Sacramento Area Council of Governments, for example, consists of 26 representatives of suburban cities and counties and 5 representatives of the relatively urban jurisdictions of Sacramento, Davis, and West Sacramento. Although board votes are weighted by population, these progressive cities represent only about 555,000 out of 2.7 million regional residents, and board politics is dominated by the suburban jurisdictions. Like similar entities everywhere else in the U.S. (except Oregon), California's regional agencies also lack statutory authority over land use, which could help them override local zoning codes that keep out affordable housing. Partly as a result, California's SB 375 mandate has not been effective. A stronger land use planning framework seems needed. Meanwhile, the state's anti-tax movement of the 1970s and 1980s has constrained government revenues at state, regional, and local scales, making new programs difficult and encouraging local governments to zone for suburban sprawl so as to maximize local tax revenues. This political movement has been based on particular "values," "ideology," and "cognition" within Figure 2, and arguably is rooted in "race" and "class" dimensions of social ecology through which voters come to believe that public sector revenues will go to support social groups different than themselves.

Economic influences (yet another dimension of social ecology) both hinder and help climate planning. As previously mentioned, petrochemical interests, the Chamber of Commerce, and other interests associated with corporate capitalism continue to push back strongly. The Chamber frequently adds climate-related bills to its annual list of "job killer" legislation, and litigated the cap-and-trade system for much of the 2010s. However, California's economy has done relatively well despite the Chamber's predictions of doom, even leading the nation in GDP growth in 2015 (Hiltzik, 2016). Silicon Valley and Hollywood are two economic dynamos many of whose leaders support climate planning. The state's rapidly growing clean tech industries may tilt the balance toward support for climate action in the future. In 2015 California generated more than 25 percent of all energy efficiency patents in the US and received 68 percent of total U.S. clean tech investment (Next 10, 2016); in 2016 clean energy alone accounted for 508,000 jobs in the state (Roosevelt, 2016). As such green economic forces expand, their ability to influence state climate policy is likely to increase. Whether this economic force can be mobilized politically remains to be seen.

In terms of the "technology" dimension of social ecology, California is well-known as a global center of innovation and technological change, which can in turn influence GHG emissions (by developing low-carbon technologies) and political and institutional dimensions of social ecology (by allowing policy innovation). For example, home storage batteries such as Tesla's PowerWall, introduced in 2015, could greatly reduce the state's need for imported electricity if they allow homes to store their afternoon surplus of photovoltaic-generated electricity for evening use. California companies such as Tesla, Google, and Apple are also pioneering autonomous and electric vehicles that have the potential to reduce GHGs from vehicle ownership and driving. However, successful adoption of such technologies is highly dependent on institutions adopting effective incentives and regulation. Meanwhile, an overemphasis on technology as the main source of solutions to climate change can have negative results, such as distracting attention from the need for institutional, political, and lifestyle reforms.

Social movements (combining social ecology dimensions such as "values," "ideology," and "politics" within Figure 2) within California could also support reducing emissions, and are likely to further build the state's identity as a climate leader and model of progressive politics. Elected officials have positioned California as a national and global leader in opposition to conservative national politics, and civil society organizations such as Move On, Equality California, and the nation's largest chapter of the American Civil Liberties Union have helped organize this resistance. In other ways movements for environmental justice, bicycle activism, LGBT empowerment, and farmworker safety hold positive implications for climate change planning, for example by advocating reduced pollution and alternative lifestyles. Environmental justice movements have played a major role to date in supporting climate planning but insist that equity considerations be included (London et al., 2013; Mendez, 2015). However, growing inequality of wealth and power ("class" in Figure 2) works against climate progress within California as within the nation as a whole. Members of disempowered communities often withdraw from civic engagement and hold resentments that can be harnessed by populist right-wing politicians. Meanwhile, stakeholders on the winning end of inequality often see little reason to seek common solutions to problems, instead withdrawing into their entitled enclaves. Along this line Holmberg (2017) argues that high social inequality works against climate solutions by promoting short-term personal and corporate profit maximization rather than longer-term collective values.

A major challenge for the state has to do with the "behavior" dimension of social ecology. California for many decades has exemplified high-consumption, motor-vehicle-oriented American lifestyles. These preferences combine with a hands-off approach to lifestyle questions will make carbon neutrality difficult. However, there are signs that lifestyles are changing for at least some residents. Relative to the generation before, the state's Millennials (like those in many other parts of the world) live in more urban locations, own motor vehicles at lower rates, and more frequently walk, bike, carpool, and use on-demand services such as Uber and Lyft (Circella et al., 2016, 2017). Although Millennials' vehicle ownership is expected to rise as they age and start families, their current behavior may lead to lower long-term vehicle use and willingness to live in smaller, more urban dwellings. Economic factors such as the loss of manufacturing jobs, the rise of contingent employment, and high real estate prices may also encourage behavioral evolution. Such changes may at least in part counterbalance traditionally consumptive behavior.

The most hopeful social ecology trend for California's climate planning has to do with racial diversity ("race" in Figure 2). Future demographic trends appear strongly positive for progressive politics, as shown in Tables 2 and 3.

Over the past 50 years the state's steady progress toward greater diversity has correlated remarkably well with increasingly progressive politics. Democrats have controlled both houses of the state's legislature since 1992 with the exception of the Assembly during 1994–1996. The state does not feature the strongly partisan gerrymandering of legislative districts found in many other U.S. states, and indeed approved ballot initiatives in 2008 and 2010 to set legislative and congressional districts through a nonpartisan Citizens Redistricting Commission, a significant reform to the "institutions" dimension of the state's social ecology. Despite the climate denial stance of the national Republican Party, the state's most recent Republican governor, Arnold Schwarzenegger, earned a reputation as a strong climate action champion. Greenhouse gas reductions are closely correlated with local air quality improvements, a top concern of many state constituencies including the state's medical establishment and Latino organizations.

8. Conclusion: Evolving California's Social Ecology

We have seen that within California's social ecology there are factors supporting strong climate action but also sig-

Table 2. Changing California Demographics (%). Source: California Department of Finance. California's population has become far more diverse since 1970, with the trend projected to continue through at least 2030.

	1970	1980	1990	2000	2010	2020 (p)	2030 (p)
White	77	67	57	47	40	38	36
Black	7	7	7	7	6	6	6
Hispanic	12	19	26	32	38	40	42
Asian/Pacific Islander	3	5	9	12	13	13	13
Native American	0	1	1	1	0	0	0

Table 3. California Presidential Voting (%). Source: LA Times. At the same time the state's electorate has become far more Democratic as shown by its voting in Presidential election.

	1980	1984	1988	1992	1996	2000	2004	2008	2012	2016
Democrat	36	41	48	46	51	54	54	61	60	62
Republican	53	58	51	33	38	42	44	37	37	32

nificant countervailing forces. Particularly promising are the state's progress toward greater social diversity and progressive politics ("race" and "politics" dimensions of Figure 2), its institutional strength around environmental policy and regulation ("institutions"), its recent improvements to democratic institutions such as redistricting (also "institutions"), its culture of innovation ("technology," "cognition," and "economics"), its progressive identity ("ideology" and "cognition"), and its growing environmentally related economic sectors ("economics" and "politics"). Particularly challenging are institutional constraints on public sector capacity, the continued political power of fossil fuel industries and other conservative economic forces, growing social inequality, and highly consumptive lifestyles (forces within the "institutions," "politics," "class," "ideology," and "behavior" dimensions of social ecology).

A number of near-term strategic moves might strengthen the state's social ecology in terms of climate and sustainability planning. To start with, a high and increasing price on carbon (an "economic" initiative within Figure 2), in addition to directly discouraging fossil fuel use, would have ripple effects throughout California's social ecology, encouraging technology and behavior change. Strengthening the state's cap-and-trade system or adopting a direct carbon tax will likely be needed to produce such pricing.

Overhauling the state's tax system (an important "institution" within Figure 2) would be another positive influence on social ecology, increasing public sector capacity to deal with challenges such as achieving carbon neutrality. Specific steps might include eliminating Proposition 13 constraints on property taxes and the two-thirds requirements for tax increases. Such changes could be phased in if necessary. Regional tax base sharing could also discourage high-GHG types of suburban and exurban development while improving social equity (Chapple, 2016). A severance tax on oil and gas production could produce revenue for GHG reduction programs and help change behavior (unlike other oil producing states, California currently has no such tax). Since these changes won't be easy, strong leadership ("politics" in Figure 2) would be needed to make the case to the public for such changes.

A stronger framework of climate planning incentives, mandates, and technical support between levels of government is another potential "institutional" step. One of the lessons from Oregon, the nation's leader in terms of urban growth management, is that such a framework of governance can produce more successful results than if any single level of government acted alone. The State of Oregon established 19 Statewide Planning Goals in 1973, and since that time has worked with lower levels of government to facilitate local implementation (Wheeler, 2000). Maryland has employed similar strategies under its smart growth framework beginning in 1998 (Hanlon, Howland, & McGuire, 2010; Shen & Zhang, 2007). Revisions to California's SB 375 framework could follow this model by setting stronger GHG reduction goals related to transportation, housing, and consumption, providing more extensive state support and funding to local governments, and conditioning local receipt of state infrastructure funds on compliance with state GHG-reduction goals. Making regional planning agencies directly elected and giving them power to approve large development projects and review local zoning codes could also help. Meanwhile, state funding for affordable housing and mandates that local governments zone for it could reduce GHGs and social inequities by ensuring sufficient affordable housing near workplaces. The state legislature took initial steps in this direction in 2017.

Evolving "values," "cognition," and "behavior" within Figure 2 is perhaps the largest challenge of all. Arguably such change has already occurred within American society with regard to issues such as smoking, civil rights, and gay rights. Those changes typically required goal-setting by high levels of government as well as massive intervention through legal, educational, and public health systems. In addition to the other strategies mentioned earlier, a great deal of research now exists on effective communication methods around climate change (a "technology" of spreading information so as to change "behavior"), particularly to help overcome individuals' defenses against depressing science or lifestyle change. Moser (2016) provides an overview of climate change communication, and Stern et al. (2016) review the potential of behavior change for households and organizations. The State of California will likely need to lead new educational efforts on this front. Previous campaigns on smoking, drunk driving, healthy eating, and the like may provide models.

In order to bring such social ecology changes about, planners and other professionals will need to articulate the need for them and help the public understand how such fundamental reforms are crucial to making progress on climate planning, social equity planning, and other important sustainability needs (to use the language of the model, planners can use communication "technology" to help change "cognition," "values," "ideology," "politics," and "institutions"). Public debates often focus on a few, limited policies. However, emphasizing the big picture of how the state can move towards carbon neutrality in 2050 (a particular communications approach) may help the public and decision-makers see how such change can come about. To put it another way, planners need to combine systems thinking with advocacy planning.

Although this discussion has focused on California, jurisdictions worldwide face similar needs to shape their social ecologies so as to support climate action or sustainability generally. Existing social ecologies rarely support the level of action required. The needs in any given place will depend on context, but the process will be similar. Planners can identify both policies that can directly address the problem in the long term, and underlying social ecology changes that can increase the chances of successful action. Bringing about change on both levels will

not be easy, but in a world in which political polarization and dysfunction are increasingly common, such strategic thinking related to social ecology is crucial.

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Conflict of Interests

The author declares no conflict of interests.

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Article

‘Living Well’ as a Path to Social, Ecological and Economic Sustainability

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Abstract
While there is wide agreement on the need to move towards fairer and more sustainable societies, how to best achieve this is still the source of some debate. In particular, there are tensions between more market-based/technological approaches and more redistributive/social approaches. Living Well, a strategy which falls into the latter category, has been proposed as a path to social, ecological and economic sustainability by several state governments of the Global South. This paper examines the Living Well paradigm as implemented in Bolivia through the lens of the recently agreed Sustainable Development Goals (SDGs). The article is based on a 3 year, ESRC funded project on transitions to sustainability and reports the findings of documentary, policy and secondary data analysis, participant observations and semi-structured interviews with local stakeholders. The work indicates that, despite constraints and set-backs, in just a decade, Living Well has achieved a major shift towards social, economic and ecological sustainability in Bolivia. This seems to be primarily a result of the emphasis on redistributive policies, an intention to live in harmony with nature, respect for traditional values and practices, local control of natural resources, and participative decision-making. It is, therefore, argued that other nations might achieve more success in transitioning to sustainability by focusing on these factors, rather than continuing to emphasise the technological/growth/market approaches which are currently dominating global sustainability debates and activities.

Keywords
Bolivia; Buen Vivir; environment; global south; green economy; human needs; Living Well; sustainability; sustainable development goals; Vivir Bien

Issue
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1. Introduction

In the face of multiple environmental and social crises, a step change in our way of living seems imperative. Recent studies indicate that we have just twenty years within which to create the social practices that will enable us to avoid irreversibly overstepping planetary boundaries (Intergovernmental Panel on Climate Change, 2013; Rockström et al., 2009; Steffen et al., 2015). At the same time, there is an urgent necessity to begin to address a number of widely unmet basic human needs. For example, approximately 60% of people globally were still without access to safe sanitation systems in 2015 (World Health Organization [WHO] & UNICEF, 2017); 15% lacked access to electricity (World Bank, 2017); 30% were without safe drinking water (WHO & UNICEF, 2017); and 11% had insufficient food to meet the minimum daily energy requirement (Food and Agriculture Organisation, 2015). Furthermore, since 2008, many countries have been impacted by a deep economic recession and austerity measures which have widened and deepened poverty and inequality (Hardoon, Fuentes-Nieva, & Ayele, 2016; Organisation for Economic Co-operation and Development [OECD], 2014; Piketty, 2014). As a result of these multiple crises, a fundamental and urgent transition to sustainability is required so as to avert further human suffering and catastrophic harm to all species of the planet.

Burke and Shear (2014, p. 130) advocate researchers contribute to our understanding of how to achieve a tran-

sition to sustainability through investigating the diverse 'already-existing experiments' with other ways of organising society. This article, and the research project upon which it is based, responds to this challenge, contributing to the literature on state-led strategies to achieve sustainability (see, for example, Duit, Feindt, & Meadowcroft, 2016; Gough, 2016; Koch & Fritz, 2014; Sommerer, 2016). Recent macro-'experiments' in new ways of bringing about eco-social transition at a state level include *Green Economy* (e.g. South Korea), *Ecological Civilisation* (China), *Sufficient Economy* (Thailand) and *Living Well* (e.g. Bolivia). All claim to address environmental, social and economic crises simultaneously, yet are diverse in terms of emphases, priorities and implementation methods. Living Well, in particular, represents a radical alternative to dominant global values. It has emerged from the Global South, particularly Ecuador and Bolivia, but has a much longer history in the customs and beliefs of the indigenous people of the Andes (Gudynas, 2011). There are a number of different interpretations of the concept, as will be discussed, but it generally implies redistribution of wealth and meeting human needs in harmony with nature.

The article begins with a description of the emergence of the Living Well paradigm in Bolivia and its theoretical underpinnings. Section 3 follows with an outline of the methodology for the study. Section 4 reports on the implementation of Living Well in Bolivia through the framework of the Sustainable Development Goals (SDGs) primarily drawing on quantitative and documentary data to give the macro-picture. Finally, Section 5 analyses the underlying factors that have enabled the achievements to date by utilizing qualitative data to give the micro-level view. The research indicates that the Living Well approach is generally successful, even in this early stage, in relation to the SDGs. However, it is difficult to fully integrate all of its aspects because of elite internal and external economic interests and Bolivia's postcolonial context.

2. The Bolivian Context of Living Well

As a result of 500 years of colonial and neoliberal domination Bolivia became severely environmentally, socially and economically impoverished. The economy increasingly focused on extractive industries, especially silver, gold and tin mining, with profits going to the rich and dominant countries of the globe. This caused land degradation, deforestation and pollution in Bolivia, leaving vast regions desertified and communities sickened, destitute or displaced. However, in late 2005, Bolivia took a radical change of direction when the Movement towards Socialism (*Movimiento al Socialismo* [MAS]) won the national election. MAS emerged out of social movement protests to the neo-liberal market reforms of the 1990s and early 2000s with a discourse critiquing neoliberalism and classical development strategies, and supporting a resurgence of indigenous knowledge and traditions that had been marginalised and repressed for centuries (Fabricant, 2013; Gudynas, 2011). With Evo Morales as its leader, the MAS government embarked on a major programme of 'decolonisation'—throwing off the practices and institutions of the colonial era. This process was initiated with the first official MAS development strategy—the National Development Plan (Ministerio de Planificación del Desarrollo [MPD], 2006)—and further embedded in Bolivian institutions and culture with a new constitution, approved by the majority in a national vote, 'based on respect and equality for all, with principles of sovereignty, dignity, complementarity, solidarity, harmony and equality in the distribution and redistribution of social goods' (Estado Plurinacional de Bolivia, 2009).

Within this context, the MAS government began a project to address the severe environmental challenges through an approach known as *Vivir Bien* or *Buen Vivir* in Spanish, also sometimes referred to as *Suma Qamaña* in Aymara, *Sumaj Kawsay* in Quechua, or *Ñande Reko* in Guaraní. The nearest equivalent translation into English is 'Living Well'. *Vivir Bien*/Living Well is defined by Law 300 as 'a civilizational and cultural alternative to capitalism based on the indigenous worldview (cosmovision)' that 'signifies living in complementarity, harmony and balance with Mother Earth and societies, in equality and solidarity and eliminating inequalities and forms of domination. It is to Live Well amongst each other, Live Well with our surroundings and Live Well with ourselves' (Estado Plurinacional de Bolivia, 2012, art. 5.5). Many of the social movements in Bolivia frame Living Well similarly as inherently critiquing the perceived separation of humans from nature and the modernist idea of infinite progress through technology. They characterise it as promoting respect and care for humans and the rest of nature in a spirit of solidarity, implying that we cannot achieve true well-being if other humans are suffering, or at the expense of destroying the environment (e.g. the World People's Agreement on Climate Change and The Rights of Mother Earth, 2010).

There is, however, a great deal of contention about the term *Vivir Bien*/Living Well (see e.g. Gudynas, 2011; Villalba, 2013) which leaves it open to a variety of interpretations and framings. Even so, as Calisto Friant and Langmore (2015, p. 64) point out *Vivir Bien* '…has core elements that can be found in all definitions…' in that '…it does not divide between nature and society; it places people as equal inhabitants of the earth alongside other species; it is strongly communitarian, ideally promoting participation and power over decision-making; and is less hierarchical and competitive, instead encouraging solidarity and reciprocity'. Based on this common understanding, the Bolivian government was the first government in the world to fully embrace this philosophy, with Ecuador following closely behind.

As well as controversies around definition, some have questioned the actual existence of Living Well, feeling that it is more of a government discourse than a set of indigenous values or concrete policies (Carlos Cre-

spo [Sociologist, University of San Simon, interview, January 9, 2017). Others have characterized Living Well as somehow mystical, and difficult, if not impossible, to implement (e.g. Fabricant, 2013). However, as this paper makes clear, it does exist and it can be implemented. There are numerous examples of practical policies and programmes focused on, and arising from, the Living Well paradigm in Bolivia. According to the new Bolivian constitution, all development projects are to be evaluated in terms of their ability to fulfil the goal of Living Well and the concept is central to the new body of legislation that has been passed since 2006. It is particularly a key component of Law 300 with its main objective to 'establish holistic development in harmony and balance with Mother Earth to Live Well…' (Estado Plurinacional de Bolivia, 2012, art. 1). This law set up a new institution: the Plurinational Authority of Mother Earth (art. 53) which now focuses primarily on mitigating climate change. Living Well is also the cornerstone of successive MAS National Development Plans e.g. '…Bolivia Sovereign, Productive and Democratic to Live Well' (MPD, 2006) and '…Framework of Integrated Development for Living Well' (MPD, 2016). The Living Well programmes and policies discussed below in relation to the SDGs are all aligned with, reflect, or in some cases, can be directly attributed to, these overall legislative changes and policy documents.

As Ranta has noted 'While considerable academic interest has developed in the concept of *Vivir Bien/Buen Vivir*, critical ethnographic examination of what is concretely done in its name *within the state apparatus* is scarce' (2017, p. 1604). Hence, with the MAS government now in place for over 11 years, it is useful to consider how effective this policy paradigm has been and to consider its propensity for implementation elsewhere. There have been a few prior assessments of specific policies associated with Living Well in Bolivia. Many report on the progressive leaps made—Andersen (2014) on deforestation, Farthing and Kohl (2010) on illicit use of the coca plant, and Simarro and Antolín (2012) on income distribution—whilst highlighting some of the constraints that restrict further progress or create negative impacts elsewhere. However, there has not formerly been a systematic analysis of Living Well, as a whole or in relation to a recognized framework, such as the SDGs as reported and discussed here.

3. Methodology

The article is based on a three year, ESRC funded, research project entitled *Fair and Inclusive Environmental and Social Transition Alternatives* (FIESTA). The research methodology encompassed both secondary (macro-level) and primary (micro-level) data collation/collection and analysis to enable a robust, contextualised and in-depth understanding of the effectiveness and viability of the Living Well approach. Data was derived from SDG relevant longitudinal statistical data from a range of sources to provide macro context, as well as participatory observations in four communities and interviews with local stakeholders.

The secondary aspect used a range of reputable, longitudinal international and comparative surveys as well as national datasets, where available, to investigate specific issues. The factors tracked primarily related to morbidity and mortality, emissions, energy consumption, inequality, poverty, access to environmental resources, green investment, quality of living environment, waste production, labour rights, employment levels, political empowerment, subjective well-being and social protection. The participatory observation component entailed living in the communities of interest and attending relevant meetings and events for a three-month period overall. In Bolivia, the four communities were two cities—La Paz and Cochabamba—and two villages—Mecapaca (in the state of La Paz) and Tarata (in the state of Cochabamba). These communities were selected because they represented a range of sizes, political contexts (Cochabamba had an opposition led local government), dominant ethnic groups (*Aymara* in La Paz and *Quechua* in Cochabamba) and environmental and social issues. The interview component included 50 participants, made up of a range of experts, government officials, NGO representatives, trades union organisers, community leaders, programme beneficiaries, and the wider public. The interviews were intended to understand how people conceptualized *Vivir Bien*, whether and how they were contributing to its implementation and whether and how they considered that the policy was making a difference to their lives or the lives of others. For example, people were asked 'What does *Vivir Bien* mean to you?' or 'What has changed here as a result of the *Vivir Bien* policy goal?'. Interviewees were selected using the following sampling strategies: *Purposive sampling*, using participants who have particularly relevant knowledge and experience, *snowball sampling*, using networks to gain access to information-rich participants, *opportunistic sampling*, making the most of opportunities to meld the sample around the unfolding fieldwork context, and *maximum variation sampling*, selecting participants who lived and worked in the maximum diversity of environmental and social situations (in order to increase the opportunities to identify the varying factors and influences). The interviews were analysed thematically, using *Nvivo*. These methods aimed to comprehensively capture needs, visions, objectives, processes, impacts, as well as the barriers to implementation and impact of the Living Well paradigm.

The SDG framework, the centrepiece of an intergovernmental agreement intended to guide global development efforts to 2030, is utilized here as a means of operationalizing 'sustainability' or 'sustainable development', which remain contested and vague terms (Giddings, Hopwood, & O'Brien, 2002). This is a controversial approach because the SDG framework has been criticized on a number of grounds, in particular for its lack

of binding commitments and, with 17 Goals, 169 associated targets, and 304 proposed indicators, its complexity (e.g. *The Economist*, 2015). It has also been argued that the SDGs inherently reflect neoliberal interests (Pingeot, 2014; Scheyvens, Banks, & Hughes, 2016). Whilst not disputing that the SDG framework has many shortcomings, it is an internationally recognized measure of sustainability achievement, widely endorsed by 193 national governments in consultation with civil society and businesses. With so much international funding, discourse and activity now taking place in relation to the SDGs, it is important to identify the most rapid, effective and integrated way to achieve them. It also makes sense to start with the dominant framing (i.e. the SDGs) because, if we want to make comparisons between different pathways, it is useful to have a common benchmarking tool.

Some might also consider the SDG framework to be an inappropriate yardstick for capturing what is most valuable about *Vivir Bien*, a paradigm which is often posited as an alternative to mainstream notions of development. The most obvious contradiction between the two is with regard to the SDG for economic growth, which would appear to go against the limits implied in Living Well's aspiration to live in harmony with nature. Globally, humans are clearly not living in harmony with nature because we currently need the regenerative capacity of 1.6 Earths to provide the goods and services we use each year (World Wildlife Fund, 2016). Since we are already overstepping planetary boundaries, continuous economic growth would inevitably make this situation worse. As key figures in the degrowth movement have predicted (e.g. Daly, 1977; Georgescu-Roegen, 1971) the increasing use of resources and production of waste means there will be accelerated, irreversible planetary destruction. Hence, unlike the SDG framework, Living Well does not prioritise growth or propose growth as a specific goal. However, it does allow space for appropriate growth—that which is necessary to meet human needs. Therefore, Living Well has some general commonality with even the most apparently contradictory SDG.

Living Well has not been assessed in terms of all the specific targets and indicators of the SDGs as this would be highly complex to report comprehensively in the context of an article. Only particularly marked achievements or failings are mentioned here based on data availability and relevance. Current quantitative data, or the most recent available data are compared with 2005, prior to the election of the MAS government which sought to implement Living Well at the state level.

4. Living Well and the SDGs

Goal 1: End poverty in all its forms everywhere

There has been significant progress towards achieving this goal. Absolute poverty levels in Bolivia fell from 59.6% in 2005 to 38.6% in 2015 (World Bank, 2017) and extreme poverty more than halved (National Statistics Institute, 2017). The eradication of poverty is a stated key goal in the Bolivian National Development Plans for Living Well (MPD, 2006, 2010, 2016). The main programmes for reducing poverty and inequality have been transfer payments targeting the most vulnerable groups, including an annual stipend for children who stay in primary school (*Bono Juancito Pinto*), a national pension and social security scheme (*Renta Dignidad*), a national health insurance programme for under-25s, a supplement for women who are pregnant or have young children (*Bono Juana Azurduy*), and long-term investments in health and education, particularly in rural areas (Simarro & Antolín, 2012). The MAS government has also approved annual increases in the national minimum wage of between 5% and 20% each year. In addition, redistribution of wealth has occurred through land reform, though any radical transformation has been prevented by fierce opposition from the Bolivian oligarchy, which controls the agricultural and industrial sectors in the East (Simarro & Antolín, 2012).

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

The 2017 report of the International Food Policy Research Institute reports sustained reductions in Bolivia's hunger indices since 2005 (IPFRI, 2017). The eradication of hunger is one of the principal objectives of all the Bolivian National Development Plans for Living Well. In addition to the measures to reduce poverty, enabling families to buy more and better-quality food, there have been specific policies to reduce hunger, including establishing local councils for food and nutrition (Dávalos Saravia, 2013) and the 'National Programme on Complementary School Feeding to Implement Food Sovereignty and Living Well'. The latter aims to ensure the human right to adequate food, to strengthen the development of local production, increase school attendance rates, enhance school performance, promote student engagement in the education system and provide healthy, adequate and culturally appropriate food. The programme entitles all of the school children in the country a breakfast and/or lunch and local producers must be prioritised as suppliers (Estado Plurinacional de Bolivia, 2015). The government aims for Bolivia to be fully self-sufficient in food by 2020 through enhancing local capacity for production, via programmes such as *Bio-Cultura* (Weyer, 2017) which supports small and medium scale farmers.

Goal 3: Ensure healthy lives and promote well-being for all at all ages

Bolivian life expectancy at birth increased by approximately 3 to 5 years in the decade from 2005 (World Bank, 2017). In the same period, infant mortality rate dropped from 46.6 to 30.6; under 5 mortality rate dropped from 61.4 to 38.4; and both female and male adult mortality also fell significantly (United Nations Development

Programme, 2016). Health has been one of main pillars of the National Development Plans for Living Well and there has been a major reform and extension of health care since the MAS government were elected. This includes a new national health policy, initiated in 2008, called *Salud Familiar Comunitaria Intercultural*—SAFCI. The SAFCI policy, based on principles of equality, access, and respect for indigenous principles, explicitly calls on the principles of *Vivir Bien* (SAFCI in Bernstein, 2017). The health improvements made over the last decade or so have generally followed a trajectory that started much earlier so it is not clear whether they would have happened anyway because of factors other than the Living Well policy. However, we would expect that the SAFCI extension of health services, as well as the reductions in poverty and hunger, described above, and improvements to water and sanitation services, as described below, would have a very positive impact on health.

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Illiteracy, which stood at approximately 14% in 2006, has now been eradicated (UNESCO, 2009) and the primary school drop-out rate, at 25.6 in 2000 (there is no data for 2005) has dropped to less than 3.3 (UNICEF, 2017). These educational achievements link to the 'Yes I Can' literacy programme and the stipend the government now provides for children who stay in primary school (*Bono Juancito Pinto*), both policies of the National Development Plans for Living Well. The Bolivian education reform act of 2010 is also radically transforming education towards the 'Critical Pedagogy' of Paulo Freire (1970) and the broader philosophical foundation of *Vivir Bien* (Reimão & Taş, 2017; Schipper, 2014). This includes retraining teachers and revising the curriculum according to four general principles or objectives: (1) decolonial, (2) intra- and intercultural along with plurilingual, (3) productive and (4) communitarian education (see Schipper, 2014). There has also been an expansion and improvement of the educational infrastructure (MPD, 2016, p. 22).

Goal 5: Achieve gender equality and empower all women and girls

The United Nation's Gender Development Index (GDI) records an overall improvement for Bolivia in terms of female relative to male development from 0.917 to 0.934 in the period 2005 to 2015 (UNDP, 2016). Similarly, their Gender Inequality Index (GII)—a composite measure reflecting inequality in achievement between women and men in three dimensions: reproductive health, empowerment and the labour market—shows a marked reduction in inequality from 0.559 to 0.446 (UNDP, 2016). In 2008, the National Plan for Equal Opportunities entitled 'Women Building the New Bolivia, to Live Well (*Vivir Bien*)' was launched (Ministerio de Justicia, 2008). Developed through a process of discussion between the national government and the Bolivian women's social organizations, it set out to identify the priority issues and to design a long-term strategy to overcome them. In the case of the GDI and the GII Indexes, there is not enough previous data to show whether this is a change that can be related to the Living Well policy or whether it was an ongoing trend arising from other factors. However, other indicators do exceed the prior trend. For example, while the proportion of women in parliament increased slightly from 11.5 percent in 1999 (the earliest data) to 16.9 percent in 2005, following the election of MAS there was a sharp increase to 53.1 percent in 2016 (World Bank, 2017). The government cabinet appointed in 2010 was, for the first time in the country's history, comprised of 50 percent women, though has fluctuated since (World Bank, 2015a). However, despite government effort, there is still some way to go to achieve this SDG. For example, despite new legislation in 2013 to stop intimate partner violence and a specific Police Force Against Violence to counteract gender abuses, gender based violence remains widespread (World Bank, 2015a).

Goal 6: Ensure availability and sustainable management of water and sanitation for all

There has also been significant progress towards meeting this goal. According to the latest World Bank data, 90% of the Bolivian population had access to a safe water source in 2015, up from 82.9% in 2005 (World Bank, 2017). Improved sanitation stood at 50.3% in 2015, up from 42.2% in 2005 (World Bank, 2017). Safe water and sanitation services are part of the National Development Plans for Living Well. Access to water was a primary goal of the MAS government with its roots in the 'water wars' against water privatization in Cochabamba and El Alto in 2000 and 2005 (see Baer, 2015). In 2010, the United Nations voted unanimously to accept Bolivia's proposal to make access to water and sanitation services a human right. At a domestic level, the new National Constitution of Bolivia (2009) states that every citizen has a right to water (Ch. 1, art. 16) and the right to water has been part of all the national development plans for Living Well. 'MiAgua', a programme to increase the funding invested in water and irrigation projects was launched in 2011 and, since then, investment in the water sector has almost tripled (Baer, 2015). There has also been an improvement expansion of sewerage systems and construction of ecological toilets using local labour. Citizen participation in water management is not yet wholly fulfilled (Baer, 2015), however, and, in December 2016 and January 2017, there were water shortages in parts of some cities, mainly as a result of climate change related glacier shrinkage, but also some local mismanagement of resources.

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all

In 2007, total access to electricity in Bolivia was 80.2%, and this has now increased to 88% (96% in urban areas and 74% in rural areas) (International Energy Agency, 2015). In the National Development Plans for Living Well universal electrification was defined as a priority, alongside energy sovereignty and independence. Similarly, the 2009 Constitution established universal access to services such as electricity as a fundamental right. In 2008, the 'National Energy Efficiency Programme' was initiated, establishing 'policies, projects and necessary actions for the rational, efficient and effective use of energy' (MPD, 2016, p. 20) with a goal to reduce Greenhouse Gas emissions. This included, for example, the 'Energy-Efficient Light Bulbs Programme' which distributed over 8 million light bulbs to the population (MPD, 2016, p. 30). Despite its reserves of gas, Bolivia is also committed to extending the provision of renewable energy photovoltaic systems and wind turbines (Roberto Calzadillo Sarmiento [Bolivian Ambassador to UK], personal communication, November 14, 2016).

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Bolivia's GDP has increased from $9.54 billion in 2005 to $33 billion in 2015 (World Bank, 2017). The country's GDP growth rate, averaging 3.6% from 1990 to 2005, increased to an average 5.1% after 2005 (MPD, 2016, p. 169). Like growth, GDP as a measurement is controversial (since it does not necessarily represent useful growth; it could arise from bombing and then rebuilding a country, for example). Though referred to in the National Development Plans for Living Well, neither GDP nor growth represent a specific goal, unlike, for example 'Joy and Happiness'. Though growth is not a goal, it is being used to improve the living conditions of the population. The government asserts that the growth has occurred in part as a result of increased domestic consumption enabled by better wages and benefits, increased public investment, social programmes for children and mothers and monetary transfers for the elderly (*Renta Dignidad*), increased wages (mainly due to the national minimum wage), and the creation of new public companies (MPD, 2016, p. 47). These are all policies associated with the National Development Plans for Living Well. In particular, the nationalisation of natural resources enabled the government to mobilize the country's resources toward Living Well projects. The tax and royalties gained by the state as a result of nationalization increased from an average 18% of profits to as much as 82% (Postero, 2010). These funds have been used to initiate social programmes, develop the local economy and create useful jobs.

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Bolivia's industrial growth rate has increased from an average 2.7 in the years 1997–2005 to 4.9 from 2006 to 2014 (MPD, 2016, p. 39). In its National Development Plans for Living Well, the Bolivian government has placed significant emphasis on infrastructure and industrialization which fosters inclusivity. Specific programmes have included the 2014 launch of the country's first telecommunications satellite into space. As well as generating an income from services from the satellite, it has also enabled greater connectivity for citizens and created less dependence on other nations. Also, since 2014, successive phases of a cable car system have been built, beginning with connecting the capital La Paz with neighbouring El Alto city. Similar transport infrastructure is planned for Oruro, Potosí and Sucre. The project is reducing local air pollution, providing affordable transport, and connecting low income neighbourhoods with jobs and services. State-sponsored science and technology projects are increasingly prominent in Bolivia and much is being done to foster work in these fields, though with an emphasis on using local sustainable materials and methods and respecting indigenous or ancestral knowledge (Centellas, 2010). For example, the government is intent, not only on creating a national system of traditional medicine, but on ensuring that it has the same status as Western allopathic medicine (Johnson, 2010; Ministerio de Salud y Deportes, 2006).

Goal 10: Reduce inequality within and among countries

This goal is also being met. According to World Bank data, the Gini Coefficient dropped from 58.47 in 2005 to 48.4 in 2014. In 2005, the richest 10% of the population earned 128 times more than the poorest 10%, a situation that was reduced to the richest earning 39 times more than the poorest by 2014 (MPD, 2016, p. 15). Reducing forms of inequality and discrimination are major goals of the National Development Plans for Living Well. The policies to reduce economic inequality have included the cash transfer payments mentioned earlier with 40.6% of the population benefitting from at least one of these payments in 2014 and the dramatic rise in the national minimum wage year on year from 2006 (MPD, 2016). Law 045, 'Against Racism and All Forms of Discrimination', passed in 2010, prohibited discrimination by public and private institutions and individuals, created a governmental Committee, and barred the dissemination of racist and discriminatory ideas through the mass media. MAS has also greatly increased indigenous participation in decision making and legislated for the recognition of indigenous rights. In terms of reducing inequality between countries, Bolivia has been a strong advocate of industrialised nations repaying an ecological debt to the poorer nations for the harm done to the planet over the last 200 years of their 'development'.

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Successive National Development Plans for Living Well address urban issues. For example, a priority goal in the latest Plan states that there should be 'access to dignified housing with basic services' including a focus to recover the traditional housing construction technologies of indigenous people (MPD, 2016, p. 83). Bolivia's State Housing Agency has constructed thousands of social housing units which are given to those who lack decent housing or who have lost their homes in natural disasters. There has been a reduction in the proportion of the urban population living in slums in Bolivia (that is, dwellings that are overcrowded, made of non-durable material, or without access to improved water or sanitation services) from 50.4% in 2005 to 43.5% in 2014 (World Bank, 2017). However, with conflicts over contracts and priorities, it has been noted that ambitious social housing goals '…have been constrained by underlying economic and market forces and the need to accommodate opposing political interests' (Achtenberg, 2009, p. 1).

Goal 12: Ensure sustainable consumption and production patterns

This SDG focuses on the ecological footprint of nations and their citizens and compliance in waste disposal accords. Although Bolivia's Global Footprint has increased since under MAS governance, which is unsurprising given the scale of infrastructure developments, it has been less than that of the surrounding nations (see Table 1). In terms of waste disposal compliance, Bolivia is party to most of the multi-lateral agreements on waste disposal (e.g. the Montreal Protocol; the Basel Convention; and the Rotterdam Convention). The National Development Plans for Living Well emphasise the implementation of sustainable policies for the disposal of waste and community environmental education and training. With regard to consumption and production patterns more generally, there is the action to promote 'The construction of a less consumerist and less individualistic society' (MPD, 2016, p. 65). There has also been a general government orientation toward changing consumption so that it is less environmentally damaging. For example, nutritious indigenous crops that can be grown locally but have fallen out of widespread popular consumption (for example, grains such as quinoa and amaranth) are being promoted (Johnson, 2010). In addition, Municipal Committees of Ecological Production have been set up to strengthen ecological production. Yet production in all sectors has increased dramatically since 2006 (MPD, 2016, p. 26) and hydrocarbons and minerals make up the majority of exports (69.9% in 2014). Whilst this extractive production is intended to be a time limited means to generate income while programmes are set up to diversify the economy '…promoting knowledge economies, creative and sustainable, beyond the exploitation and processing of natural resources' (MPD, 2016, p. 100), for the time being it undermines the achievement of this SDG.

Goal 13: Take urgent action to combat climate change and its impacts

Since the MAS government came to power, Bolivia's total Greenhouse Gas emissions have shot up and this would seem to contradict the Living Well paradigm but, to put this in context, the country is still one of the world's smallest contributors to climate change. The population take climate change seriously as the country is already being severely impacted, experiencing rising temperatures, melting glaciers and more frequent extreme weather events, including floods, droughts, frosts and mudslides (see e.g. Ramirez et al., 2011). Glaciers that lie below 5,000 m are expected to disappear completely within 20 years, leading to severe water shortages that will affect agricultural production. Hence, the Bolivian government has taken a principled position in the United Nations climate change negotiations, pushing for a binding, ambitious and justice-based agreement. For example, in December 2009, at the UN Conference of the Parties in Copenhagen (COP15), Bolivia advocated climate reparations from the Global North to the South, and called for a 1°C maximum limit on temperature increases.

Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

This Goal is currently not directly relevant to Bolivia. The country lost its coastline in the 1879–84 war of the Pacific, though it has recently gained a small stretch from Peru.

Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Where Bolivia formerly had one of the highest deforestation rates in the world (UN-REDD, 2010), this has now dropped dramatically—by 64% since 2010 (Andersen, 2014). Fuentes (2015) points out that 2010 is the year the government officially opposed carbon offset schemes, set up a state body to protect forest areas, and put large areas of forest under the management of local indigenous people—all programmes that fit with the principles of Living Well. The latest National Development Plan for Living Well claims a reversal in the trend of forest ownership where, between 1997 and 2005, only 3 million hectares were managed by indigenous and peasants, this is now more than 7 million (MPD, 2016, p. 37). The intention to protect ecosystems is laid out in the 'Framework Law of Mother Earth and Integral Development for Living Well'. This national legislation establishes 11 new rights for nature, including: the right to life and to exist; the right to continue vital cycles and

processes free from human alteration; the right to pure water and clean air; the right to balance; the right not to be polluted; the right to not have cellular structures modified or genetically altered; and the right not be affected by mega-infrastructure and development projects that affect the balance of ecosystems. However, as has been touched upon, there are constraints and tensions in terms of there being an undiversified economy which mean that this Law is not yet fully implemented.

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

This SDG focuses on anti-corruption measures and inclusive, participatory and representative decision-making at all levels. According to World Bank Governance Indicators, Bolivia has improved in control of corruption over the last decade (25.4 in 2005 to 29.8 in 2014) (World Bank, 2015b). The National Development Plans for Living Well emphasise the importance of this, for example, stating that there must be 'Transparent public administration with ethical, competent, and committed public servants fighting corruption' (MPD, 2016, p. 156). The government has made significant efforts to enhance transparency and accountability, including passing a new anti-corruption law in 2010. Evo Morales declared 'zero tolerance' against corruption and, according to Transparency International '…his government has created an institutional and legal framework that appears robust' (2012, p. 1). In terms of promoting inclusive decision making, it is considered that the involvement of social movements and local people is essential to the success of the MAS project (Dangl, 2010). Article 7 of the 2009 Constitution states that the democratic system is exercised both directly (that is, communal self-government) and via representation (that is, through the representative democratic system). The Constitution protects freedom of expression, laying out an expansive right to communicate freely (art. 2), while also imposing a duty to communicate with 'truth and responsibility' (art. 107).

Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development

In 2010, in response to the perceived inadequacy of the COP15, Bolivia hosted the World Peoples' Summit on Climate Change and the Rights of Mother Earth. Living Well was prominent within the ethos and approach of the conference which brought together 35,000 people (of which 9,000 were from outside Bolivia), made up of social movements activists, government representatives, scientists and academics. Discussions went beyond the impacts and effects of climate change to identifying its structural causes. Bolivia has also led a campaign for universal acceptance of the rights of Mother Earth. In 2009, the General Assembly of the United Nations passed a Bolivia-led resolution proclaiming April 22 as 'International Mother Earth Day'. The government continues to campaign for a Declaration on the Rights of Mother Earth at the UN level.

5. Discussion

The above analysis suggests that Bolivia is making great strides towards sustainability under the banner of Living Well. However, some might argue that the changes since 2005 were not necessarily the result of the Living Well policy, itself, but of other national policies, supranational policies or numerous other possible confounding factors. For example, when the MAS government came to power, it joined the socialist and social democratic 'ALBA' regional pact which maintains a similar vision of social welfare, the rights of indigenous peoples, protection of the environment, social participation and solidarity (Muhr, 2010). Therefore, ALBA could also have been a steerer or facilitator of the above gains. As an overarching paradigm, rather than a discreet and limited policy, there is no way to take account of all the multiple variables that could have influenced the outcomes over the time period.

In order to further understand something of the contextual factors, it is useful to look at Bolivia's performance in relation to other countries in the area. If we compare Bolivia's progress with those of other South American countries according to 4 widely recognised and respected indicators we can see that, though there are general regional trends in terms of reduction in absolute poverty, greater life expectancy and improved sanitation, Bolivia is above the average in all dimensions (see Table 1). In terms of Bolivia's comparison with the average, it has reduced absolute poverty by 21%, compared to the average 18.1%; increased life expectancy by 2.6 years, compared to the average 1.8 years; and expanded sanitation coverage by 8.1%, compared to the average 4.9%. All this has occurred with an increase in the Global Footprint score that is less than that of the other South American countries (0.52, compared to 0.6 for the other countries).

These are only four indicators, selected here to cover a wide range of aspects of both *Vivir Bien* and the SDGs. However, taken together with the evidence from the various aspects of the study, this comparison does indicate that Bolivia is delivering on some of the social elements of the SDGs whilst still managing to balance this with less overall ecological harm than its neighbouring countries.

To some extent we can expect similar trends across South America because the Latin American countries adopt policies from their neighbours—Living Well is not a new ethos or set of policies but attempts to integrate, prioritise and promote a particular package of policies at the state level. It is the attempt to integrate the policies and the government and society commitment to them that is the essence of Living Well. For example, the 'Na-

Table 1. Regional comparisons with South American countries (2005–latest data) on 4 indicators.

	Absolute Extreme Poverty Levels[1]		Life Expectancy at Birth[2]		Improved Sanitation[3]		Global Footprint[4]	
	2005	2015	2005	2013	2005	2015	2005	2015
S. America	38.3	20.2	72.5	74.3	82.6	87.5	2.7	3.3
Bolivia	59.6	38.6	64.7	67.3	42.2	50.3	2.54	3.06

Source: Author based on World Bank, UNDP, WHO and Global Footprint Network data. S. America = average of other South American countries with data.

[1] National poverty headcount ratio is the percentage of the population living below the national poverty lines.

[2] Number of years a newborn infant could expect to live if prevailing patterns of age-specific mortality rates at the time of birth stay the same throughout the infant's life.

[3] Improved sanitation facilities—% of population with access.

[4] The GF is 'A measure of how much area of biologically productive land and water an individual, population, or activity requires to produce all the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices' (measured in global hectares) (Global Footprint Network, 2017).

tional Programme on Complementary School Feeding to Implement Food Sovereignty and Living Well 2015–2020' is emblematic in this, impacting simultaneously on many of the Goals, notably 1 (Poverty), 2 (Hunger), 3 (Health), 4 (Education), 11 (Settlements), 12 (Consumption) and 13 (Climate Change). This is not to imply that integration is always successful but this comparison with other countries, alongside the previous data, suggests that Bolivia has had some success in balancing social and ecological goals. Analysis of the qualitative data reveals some of the factors that could have played a role in this achievement, as discussed below. These are primarily: the emphasis on redistributive policies, an intention to live in harmony with nature, respect for traditional values and practices, local control of natural resources, and participative decision-making practices. Each will now be discussed briefly.

5.1. The Emphasis on Redistributive Policies

Redistributive policies, such as income transfers, increase in public goods and wealth taxation have been an important element of the Living Well paradigm in Bolivia. As well as helping to meet the social goals, redistribution aids ecological goals since inequality links to environmental degradation because a) it encourages more consumption (Dorling, 2010a, 2010b; Dorling, Barford, & Wheeler, 2007; Wilkinson & Pickett, 2010); b) it reduces the demand for environmental protection policies (Franzen & Vogl, 2013; Johnstone & Serret, 2006); and c) it reduces the likelihood of engaging in environmentally friendly behaviour (Boyce, 1994, 2003, 2007; Ekins, 1999). A number of interviewees attested to the importance of redistribution for achieving these sustainability goals. For example, one of the political leaders said:

> Living Well requires that…all live equally that is, there are no rich or poor…If one person has basic services, everyone has basic services…There is respect between humans but there is also respect for Mother Earth. (Interview, 3rd January 2017, Leonardo Loza, President of MAS-IPSP, Cochabamba Department)

Therefore, redistribution of wealth and income is an important basis for the Living Well policy and appears to have been a key part of its success. The addition of '…but there is also respect for Mother Earth' in Leonardo Loza's comment links to the next theme and indicates the interlinkage of the themes.

5.2. Intention to Living in Harmony with Nature

Though some have characterized *Vivir Bien* as harking back to pre-industrial times and being anti-modernist, in essence its orientation is towards healing the rupture between humans and nature, whether using traditional or modern ideas and ways. Many of the interviewees and informants discussed the importance of this for themselves, their communities and the government. For example, a young activist in the social movements stated:

> Living Well means to be well with equals, with brothers, with Mother Earth…the President said a very, very, very important sentence…"Earth does not belong to us, we belong to it". Living Well implies that, we respect the earth and do not harm it. (Liss Gutierrez [Youth Leader], interview, February 16, 2017)

Some argued that, historically, there has been a denial of the rights of Mother Earth in the name of 'development' and, consequently, that Living Well can only be achieved by taking a different path, away from the classical notions of development, and putting the environment first.

> With Mother Earth, with ourselves, we aim for real development—communitarian socialism—where we have reciprocity with our ancestral cultures and, in this way, develop with a new approach, not a consumerist approach that is crushing us every day… It is a struggle for a change of attitude… (Juan Martinez,

> [Project Co-ordinator, Unified Sindicate of Rural Workers of Bolivia], interview, February 15, 2017)

Some of the middle-class interviewees, those who had the finances to implement their own local level transition, were constructing eco-homes and household water recycling projects, shopping at health food shops and making other environmentally beneficial lifestyle choices. The less well-off generally continued to live low impact lifestyles, though sometimes with aspirations for more consumer goods. Some interviewees stated that the MAS government, despite their rhetoric, are still dedicated to an environmentally and socially harmful industrialised development process, as have some academics (e.g. Bebbington, 2009; Postero, 2013). Evo Morales's election campaign for his second term promised an 'industrial leap forward', alongside the physical integration of the country. His critics allege that the MAS government has developed its own interpretation of *Vivir Bien* and extraction and industrialization are contradictory to the true meaning. However, this is because, in general, social movements in Bolivia have asked for more, not less, of this kind of development (Bell, 2014). For many, decolonisation can be accomplished only through industrialisation accompanied by redistribution. Therefore, in the MAS strongholds, protesters have tended to march for access to basic services, for more factories and for roads. In order to provide these services and facilities, the government currently has to depend on natural resource extraction. They could have raised income and wealth taxes to raise the finances to provide the infrastructure and services but it is likely that they do not want to antagonise the Bolivian elite who have tried to topple the government since they came to power.

5.3. Respect for Traditional Values and Practices

This is a fundamental aspect of 'decolonisation' and it has allowed sustainable practices to be revived. Whilst decolonization traditionally refers to emancipation from 'the political control, physical occupation, and domination of people over another people and their land for purposes of extraction and settlement to benefit the occupiers' (Crawford, 2002, p. 131), some Latin American theorists, including Escobar, argue that decolonization also addresses current economic globalization, neoliberal development paradigms and discourses, practices, structures and institutions from the dominant world (Escobar, 2010a, p. 9). This includes questioning current cultural norms and replacing them with pre-colonial understandings and knowledge. In Bolivia there has been a renewed appreciation and valorisation of pre-colonial knowledge, as one interviewee explained:

> We have a process of change that has even been raised in the United Nations, to take care of Mother Earth, to recover the customs of our grandparents. They had knowledge, before the colonial invasion, a more advanced scientific knowledge, perhaps 100 years in advance. They had knowledge of astrology, biology, mathematics. They understood a form of agriculture, today called ecology, and they had food sovereignty and security…We have remained as guardians of agro biodiversity. (Elias Ramirez Toribio [Red Tinku, environmental and social activist organisation], interview, December 25, 2016)

Bolivia is often portrayed as proudly, even defiantly, anti-modern, and against science and progress. Yet, appreciating and valuing traditional ways and knowledge does not mean that the Bolivian government is any of these as it combines new and traditional technologies, as appropriate. At the household level, people told me, and I saw for myself, that some now adorn their houses with traditional images, materials and representations of Andean spirituality where this had once been 'unfashionable'.

5.4. Local Control over Natural Resources

Linked to decolonization is local control over natural resources. This has been an important aspect of enabling sustainability in Bolivia, providing the funds to deliver on many of the SDGs and the freedom to make decisions which may go against the dominant trend. Many interviewees pointed out the need for this freedom. For example, stating:

> They [the neoliberal countries] take advantage of third world countries, so that we must, not only ideologically, as our brother President says, we must liberate ourselves financially, not depend on the neoliberal countries, the great world powers that manage countries, that even control our governments…They govern, manage, manipulate, imposing their same ideology, their same way of managing the economy…only through decolonization we can, perhaps, create our own great homeland… (Pascual Huallpa [Executive Secretary of 6 federations, Youth Section, MAS], interview, February 16, 2017)

These perceptions are in line with those of Dependency (Frank, 1967) and World Systems (Wallerstein, 2004) development theorists, as well as decolonization theorists (e.g. Escobar, 2010b), who point out that the global economy has long been structured around the mass extraction of resources in the periphery nations of Latin America, Africa and Asia for consumption in Europe and the United States. Despite the progress made in terms of nationalising resources, Bolivia remains part of this periphery as MAS has been unable to alter the extractivist, primary export model of the colonial and neoliberal era (Simarro & Antolín, 2012). However, while private multinational firms continue to extract the majority of the country's natural gas and minerals, the share of income from these industries that goes to the state has increased significantly under the MAS administra-

tion. This has enabled the government to introduce new programmes in health, education and social security and helped to reduce rates of extreme poverty (Kohl & Farthing, 2012). Local control over natural resources not only enables internal investment but also has meaning in terms of identity construction and pride, knowledge orientations and power relations. Even so, in Bolivia resource extraction can generate conflicts because, while taxes from natural resource exploitation go to boost national or sub-national budgets, there are environmental and social costs, often felt at the point of extraction. Analysts have pointed to the constraints that limit moving beyond extractivism, not only due to the lack of economic diversity resulting from a history of resource plundering colonialism, but also neo-liberalisation of trade in the decades prior to MAS governance and subsequent path dependency and globalized economic pressure (e.g. Kaup, 2010).

5.5. Participative Decision-Making Processes

The 2009 Bolivian constitution refers to a 'participatory, representative, and communitarian' model of democracy (art. 11). The people I interviewed were very aware of the need to participate in the Bolivian process of change and to take charge of decisions and resources. For example, one interviewee remarked:

> We must understand that…a revolution is not only what the government does, but it implies also a challenge to society…we have to organize people…to generate wealth but to manage it in a communitarian way, not in individual terms…these small manifestations of the common, of the community, we must take hold of and empower, give strength and take forward. That is, I believe, the fundamental challenge now…(Alvaro Zuleta [*Red Tinku* activist], interview, February 15, 2017)

Through the local decision-making bodies, the Organizaciones Territoriales de Base (OTBs—Base Territorial Organisations) and other federations, syndicates and social movements, citizens take part in direct local democracy. I witnessed these decision-making processes, and also heard, through the interviews and informal discussions, about some of the decisions that citizens were able to make about aspects of their local environments, such as whether to tarmac over stone roads in the neighbourhood or make the local woodlands into a golf-course (Cristina Arcos [environmentalist and OTB member, Cochabamba], interview, February 10, 2017). It seems that creating inclusive decision making processes has been fundamental to the shift to sustainability. As one interviewee remarked:

> Before we [the indigenous rural people] were highly discriminated against, humiliated, marginalized. Today we are involved in the different political spheres, in the administrative sector. This is really very important. We have positions in all the various committees and political decision-making structure…In this process of Living Well, we hope that all are taken into account, we are all part of this Pachamama [Mother Earth] and we all have to listen and be listened to. (Maribel Santamaria Mamani [National Secretary of *La Confederación Nacional de Mujeres Campesinas Indígenas Originarias de Bolivia 'Bartolina Sisa'*, Federation of Rural Women], interview, January 27, 2017)

The government also often directly consults the population on major issues. For example, in the case of the construction of a road through the Isiboro Ségure Indigenous Territory and National Park (TIPNIS) in the central lowlands of Bolivia. This proposal was debated around the world via the international media who focused on the supposed hypocrisy of the government, in particular, Evo Morales, in wishing to build a road through a sensitive ecosystem. The government, as well as unions and some indigenous groups, considered the road to be essential to connect the states of Beni and Cochabamba and to bring services to the people living in the TIPNIS region. Yet, international environmental NGOs, as well as some local organisations, argued that the construction of the road would be ecologically and socially very damaging. The government set up a dialogue with stakeholders and a consultation process regarding whether the road should be constructed. Many saw the process as a triumph for participatory democracy, while others continue to allege that the consultation was manipulated (see Bell, 2014). This situation highlights the importance and the difficulty of integrating the various aspects of Living Well.

6. Conclusion

As Giddings et al. (2002) argued 'Sustainable development, to have long-term meaning, will be an integrated and principle based outlook on human life and the world we live in'. Implementing an integrated and principle based Living Well paradigm is difficult, and made more so by elite interests, economic pressures and colonial history.

Living Well, as discourse and policy in Bolivia, has enabled the country to make a major shift to sustainability as evidenced by its progress in relation to the Sustainable Development Goals. However, there have been some limitations to its effective implementation and integration. In particular, a continued dependence on extractivism is undermining the vision to live 'in harmony with nature' and elite interests restrict raising revenue through other means, such as increased taxation, or redistributing wealth without raising revenue, such as through land reform. Yet, since MAS has been in power for only eleven years, it does not seem fair to expect the Living Well paradigm it promotes to correct the legacy of almost 500 years of colonial and neoliberal rule and the rupture between humans and nature in such a short time.

The key features that have underpinned the gains that have been made in terms of sustainability appear to be the emphasis on redistributive policies, an intention to live in harmony with nature, respect for traditional values and practices, local control of natural resources, and participative decision-making practices. This suggests that other nations might achieve more success in transitioning to sustainability by pursuing these themes, rather than continuing to emphasise the technology/growth/market approaches which are currently dominating global sustainability debates and actions. Bolivia did not focus on technological fixes, commodification of nature or growth for its own sake as promoted by the dominant sustainability discourse of the Global North. It chose a politically, economically and culturally radical alternative based on redistribution, inclusion and thoughtful use of natural resources.

Whether the Living Well model could be transferable to other situations is debatable. Policy transfer between countries is far from straightforward and not always successful. Fabricant points out that the Living Well discourse, once detached from concrete projects, may not work in other contexts and may become '…commoditized, and refashioned to advance corporate/rightist agendas' (2013, p. 173). On the other hand, the global majority who still struggle to eke out a very difficult existence might welcome a Bolivian-style Living Well transition. Even the wealthier and more comfortable, in the face of the most severe environmental crises that have ever faced humanity and increasing levels of global inequality, might support such a transition out of a sense of urgency or even guilt. Bolivia has invented and implemented a social and governance model that demonstrates how we can move toward an ecologically harmonious, efficient, and equitable society. Living Well could guide us to a new reality of reciprocity and solidarity by encouraging us to remember that we cannot live well if others do not.

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Conflict of Interests

The author declares no conflict of interests.

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Article

Risk Communication and Climate Justice Planning: A Case of Michigan's Huron River Watershed

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Abstract
Communicating climate risks is crucial when engaging the public to support climate action planning and addressing climate justice. How does evidence-based communication influence local residents' risk perception and potential behavior change in support of climate planning? Built upon our previous study of Climate Justice maps illustrating high scores of both social and ecological vulnerability in Michigan's Huron River watershed, USA, a quasi-experiment was conducted to examine the effects of Climate Justice mapping intervention on residents' perceptions and preparedness for climate change associated hazards in Michigan. Two groups were compared: residents in Climate Justice areas with high social and ecological vulnerability scores in the watershed (n = 76) and residents in comparison areas in Michigan (n = 69). Measurements for risk perception include perceived exposure, sensitivity, and adaptability to hazards. Results indicate that risk information has a significant effect on perceived sensitivity and level of preparedness for future climate extremes among participants living in Climate Justice areas. Findings highlight the value of integrating scientific risk assessment information in risk communication to align calculated and perceived risks. This study suggests effective risk communication can influence local support of climate action plans and implementation of strategies that address climate justice and achieve social sustainability in local communities.

Keywords
climate change planning; climate justice; risk communication; risk perception; social sustainability; vulnerability

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1. Introduction

As of August 2017, 372 U.S. Mayors representing 67.5 million people in American cities are committed to upholding the Paris Climate Agreement—an agreement within the United Nations Framework Convention on Climate Change to curtail greenhouse gas emission mitigation and to strengthen adaptation and finance—in response to the derailing of the White House's policy on climate change (climatemayors.org). Climate change as-

sociated extreme events (e.g., extreme heat and cold, storms, and droughts) have become more frequent, intense, and uncertain across geographical locations around the globe (Intergovernmental Panel on Climate Change [IPCC], 2014); subsequently, more communities are likely to be exposed to climate change associated hazards and the hardest hit are socially vulnerable groups (e.g., minority populations, the elderly, children, women, people living in poverty or those with low education attainment) (Cutter, Boruff, & Shirley, 2003).

Social ecology studies human-environment relations that reflect psychological, cultural, and institutional context to environmental change and vice versa (Lejano & Stokols, 2013). It provides a holistic frame for examining the dynamic relationship between equity, planning, climate change, and sustainability. Besides environmental and economic sustainability, social sustainability has been overlooked in many U.S. cities. Schrock, Bassett and Green (2015) found that over a hundred cities' sustainability plans failed to include equity as a measurable outcome comparing to extensive measures developed for achieving environmental and economic goals of sustainability. In addition, there is a lack of climate justice outcomes in climate action plans. The deficiency of equity outcomes in public policies implies the need for public support. As climate change adaptation becomes an integral part of urban planning for coping with climate change threats (e.g., municipal climate action plans), identifying strategies for communicating climate change risks and adaptation strategies plays a critical role in engaging the public to support climate planning goals (Hagen, 2016a; Hagen, 2016b; Maibach, Roser-Renouf, & Leiserowitz, 2008; Moser, 2014). One of the goals should address climate justice—the inequitable distribution of burdens and impacts from climate change (Cheng, 2016; Page, 2008)—and equity in local climate planning.

Climate justice was originated from global debates on climate change policies that concern unjust distributions of the causes and burdens of climate change impacts among greenhouse gas emissions contributing countries and countries with lower carbon emissions (e.g., island nations) and suffering the most from environmental changes (e.g., sea level rise) (Page, 2008). Considering unjust social, environmental, and health impacts locally in the U.S., the theory of environmental justice helps to put climate justice in a local planning context. Decades of environmental justice research suggest that racial segregation and discrimination in the U.S. has contributed to placing socially vulnerable groups at disproportionate risk due to toxic and hazardous wastes facilities (Bullard, Mohai, Saha, & Wright, 2007; Mohai, Pellow, & Roberts, 2009; United Church of Christ, 1987), air pollution (Grineski, Bolin, & Boone, 2007), as well as a lack of access to clean water in U.S. cities (Bolin, Seetharam, & Pompeii, 2010). Recent studies have extended environmental justice concepts to climate justice at local scale to include the exposure to climate change associated hazards such as climate change-induced flooding (Cheng, 2013) and extreme heats (Harlan, Brazel, Prashad, Stefanov, & Larsen, 2006) in socially vulnerable communities.

Risk communication connects to sustainability science through the understanding of societal systems via feedbacks from individual-level beliefs and perceptions, as well as identifying communication strategies for improving public engagement with climate change. In turn, societal capacity for anticipating uncertainty can be increased for future planning (Lindenfeld, Smith, Norton, & Grecu, 2014; van der Linden, Maibach, & Leiserowitz, 2015). Communicating risks associated with future climate extremes and adaptation motivates the public to change behavior and support climate planning goals (Moser, 2014; Wolf & Moser, 2011). Moreover, visual representation of scientific evidence is easily comprehended by lay people (Severtson & Henriques, 2009) and offers opportunities for bridging calculated and perceived climate change risks and subsequent behaviors change in support for local planning. This study focuses on the impact of a scientific information intervention on individuals' risk perception of climate change associated extreme events in local communities from planning perspective. To address the linkage between risk communication literature and climate justice planning, we investigated how communicating the notion of climate justice facilitates community's capacity to cope with climate change impacts. Specifically, we examined the effects of an evidence-based visualization (e.g., mapping) intervention on residents' risk perception and potential behavior change in support of climate planning from a case built upon our previous study in Michigan, U.S.

1.1. Risk Assessment, Communication, and Perception

Risk assessment that addresses complex coupled human and natural systems in coping with environmental and social changes can be depicted based on assessment of both ecological vulnerability of a place (e.g., biophysical characteristics susceptible to natural hazards) and social vulnerability (e.g., Birkmann, 2006; Blaikie, 1994; Cutter et al., 2003; Cutter & Morath, 2013). This study built upon previous research on investigating the spatial pattern of climate justice using a *Climate Justice Index* in a social-ecological vulnerability assessment framework (Cheng, 2016) modified from the Hazards-of-Place (HOP) model (Cutter et al., 2003). The HOP model integrates ecological vulnerability (i.e., natural hazards) and social vulnerability (i.e., exposure, sensitivity, and adaptability to hazards) at specific geographic locations and has been widely applied for measuring vulnerability to environmental hazards (e.g., Borden, Schmidtlein, Emrich, Piegorsch, & Cutter, 2007) and assessing climate change associated risks (e.g., climate change-induced flooding risks in Cheng, 2013). Study units (e.g., census tracts) that have high vulnerability scores in both social and ecological vulnerability are defined as "Climate Justice areas" in this study.

The concept of vulnerability involves three interrelated dimensions: 1) exposure to specific social or environmental stresses (e.g., climate change associated hazards), 2) sensitivity to those stresses (e.g., socioeconomic characteristics), and 3) adaptive capacity to cope with impacts from those stresses at multiple institutional scales from an individual to collective adaptive capacity (Adger, 2006; Birkmann, 2006; Polsky, Neff, & Yarnal, 2007). Figure 1 illustrates a theoretical framework of relationships and dimensions of risk assessment, risk perceptions, and risk communication. Risk assessment is measured from social and ecological vulnerability, which includes elements of exposure, sensitivity, and adaptability to climate change associated hazards. The risk information derived from risk assessment can be used in risk communication tools as an intervention to affect risk perceptions, which in turn could affect adaptation behavior change. In the meantime, the feedback loop occurs when local knowledge becomes information that is communicated through scientific analysis and becomes new knowledge for risk assessment.

Social vulnerability reflects the dynamic socioeconomic and cultural structure and fabric of a society which varies from place to place. The complex political and economic systems that result from urbanization often create socially vulnerable groups within society who are more susceptible to various hazards (Blaikie, 1994; Colten, 2006; Cutter et al., 2003). When communities have insufficient coping capacity for shocks and disturbances, they are likely to become more vulnerable to the adverse effects of uncertainty and extreme variation imposed by climate change associated hazards (IPCC, 2014). Measures of adaptability include wealth, education level, migrant status and associated language barriers, and access to social resources (Cutter et al., 2003; Polsky et al., 2007) that can affect preparedness for coping with disasters. Sensitivity can be a factor of demographic background (e.g., age, gender, race, disability), household structure, social resources dependency, economic status (e.g., poverty status, income level, unemployment, agricultural and service dependent occupations), in addition to the built environment context (e.g., housing density, housing structure, infrastructure age) (Polsky et al., 2007).

Ecological vulnerability can be measured through calculated risks (e.g., integration of climate and hydrological models for climate change-induced flooding hazards in Cheng, Yang, Ryan, Yu, & Brabec, 2017). Exposure to hazards, aside from calculated spatial analyses, could be measured through perceived risks (e.g., past experiences of extreme events). The tension between objective and perceived risks affects behaviors and capacity for coping environmental change (Adger, 2006). Studies have shown that demographic background and individual traits can factor into one's perceived risks. Women (Ho, Shaw, Lin, & Chiu, 2008; Whyte, 1986; Zhang, 2010)

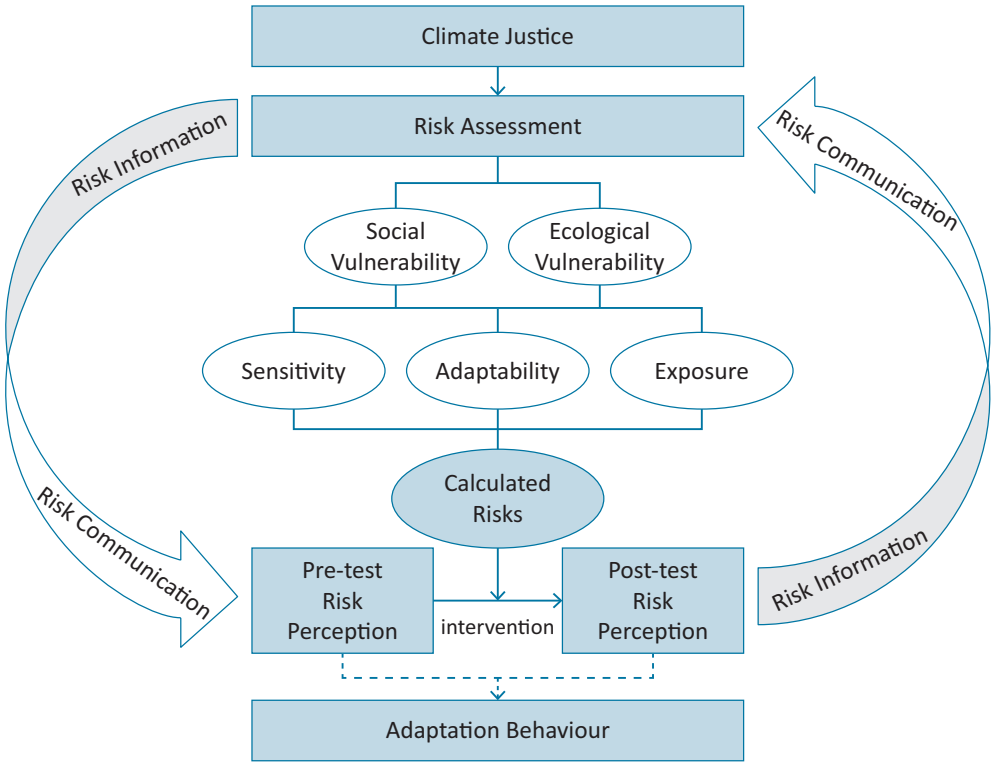


Figure 1. Research framework of relationships between climate justice and dimensions of risk assessment, risk communication, risk perceptions and adaptation behavior. Risk communication using scientifically determined risks (i.e., calculated risks) serves as an intervention in this study to gauge residents' subjective assessment of risk perceptions that affect adaptation behaviors (dashed line indicates using perceived preparedness as a proxy for adaptation behavior).

and the elderly (Alexander, 1998; Whyte, 1986) tend to have increased perceived risks. In general, people who have more experience with hazards tend to think they are more likely to be future victims and have more awareness about the risks (Ho et al., 2008; Weinstein, 1989). On the contrary, people who recently experience disasters tend to have a lower risk perception to future hazards (Ryan & Hamin, 2008; Vinh Hung, Shaw, & Kobayashi, 2007).

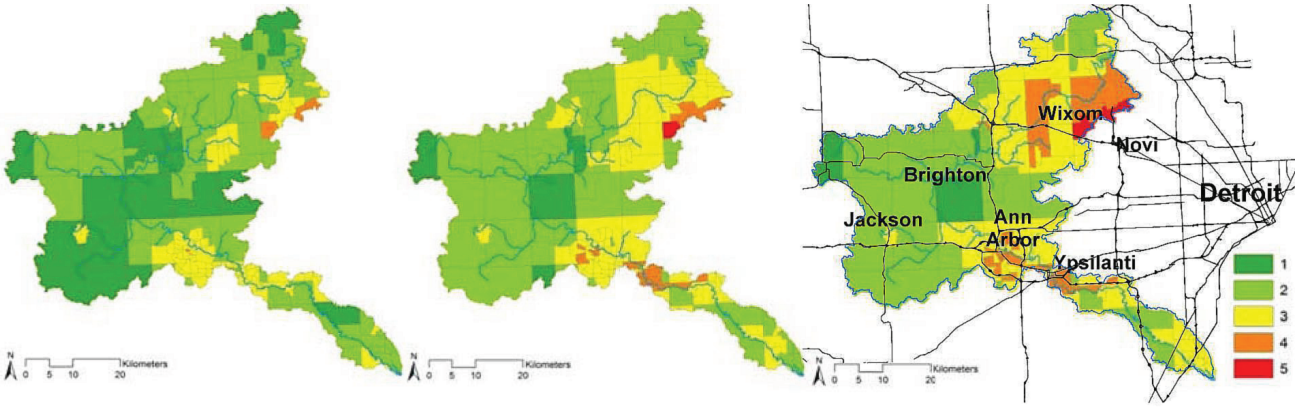
Risk perception is a key determinant of people's behavioral responses to combat climate change (e.g., Maibach et al., 2008). The factors that affect risk perception are also strongly related to hazard mitigation, preparedness, and adaptation behaviors. For example, education and past experiences to disasters are both positively correlated with risk perceptions and flood preparedness (Mishra & Suar, 2007). Those sociodemographic indicators that affect risk perception also are included in the indicators of social vulnerability (e.g., SoVI by Cutter et al., 2003; Cutter & Morath, 2013). Therefore, risk perception serves as a mediator between the explanatory factors of risk assessment and adaptation behavior.

1.2. Research Framework and Hypotheses

This study investigated how visual communication such as mapping of climate vulnerability based on scientific evidence can influence risk perception and subsequent adaptation actions among local residents (Adger et al., 2009.; Lu et al., 2016; Safi, Smith, & Liu, 2012). Vulnerability mapping has been identified as an effective tool to support urban planning and to inform the public about local climate change impacts (Preston, Yuen, & Westaway, 2011). We utilized mapping as a visualization tool in risk communication with climate justice information derived from a previous study in the Huron River watershed in southeastern Michigan (Cheng, 2016; Xu et al., 2017) as a risk information intervention (Figure 2). The *Climate Justice Index* was represented in a 5-scale ranking. The orange (scale = 4) and red (scale = 5) colors indicate places where 1) flooding is more likely to occur as the climate changes, 2) there is a greater threat of environmental hazards occurring based on the presence of contaminated sites, waste disposal facilities etc., and 3) a higher portion of the population is vulnerable to disasters (the elderly, children, minorities, etc.). In other words, a higher ranking represents a community having greater social and ecological vulnerability under climate change impacts. In this study, these highlighted areas are referred to as "Climate Justice areas" and we focus on the three cities they contain largely: Ann Arbor, Ypsilanti, and Wixom.

We compared samples from two groups: 1) residents living in the zip codes or cities that contain large "Climate Justice areas" identified in Figure 2, and 2) residents in Michigan zip codes that do not contain Climate Justice areas as "comparison areas."

Our study explored the following questions: 1) how well are residents aware of their climate risks and social and ecological vulnerability to climate change; and 2) to what degree does climate risk information affect residents' perceptions and adaptation behaviors? Taken together, we hypothesized that the communication of visualized risk information would increase individuals' awareness of climate associated hazards and decrease their perceived levels of preparedness to respond to future extreme events, especially in Climate Justice areas.



(a) Baseline (Current Conditions)

(b) Lower Climate Change Impact (Better case scenario)

(c) Higher Climate Change Impact (Worse case scenario)

Figure 2. The Climate Justice maps as included in the survey illustrate the results from a previous study conducted for the Huron River watershed in Michigan, which found various degrees of climate change impacts of flooding and associated environmental hazards (Cheng, 2016; Xu et al., 2007). The following texts were used in the survey to describe the maps: "The color represents a 5-scale ranking and the orange (scale = 4) and red (scale = 5) colors indicate places where 1) flooding is more likely to occur as the climate changes, 2) more environmental hazards occur (contaminated sites, waste disposal facilities etc.), and 3) a higher portion of the population is vulnerable to disasters (elderly, children, minorities, etc.)."

Hypothesis 1: The effect of risk mapping intervention on perceived exposure will be more pronounced for residents who live in Climate Justice areas than for those in comparison areas. Residents receiving the risk information intervention will report higher ratings of perceived exposure to climate change associated extreme events than their pre-intervention scores, particularly in Climate Justice areas.

Hypothesis 2: The effect of risk mapping intervention on perceived sensitivity will be more pronounced for residents who live in Climate Justice areas than those in comparison areas. That is, residents receiving the risk information intervention will report higher ratings of perceived sensitivity to extreme events than their pre-intervention scores, particularly in Climate Justice areas.

Hypothesis 3: The effect of risk mapping intervention on perceived adaptability will be more pronounced for residents who live in Climate Justice areas than those in comparison areas. That is, residents receiving risk information intervention will report lower ratings of perceived adaptability than their pre-intervention scores, particularly in Climate Justice areas.

2. Study Area and Background

The Huron River watershed is located southwest of the Detroit metropolitan area in Michigan, U.S. The Huron River Watershed Council (HRWC), a not-for-profit organization dedicated to river protection, has served the watershed communities since 1965. HRWC runs several scientific programs, outreach and education, and watershed management projects that engage with the public, local stakeholders, and governments to influence decision-making and strengthen stewardship of the watershed. In recent years, in an effort to build climate-resilient communities, HRWC brought together scientists, policy advisors, and local practitioners to improve stormwater management, public awareness of drinking water safety, and green infrastructure implementation.

In collaboration with HRWC, our research team integrated hydrological modeling (Xu et al., in press), environmental justice, and social vulnerability sciences to develop a Climate Justice Index forecasting the probability and spatial distribution of climate change-induced flooding hazards in the next fifty years in addition to water quality impairment and social vulnerability implications (see detailed methods in Cheng, 2016).

The social-ecological vulnerability assessment included in the *Climate Justice Index* was conducted in the census tract level, rather than specific cities. However, local planning relies on municipal governance and the assistance of regional planning agencies such as the HRWC. To understand the context of social and institutional capacity in coping with climate change (e.g., sensitivity and adaptability measures), Table 1 summarizes commonly used social vulnerability indicators from U.S. Census data across the Huron River watershed (HRW), the three cities that contain large Climate Justice areas in the watershed, the state of Michigan, and the entire U.S.

Overall, the populations of young children, the elderly, and women in the HRW are comparable to the demographics of the state and the nation. Older adult populations are slightly relatively smaller in the three cities (11.9% in HRW compared to 9.3% in Ann Arbor and 7% in Wixom) whereas Wixom has slightly more children (6.8% comparing to 5.4% in HRW and 4.3% in Ann Arbor). The watershed is predominately white (83.5%) while the three cities are more diverse. Ypsilanti and Wixom have a larger African American population (29.2% and 11.1% respectively compared to 8.1% in the HRW) while Ann Arbor has more Asians (14.4% compared to 4.8% in HRW) and Wixom has slightly more Hispanics (4.3% compared to 2.6% in HRW). In general, the HRW has a smaller population without a high school diploma (6.7% compared to 10.4% in Michigan and 13.3% in USA), yet Ypsilanti is higher than the HRW in percentage of its population (9.9%) with lower education attainment. In addition, the three cities also have significantly more renters, which are generally more vulnerable to disasters, than the HRW (69.1% in Ypsilanti, 55.2% in Ann Arbor, 49.3% in Wixom compared to 27.7% in HRW). Michigan's median household income is $49,576 in 2015 dollars with 15.8% of the population in poverty, compared to $46,420 and 15.4% in Wixom, $31,061 and 33.4% in Ypsilanti, and $55,990 and 23.4% in Ann Arbor. Ypsilanti has the lowest median housing values and lowest per capita income among all study areas, Michigan, and the U.S., in addition to its high poverty rate (33.4% compared to 23.4% in Ann Arbor, 15.4% in Wixom, 15.8% in Michigan, 13.5% in the U.S., and the lowest of 11.6% in the HRW).

3. Method

3.1. Study Design and Participant Recruitment

We conducted a *quasi-experiment* with the nonequivalent pretest-posttest design by recruiting adults over 18 years old living in Michigan to assess the impacts of climate risk mapping intervention. The between-subject factor is participants' current area of residency in two groups: 1) Climate Justice areas and 2) comparison areas (defined in Section 1.2). The within-subject factor is *Time*—pre- vs. post-receipt of Climate Justice mapping intervention (shown in Figure 2).

The term *quasi-experiment* was firstly coined by Cook and Campbell (1979) to describe an approximation of a true randomized experiment where researchers have absolute control over randomly assigning participants to two or more treatment conditions. The process of randomization ensures internal validity for testing effects of a treatment by isolating between-group variations (Leedy & Ormrod, 2010). As described by Shadish, Cook & Campbell (2002), quasi-experiments share the similar advantage of true experiments: "to test descriptive causal hypotheses about manipulable causes (p. 14)."

Table 1. Summary of commonly used socio-economic indicators of social vulnerability in U.S. census data across the Huron River watershed (HRW), three cities containing large Climate Justice areas in the watershed (Ann Arbor, Ypsilanti, and Wixom), the state of Michigan, and the U.S.

Indicators	HRW	Ann Arbor	Ypsilanti	Wixom	Michigan	USA
Population[a]	812,170*	113,934	19,435	13,498	9,883,640	308,745,538
Age and Sex						
Persons under 5 years old, percent[a]	5.4	4.3	4.9	6.8	6.0	6.5
Persons 65 years old and over, percent[a]	11.9	9.3	8.3	7.0	13.8	13.0
Female persons, percent[a]	50.6	50.7	50.3	50.1	50.9	50.8
Race						
African American, percent[a]	8.1	7.7	29.2	11.1	14.2	12.6
Native American, percent[a]	0.2	0.3	0.6	0.2	0.6	0.9
Asian, percent[a]	4.8	14.4	3.4	4.9	2.4	4.8
Two or More Races, percent[a]	2.7	4.1	3.9	5.1	4.4	16.3
Hispanic or Latino, percent[a]	2.6	3.6	2.1	4.3	2.3	2.9
White, percent[a]	83.5	70.4	59.4	77.0	76.6	63.7
Housing						
Housing density[b]	903	1789	2141	719	80	37
Renter-occupied housing unit rate[c]	27.7	55.2	69.1	49.3	29.0	36.1
Median value of housing units[d]	$190,233	$240,700	$118,000	$191,300	$122,400	$178,600
Median gross rent[d]	$848	$1,063	$746	$644	$783	$928
Education						
Age 25 years+ with no high school diploma, percent[e]	6.7	3.6	9.9	5.8	10.4	13.3
Economy						
Age 16 years+ in civilian labor force, percent of total population[d]	53.6	61.1	69.4	77.1	61.2	63.3
Age 16 years+ female, percent of total civilian labor force[d]	62.4	57.8	67.3	70.8	57.1	58.5
Income and Poverty						
Per capita income in past 12 months[f]	$33,018	$36,334	$22,346	$32,085	$26,607	$28,930
Persons in poverty, percent[d]	11.6	23.4	33.4	15.4	15.8	13.5

* HRW population was estimated based on entire census tracts that are intersected with the watershed without area appropriation adjustment. This estimate is greater than HRWC's estimate of a 600,000 population within the watershed boundary only.

[a] U.S. Census 2010 for U.S., Michigan, Ann Arbor, Ypsilanti, and Wixom; U.S. Census 2009–2013 estimate for HRW census tracts mean (n = 220).

[b] calculated from total population/total square miles from data source (a)

[c] calculated from 100%–%owner occupied housing unit rate of data source (d)

[d] U.S. Census 2011-2015 estimate for U.S., Michigan, Ann Arbor, Ypsilanti, and Wixom; U.S. Census 2009–2013 estimate for HRW census tracts mean (n = 220)

[e] calculated from 100%–%high school graduate or higher of persons age 25 years+ from data source (d)

[f] U.S. Census 2011-2015 estimate in 2015 dollars for U.S., Michigan, Ann Arbor, Ypsilanti, and Wixom; U.S. Census 2009-2013 estimate in 2013 dollars for HRW census tracts mean (n = 220)

However, quasi-experiments do not assign individuals to treatment conditions randomly. In applied social science, random assignment of study participants is often not feasible. Accordingly, this method is the preferred method to evaluate the effects of educational programs in schools, community-based health interventions, and risk communication programs for natural hazards (e.g., Tanaka, 2005; Terpstra, Lindell, & Gutteling, 2009).

In summary, the nonequivalent pre- and post-intervention design in quasi-experimental studies offer several methodological advantages. First, a quasi-experiment is the most sensible way to answer our research questions as random sampling of assigning participants to different areas of residency was not applicable. Second, incorporating a pre-intervention assessment offers the possibility for controlling initial participants' de-

mographic differences due to self-selection (Shadish et al., 2002). Third, the mean differences between treatment (Climate Justice areas) and comparison (comparison areas) groups allows us to estimate the effects of a risk mapping intervention on perceived risk of extreme events (Cook & Campbell, 1979).

We conducted a web-based survey using a convenience sample (i.e., non-random sample) of Michigan residents. Survey responses were collected during October 2016 and January 2017 using the professional software *Qualtrics*. In order to yield sufficient statistical power to detect accurate and reliable inferences, participants were solicited using multiple ways to reach a sample size required in experimental designs. Statistical power is critically important to experimental studies, as it represents the probability of finding an observed difference between two groups when a difference actually exists (Oakes & Feldman, 2001). According to Guo et al. (2013), a sample size of 40 participants per treatment group was our target to yield a statistical power of at least 0.80 for assessing the significance of a *Time by Treatment* interaction in our repeated measures design.

Participants living in the Huron River watershed were recruited through a liaison in HRWC since the project outcomes can advance HRWC's efforts in assisting communities in the watershed for developing their climate action plans and implementing adaptation strategies. In October 2016, the liaison distributed the first wave of invitation emails to members of HRWC who subscribe to HRWC's electronic newsletters. The first solicitation email went to 6,488 recipients, 1,428 opened the newsletter, and 34 clicked on the embedded survey link. The second wave of invitation emails was sent out in November, and 28 more HRWC members clicked on the survey website. In addition, we recruited participants through social media platforms such as public community-based Facebook pages in targeted three cities as well as other local community groups (e.g., *Taiwanese in Michigan*).

The quasi-experiment consisted of the following three procedures. First, participants responded to a range of demographic characteristics associated with social vulnerability to hazards such as age, gender, race, employment status, housing status, educational attainment, length of living in the community, and past experiences. Second, questions were asked to reveal their risk perceptions before receiving the risk mapping intervention and to indicate how well they feel connected with their communities. Third, both groups received the same intervention derived from the previous climate justice study in the watershed. During the intervention, participants were instructed to read the scientific study results carefully and not allowed to click back in previous survey questions. Lastly, participants finished surveys with measures of risk perceptions and behavioral intention to support climate change actions in city policies such as implementing green infrastructure instruments.

3.2. Characteristics of Study Participants

Of the 241 adults that attempted the online survey, a total of 149 completed questionnaires (response rate = 62%) with no missing values. Among completed samples, four cases were excluded because they did not indicate their zip code within Michigan when they took the survey, resulting in 145 valid cases for final analysis. Among valid samples (N = 145), 52% (n = 76) reside in Climate Justice areas (6.6% from Wixom, 30.2% from Ypsilanti, 63.2% from Ann Arbor) and 48% (n = 69) are from comparison areas (26.1% within the Huron River watershed and 73.9% outside the watershed area but within Michigan). The decision to include respondents living outside the watershed in the comparison group was driven by two reasons. First, since the hydrological modeling did not project social-ecological vulnerability outside the watershed, participants from these areas are assumed to not be affected by the Climate Justice mapping intervention, which made them equivalent to a control condition that received no treatment. Second, we included more eligible participants into the comparison group to give us more statistical power to detect smaller effect sizes (Oakes & Feldman, 2001).

The majority of respondents are female (70.3%) and white (73.1%). The average age is 35–44 years old. In terms of ethnicity, 11.7% are African Americans; 2.8% Hispanics; 7.6% Asians. The relatively larger Asian participants in our sample represent a higher Asian population in Ann Arbor. All participants have a high school diploma and 7.6% have an associate's degree, 29.7% have a bachelor's degree, 46.2% have a master's degree and 11.7% have a doctorate degree. Our samples represent higher education attainment than Michigan's 26.9% of bachelor's degree or higher education population, which is comparable to 39.1% in Ypsilanti, 41.2% in Wixom and reflects the exceptionally high 71.9% in Ann Arbor, a city with a public research university. Approximate 63% live in an owned property. Participants varied in the annual household income (median income = $60k~79k), and about 23% report the income level of more than $100K.

Table 2 summarizes social vulnerability indicators comparing sample characteristics between Climate Justice areas and comparison areas. Participants of two respective groups did not significantly differ (p-value less than 0.05) in their age, gender, educational level, household income, length of residence in the community, and the elder and youth composition in their households. Nevertheless, samples from Climate Justice areas did present a significantly higher percentage of socially vulnerable population of renters (46.1% vs. 27.5%) and part-time employees (25% vs. 7.2%), whereas samples in comparison areas have more African Americans (21.7% vs. 2.6%).

3.3. Survey Measures

The complete survey includes six sections with a total of 41 questions: 1) demographic information; 2) past expe-

Table 2. Summary of demographics associated with social vulnerability comparing among all samples and two groups (Climate Justice areas and comparison areas).

Selected Social Vulnerability Indicators from 33 variables in Cheng, 2016	**All samples** (N = 145)	**Comparison** (n = 69)	**Climate Justice** (n = 76)	**Chi-Square** (*p*-value * < 0.05)
Age and Gender				
Household with more than one person under 14 years old	23.4	27.5	19.7	1.61 (0.806)
Household with more than one person of 65 years and over	19.3	23.1	15.8	1.28 (0.527)
Women	70.3	75.4	65.8	1.20 (0.274)
Race				
African American	11.7	21.7	2.6	12.76*(0.000)
Asian	7.6	7.2	7.9	0.02 (0.883)
Hispanic	2.8	2.9	2.6	0.01 (0.922)
Two or more races	4.8	4.3	5.3	0.06 (0.797)
White	73.1	63.8	81.6	5.84*(0.016)
Housing				
Owners	62.8	72.5	53.9	5.31*(0.021)
Renters	37.2	27.5	46.1	
Homeowner property insurance	61.4	69.6	53.9	3.72 (0.054)
Renters insurance	24.1	20.3	27.6	1.07 (0.302)
Education				
High school	4.8	2.9	6.6	6.53 (0.163)
Associate's degree	7.6	13.0	2.6	
Bachelor's degree	29.7	29.0	30.3	
Master's degree	46.2	44.9	47.4	
Doctorate degree	11.7	10.1	13.2	
Economy: Employment status				
Employed, full-time	60	66.7	53.9	2.44 (0.118)
Employed, part-time	16.6	7.2	25	8.25*(0.004)
Retired	16.6	20.3	13.2	1.33 (0.248)
Others(Including not-employed and disabled)	6.9	5.8	7.9	0.25 (0.619)
Economy: Annual household income level				
Less than $20,000	11.7	11.6	11.8	6.11 (0.296)
$20,000-$39,999	15.9	15.9	15.8	
$40,000-$59,999	18.6	26.1	11.8	
$60,000-$79,999	20.0	14.5	25	
$80,000-$99,999	10.3	10.1	10.5	
More than $100,000	23.4	21.7	25	
Residency in the community/city				
Less than 1 year	6.2	7.2	5.3	6.78 (0.238)
1–5 years	30.3	24.6	35.5	
5–10 years	13.1	17.4	9.2	
10–20 years	18.6	14.5	22.4	
20–30 years, percent	13.8	13	14.5	
More than 30 years, percent	17.9	23.2	13.2	

rience to extreme events and perceptions of future risks; 3) perceived responsible parties for risk management; 4) beliefs and behaviors regarding green infrastructure implementation; 5) Climate Justice maps and risk perception and behaviors; and 6) attitudes and emotions toward climate change. Major measurement of risk perceptions demonstrated satisfactory internal consistencies. All these questions were rated on a 5-point Likert scale ranging from 1 (very unlikely/very vulnerable/not well at all) to 5 (very likely/ very vulnerable/extremely well)

(Kaplan & Kaplan, 1989). To ensure measurement reliability and validity of the survey scales, we conducted a pilot study with a total of 187 college students enrolled in two public Southwestern Universities in early October 2016. After obtaining voluntary consent, student completed the baseline assessments, mapping intervention, and answered posttest questionnaires online to receive extra credits for courses. The pilot study provided feedback on question wording to help improve the survey's organization and clarity.

This study focused on comparing participants' ratings of perceived risk associated with climate change impacts pre- and post-receiving the intervention. Table 3 summarizes a selected set of questions comparing risk perceptions across past experience, pre-intervention, and post-intervention temporal scales and in responding to the three dimensions of vulnerability concepts—exposure, sensitivity, and adaptability.

Perceived exposure was assessed using two identical items in pre- and post-intervention (Terpstra et al., 2009): "How likely do you think you may experience any one of those extreme events in the next 10 years?" Examples of possible extreme events included storms, floods, droughts, extreme heat or cold, tornadoes, and forest fires, in addition to an option of "others" with a write in for other types of extreme events that were not listed. Perceived sensitivity was captured by a single-item measure: "Based on your experience, how vulnerable do you consider your community is to future extreme events?" Finally, participants were asked the extent to which they feel well-prepared for future extreme events as a proxy for measuring perceived adaptation in this study. This study applied selected questionnaires rather than using comprehensive indices for measuring each dimension of perceived vulnerability.

3.4. Statistical Analysis

All Michigan residents who completed the pre-intervention and post-intervention measures were included in the analyses (N = 145). No data points were missing. Descriptive statistics were used to report mean and standard deviation for interval/ratio variables and percentage frequencies for nominal measurement. The assumption of univariate normality was met for dependent variables.

To evaluate the effects of the Climate Justice mapping intervention on participants' perceived exposure, sensitivity, and adaptability scores over time, we performed a series of statistical analyses including repeated measures and mixed model analysis of variance (ANOVA). In each of these mixed models, *Group* (Climate Justice areas or comparison areas) served as the between-subject factor and *Time* (pre- vs. post- intervention) as the within-subject factor. As recommended by O'Brien and Kaiser (1985), using the multivariate approach of the general linear model test to conduct the repeated measures mixed ANOVA is robust for testing the main effects of between-subject and within-subject factors. More importantly, it examines the *Group X Time* interaction to indicate that the Climate Justice areas and comparison group differed in the change over time of their perceptions of risk to climate associated hazards. Effect size was computed using partial eta squared: 0.01, 0.06, and 0.14 indicate

Table 3. Summary of measurement of risk perceptions aligned with dimensions of vulnerability—perceived exposure, sensitivity, and adaptability—across temporal scales of past experience, pre-intervention and post-intervention.

	Exposure	**Sensitivity**	**Adaptability**
Past Experience	2-1. Please indicate the most recent extreme events that you have experienced during the period of time you have lived in this community/city.		2-3. In general, how well were you prepared to respond to the latest extreme events?
Pre-Intervention	2-5. How likely do you think you may experience any one of those extreme events in the next 10 years?	2-7. Based on your experience, how vulnerable do you consider your community is to future extreme events?	2-8. Since the last event, how well have you prepared to respond to future extreme events?
Post-Intervention	5-1. After viewing the results of the previous study, how likely do you think you are to experience an extreme event(s) (e.g., floods, droughts, extreme cold and heat) associated with climate change in the next 10 years?	5-3. After viewing the results of the previous study, how vulnerable do you consider your community to future extreme events?	5-4. After viewing the results of the previous study, how well have you prepared to respond to future extreme events?

small, medium, and large effects respectively (Cohen, 1988). All analyses were performed in *SPSS Version 24*. An alpha level of 0.05 was used to determine statistical significance.

4. Results

As reported in Table 4, means and standard deviations for three indicators of vulnerability in the pre- intervention baseline showed that participants reported high levels of perceived exposure (M = 4.41, SD = 0.89), moderate levels of perceived sensitivity (M = 3.70, SD = 1.02), and moderate ratings of perceived adaptability (M = 3.33, SD = 0.99). In addition, respondent from Climate Justice areas had slightly higher levels of perceived exposure (M = 4.57, SD = 0.74) than that of comparison group (M = 4.25, SD = 1.01, t(143) = 2.16, p = 0.032). No significant differences were found between two groups in their pre-intervention scores of sensitivity (t(143) = 1.30, p = 0.195), preparedness for past extreme climate change associated hazard events (t(143) = 0.25, p = 0.806), and adaptability for future extreme events (t(143) = 0.89, p = 0.373).

The first hypothesis stated that risk communication intervention increased respondents' perceived exposure to climate change risk, and the effect was stronger among individuals living in Climate Justice areas. A two (*Group*: Climate Justice areas vs. comparison areas, between-subject factor) by two (*Time*: pre-intervention vs. post-intervention, within-subject factor) mixed ANOVA revealed a significant main effect of *Time* (F(1, 143) = 9.61, p = 0.002, partial η^2 = 0.063). Contrary to our prediction, participants judged the likelihood to experience extreme events in the next 10 years after the intervention (M = 4.13, SD = 1.10) to be significantly lower than they did in the pre-intervention (M = 4.41, SD = 0.89) (Table 4). The main effect of group was significant (F(1, 143) = 8.61, p = 0.004, partial η^2 = 0.057). On average, respondents living in the Climate Justice areas reported significantly higher levels of perceived exposure (M = 4.46, 95% CI: 4.28–4.64) than did those who lived in other comparison areas (M=4.07, 95% CI: 3.87–4.25). Notably, both groups' perceived exposure to extreme events decreased significantly after reading the Climate Justice mapping intervention, indicating an opposite trend of our hypothesis. Last, the interaction effect of group by time interaction on perceived exposure was not significant (Figure 3). Therefore, Hypothesis 1 was not supported.

The second hypothesis predicted that an increase in participants' perceived sensitivity assessment as a result of the intervention differed between two groups. As shown in Table 5, the results support Hypothesis 2 with a significant *Group* × *Time* interaction effect (F(1, 143) = 10.02, p = 0.002, partial η^2 = 0.065) and a significant linear effect of *Time* (F(1, 143) = 10.02, p = 0.002, partial η^2 = 0.065. The results indicate that the Climate Justice mapping intervention significantly increased participants' scores of perceived sensitivity from 3.70 (95% CI: 3.54–3.87) to 3.96 (95% CI: 3.80–4.10). The impact of risk communication intervention on increasing perceived sensitivity was stronger among respondents living in Climate Justice areas than those residing in other comparison areas. Figure 4 indicates that that the mapping intervention has substantially elevated residents' concerns about community's vulnerability to future extreme events in Climate Justice areas, while participants from comparison areas experienced no change on this scale. Thus, we concluded that Hypothesis 2 was supported.

The third hypothesis assumed the residents in Climate Justice areas would have lower scores in perceived adaptability after the intervention than participants from other Michigan cities. As shown in Figure 5, analysis of the changes in adaptability using a mixed ANOVA indicates a significant main effect of *Time* (F(2,286) = 32.86, p = 0.000, η^2 = 0.187) suggesting that 18.7% of multivariate variance of perceived adaptability ratings is associated with the pre-intervention and post-intervention factor. The main effect of *Group* and *Group by Time* interaction effect were not significant. Two groups did not differ significantly in ratings of preparedness at pretest (t(143) = 0.89, p = 0.373) and posttest (t(143) = 1.37, p = 0.174). All participants reported significantly lower levels of preparedness in response to future extreme events after receiving the risk information intervention (M = 2.65, 95% CI: 2.49–2.82) than they did

Table 4. Means and standard deviations for three dimensions of vulnerability for participants in climate justice and comparison areas at pre- and post-intervention.

	Exposure		**Sensitivity**		**Adaptability**		
Intervention	Pre- M (SD)	Post- M (SD)	Pre- M (SD)	Post- M (SD)	Past M (SD)	Pre- M (SD)	Post- M (SD)
Climate Justice areas (n = 76)	4.57 (−0.74)	4.36 (−0.84)	3.59 (−1.01)	4.09 (−0.8)	3.32 (−0.93)	2.78 (−1.02)	2.54 (−1.04)
Comparison areas (n = 69)	4.25 (−1.01)	3.88 (−1.29)	3.81 (−1.02)	3.81 (−1.05)	3.28 (−1.06)	2.93 (−1.02)	2.77 (−0.97)
All sample (N = 145)	4.41 (0.89)	4.13 (−1.1)	3.7 (−1.02)	3.96 (−0.93)	3.3 (−0.99)	2.85 (−1.02)	2.65 (−1.01)

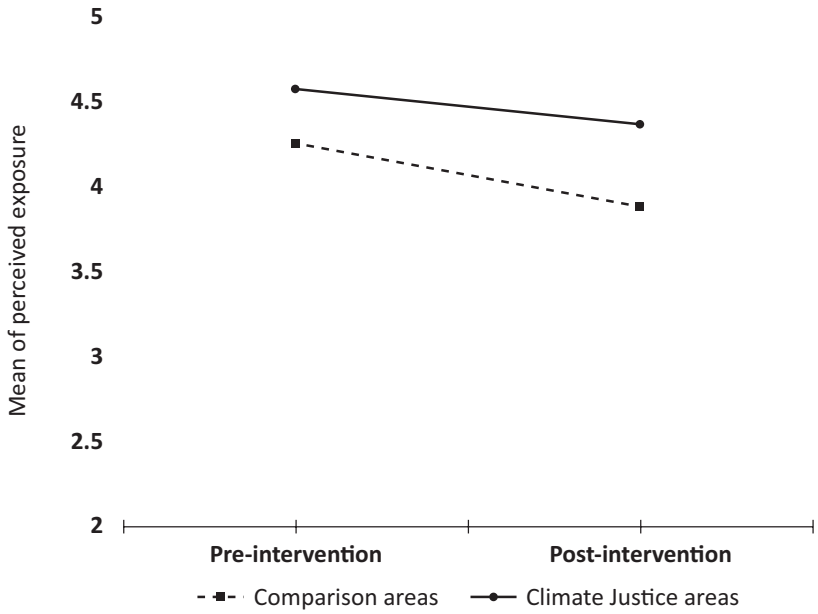


Figure 3. The effects of the Climate Justice mapping intervention and group on participants' ratings of perceived exposure to future extreme events.

Table 5. Repeated measures mixed ANOVA analysis on participants' ratings of perceived sensitivity.

Effect	MS	df	F	p	Partial eta squared
Time	4.52	1	10.02	0.002	0.065
Group	0.07	1	0.05	0.829	0.000
Time × Group	4.52	1	10.02	0.002	0.065
Error	64.5	143			

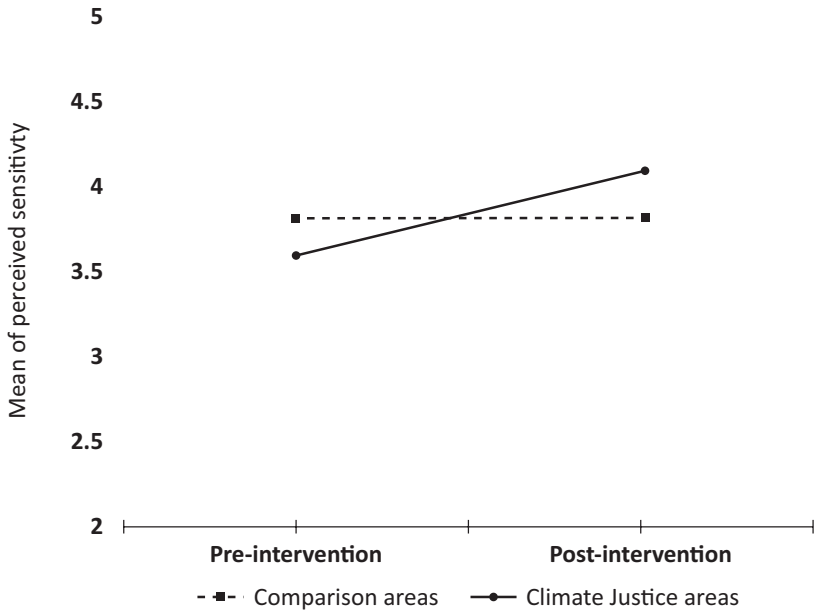


Figure 4. The effects of Climate Justice mapping intervention and group on participants' scores of perceived sensitivity to future extreme events.

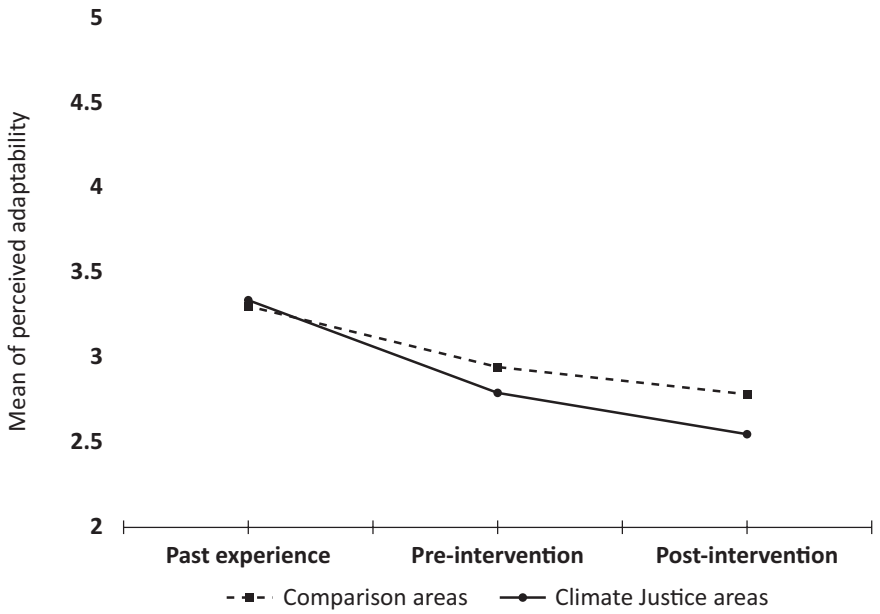


Figure 5. The effects of Climate Justice mapping intervention and group on participants' ratings of perceived preparedness for future extreme events.

before reading the Climate Justice maps (M = 2.85, 95% CI: 2.69–3.02). Hence, Hypothesis 3 was partially supported with a general trend of lower perceived adaptability ratings after receiving the intervention regardless of participants' residency in Climate Justice areas or not.

5. Discussion

5.1. Calculated vs. Perceived Climate Justice

In contrast to our predication, results from Hypothesis 1 indicated that risk mapping intervention significantly decreased participants' perceived likelihood of experiencing extreme events in the next 10 years. One possible explanation could be that recent past experience (e.g., less than 5 years) can lower people's perceived possibilities of encountering extreme events in the near future (e.g., in 10 years) (Ryan & Hamin, 2008; Vinh Hung et al., 2007). Our survey instrument also asked one question about past experience with extreme events: *Please indicate the most recent extreme events that you have experienced during the period of time you have lived in this community/city?* Seven time period options included none, less than a year ago, 1–5, 5–10, 10–20, 20–30, and more than 30 years ago. Specifically comparing flooding hazard that was included in the Climate Justice mapping intervention, over half of the samples (55%) have experienced floods within the past five years. Respondents' recent personal experience with flooding might lead to engaging in temporal and spatial discounting psychologically after the intervention (van der Linden et al., 2015). That is, people tend to view climate change associated risks as a distant future threat. In addition, negative impacts are more likely to be more serious for other people and communities than for themselves.

Notably, residents in Climate Justice areas did perceive higher likelihood of exposure to future climate change associated hazards in addition to being more vulnerable and less prepared in general. Results imply that people who are identified as socially vulnerable to climate change associated hazards may indeed perceive themselves to be more vulnerable. Since most literature using vulnerability mapping focusing on ecological or biophysical vulnerability of a place without including social vulnerability or justice impacts, this research presents a novel approach in combining both social and ecological vulnerability into climate justice mapping for risk perception and behavioral science studies. Our findings could support climate change and equity planning through the alignment of calculated and perceived climate justice at a local scale. The large gap between the calculated and perceived climate justice (e.g., high calculated social-ecological vulnerability areas with population of low perceived climate justice) implies the community is potentially at high risks to climate change associated hazards. Climate justice planning should focus on reducing the gap to lower both social and ecological vulnerability through prioritizing strategies to mitigate hazards and make resources assessable to socially vulnerable groups. Subsequently, socially vulnerable communities that lack support in risk management and adaptability to cope with changes can be addressed in climate justice planning.

5.2. Reframing Climate Justice for Planning

Environmental justice theory, which is largely based on environmental racism presented in the U.S., was initially employed for framing climate justice at the local scale in this study. Unlike typical environmental justice cases

in which minority neighborhoods are targeted for hazardous waste disposal and unwanted land uses, natural hazards and climate change associated extreme events such as hurricanes, floods, droughts, heat waves, and extreme cold, do not target any particular population. In addition, the Social Vulnerability Index (SoVI) presented in the previous study (Cheng, 2016) applied 33 indicators, including not only demographic and socio-economic variables but also built environment variables such as urban/rural population, building structure (e.g., mobile home), housing density, and social infrastructure such as per capita number of community hospitals. SoVI was calculated using a series of statistical methods including standardization and principal component analysis. Substantial research has revealed vulnerability of a place reflects socio-economic characteristics and accumulated racial divide and inequitable planning practices throughout the urban development history in the U.S. (e.g., Colten, 2006; Bolin et al., 2010). The unequal adaptive capacity as a result of societal context should serve as the fundamental framing for climate justice, not race or environmental justice theory alone. Therefore, SoVI implies a dynamic and complex nature of societal context that varies from place to place and changes upon different units of comparison. We do not intend to use SoVI for identifying specific variables for representing social vulnerability; on the contrary, SoVI serves as a tool to gauge potential decline of social services and adaptive capacity of a place in coping with environmental and societal stresses. This study revealed the values of using social science research methods such as surveys and interviews to complement or contrast quantitative tool such as SoVI. Having comprehensive understanding of social vulnerability at various institutional levels from individual, neighborhood, municipal to regional governance can assist prioritizing resources in climate change planning and address climate justice.

5.3. Risk Communication, Climate Justice Planning, and Sustainability

Climate justice emphasizes social impacts of inequitable burdens from the impacts of climate change associated hazards. Social sustainability can be accomplished through: a) attainment of social justice and the sustainability of communities (e.g., social capital, social cohesion), b) cultivation of behavior changes to achieve environmental sustainability goals; and c) maintenance of the socio-cultural characteristics of the community in the face of change, and the ways in which people actively embrace or resist those changes (Vallance, Perkins, & Dixon, 2011). Therefore, addressing climate justice works toward achieving social sustainability. To this end, risk communication plays a vital role in urban planning for facilitating the development and influencing public behaviors to reduce greenhouse gas effects—climate change mitigation—while becoming more resilient in coping with change and uncertainty—climate change adaptation (Hagen, 2016b). Based on the findings from this study, we recommend the following for urban planners in pursuit of climate justice planning and social sustainability:

- *Make residents scientifically informed*. This study demonstrated the positive effects of using well-presented empirical and scientific information as interventions in communicating risks and influencing people's risk perceptions and behaviors. Engaging stakeholders and residents in place-based risk assessment and climate justice analysis should be integrated into spatial planning and be made easily accessible and understandable for the general public. Additional efforts should be made to reach out socially vulnerable groups.
- *Reduce the gap between calculated risks and perceived risks*. Planners should be alarmed when the gap between calculated risks and perceived risks among residents, planners, and decision-makers is substantial. Each level of institutional capacity can make significant impacts on the development and implementation of climate action plans. This study revealed mixed results that vulnerable populations would tend to have higher levels of perceived exposure, sensitivity, and lower levels of perceived adaptability to climate change associated hazards. Calculated social vulnerability indicators may initially serve as a planning tool; nevertheless, ground-truthing using risk communication to gauge people's risk perception and adaptive behavior is even more valuable and necessary.
- *Assist residents to be prepared*. Our findings suggest that residents felt significantly less prepared after receiving risk information that they are likely to be exposed to future climate change associated hazards. This implies local Michigan respondents may not be well informed about where and how to access risk information and management resources. In turn, they may perceive themselves to be less prepared for coping with uncertainties of future extreme events. Planners should incorporate education and outreach programs that outline risk information and access to currently available risk management resources in climate action plans. In particular, plans shall outline proposed expansion of community resources in risk management and climate change adaptation for vulnerable populations.
- *Improve risk communication to facilitate decision-making*. This study supports the strong relationship between an evidence-based intervention and local resident's risk perception. By acknowledging scientific information and understanding risks, vulnerable populations can make informed decisions that support planners' efforts in climate action plans and implementation. Our results suggest residents in Climate Justice areas given the cli-

mate justice mapping did perceive lower preparedness to climate change impacts compared to their pre-intervention scores. The same pattern was consistent among residents in comparison areas where have higher percentages of African Americans likely living outside the Huron River watershed boundary (e.g., part of Detroit's 82% black population). We only provided climate justice mapping information within the watershed boundary in this study, the comparison groups were influenced by reviewing limited available risk information they received. Their adaptive capacity can be enhanced with additional risk information provided in their areas. Thus it is particularly critical in local planning to ensure all residents, especially socially vulnerable groups, receive transparent and up-to-date risk information in preparing for climate actions.

5.4. Future Research

Based on a convenience sample of local respondents in Michigan, our final sample size yields a statistical power required for making valid and reliable inferences to the study population who participated in the quasi-experimental design. It should be noted that people who chose to participate in the study might be moderately aware of the risks of climate change impacts and might not represent all characteristics of socially vulnerable groups in the study area. Future research could invest more resources in recruiting representative participants (e.g., cash incentives), particularly in Climate Justice areas, and target socially vulnerable groups in order to better understand the needs for equity planning. Second, further studies could investigate the effectiveness of using message framing and graphic designs associated with delivering risk information as interventions for influencing risk comprehension and perceptions. Finally, future research could include linking the survey results with additional modeling efforts. The survey results describing risk perception and adaptation behavior can be summarized as residents' behavioral rules for future modeling purposes. An agent-based model can be built upon these behavioral rules—defining residents as "agents"—and coupled with a process-based hydrologic model to quantitatively identify the link between individual adaptive behavior and effective adaptation policy to mitigate climate change impacts.

6. Conclusion

Climate change planning to address climate justice and enhance adaptive capacity of the community is crucial to the sustainability of a community. This study moves toward a better understanding of the role of risk communication in minimizing the gap between people's perception and behavior in response to climate change threats, particularly in climate justice communities. Using a novel experimental design to uncover differences between Climate Justice and comparison areas in both their calculated and perceived risks, findings presents common challenges in risk perception and behaviors. In turn, climate justice risk perception could affect the willingness to act upon climate action plans and implementation, particularly for addressing equity planning under climate change impacts. Communities who are socially vulnerable to hazards have common characteristics to those of low social sustainability outcomes drawing from social ecology framework such as a lack of sense of community and low social capital and social cohesion (Vallance et al., 2011). Therefore, tailored communication interventions addressing different levels of social sustainability should be integrated into climate change planning to motivate adaptation actions.

Risk communication plays a critical role in bridging individual and collective actions in governance. In light of the increasing importance of local actions to combat climate change, effective risk communication plays an important role in serving a platform for consensus-building and decision-making at multiple scales. In addition, integrating scientific information in climate justice risk communication can influence risk perception and behavior to better support local climate action plans that integrate equity goals toward achieving social sustainability.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Engaging Youth in Climate Resilience Planning with Social Media: Lessons from #OurChangingClimate

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Abstract
In light of the socio-ecological complexities associated with climate vulnerability, planning for community resilience will require participatory techniques to engage those most vulnerable. In particular, youth set to inherit the predicted impacts of climate change must be engaged with the processes that determine the future of their built environments. Drawing from existing literature on youth-based participatory planning and climate engagement, this paper presents an alternative process for engaging youth in climate resilience planning by employing digital technology as a tool for youth-based evaluations of existing built environments. Using the pilot project #OurChangingClimate as a case study, the authors propose a new model for engaging youth with an understanding of their communities and their resilience or vulnerability to climate change. The article details the use of social media and digital narratives as tools for participatory resilience planning and presents some of the preliminary content generated in four pilot youth workshops held from 2015–2017. Lastly, implications of youth-generated content on climate resilience planning are discussed.

Keywords
climate resilience planning; digital narratives; participatory design; social media; youth engagement

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1. Introduction

> Climate change provides a good example of a complex systems problem for which place-specific case studies and participatory methodologies are particularly apt. (Berkes & Jolly, 2001, p. 29)

Climate change is a complex socio-ecological problem: vulnerability to its impacts are determined not merely by environmental conditions, but also by a broad range of social conditions (Reid et. al, 2009; Reid & Huq, 2007). While mitigation efforts are crucial, so too are efforts at adaptation, and in particular, building community resilience to climate impacts. Borrowing from ecological definitions of resilience, community resilience is defined as the ability for a community to respond to change and disruption while still maintaining its general function, structures, form and identity (Allen & Bryant, 2011; Amundsen, 2012). Like climate change, resilience does not imply steady states and equilibrium, but instead focuses on questions of the qualitative characteristics of a system, its strengths, long-term viability, and ability to learn and adapt (Allen & Bryant, 2011; Vale, 2014). Specifically, the ability to learn, adapt, and manage change becomes an important aspect of identifying and understanding climate resilience within a community (Folke, 2006; Magis, 2010; Ross & Berkes, 2014; Tyler & Moench, 2012). Thus, community resilience to the com-

plex socio-ecological challenges associated with climate change requires "communication, social equity, and participation to facilitate transformative learning processes" (Paschen & Ison, 2013, p. 1084). It requires participatory and engaged planning processes (Berkes & Folke, 1998; Berkes & Jolly, 2001).

Community-based adaptation planning, which seeks to engage those most vulnerable to climate impacts, is growing in practice in North American cities (Ebi & Semenza, 2008), with notable examples in more vulnerable communities in the Northwest Territories of Canada (Armitage, 2005; Cohen, 1997), Florida (Frazier, Wood, & Yarnal, 2010) and California (Garzon et al., 2012; Moser & Ekstrom, 2011). These participatory approaches allow planners, decision-makers, and stakeholders to effectively address the complex challenges associated with climate change, linking the social with the ecological factors that contribute to vulnerability or resilience within a community. In addition, these engaged efforts give voice to those most vulnerable to climate change (Ross & Berkes, 2014). In communities throughout North America (and beyond), vulnerability to climate impacts is inequitably distributed, disproportionately impacting communities of color as well as immigrant and low-income communities (Reid et. al, 2009; Reid & Huq, 2007). Notably, this includes youth set to inherit the long-term and devastating impacts associated with climate change; youth that are more often limited in their opportunity to participate in political discourses on mitigation or adaptation planning. While young people arguably have the most to lose, "their voices are not prominent in the political, media, or cultural discourse on climate change" (Corner et al., 2015, p. 523).

That urban environments are best planned with the participation of youth has become well-established through research and practice (Derr, Chawla, Mintzer, Cushing, & Van Vliet, 2013; Francis & Lorenzo, 2002; Hart, 1997). Integrating youth effectively in community-based climate resilience planning is also necessary. Examples of effective youth-led responses to climate-related disasters have been studied in communities within the Philippines, El Salvador, and New Orleans, and reveal the important role of youth participation to support community resiliency efforts (Mitchell, Haynes, Hall, Choong, & Oven, 2008; Tanner, 2010; Tanner & Seballos, 2012). These approaches counter the 'vulnerable youth narrative,' and empower young people to play a role in adapting to climate change and responding to related disaster events (Haynes & Tanner, 2015; Peek, 2008; Tanner et al., 2009). These examples employ youth engagement to build resilience to climate disasters already threatening their communities; they also suggest possibilities for engaging youth in planning for resilience to predicted impacts.

Building from precedent work, this paper presents an alternative process for engaging youth in climate resilience planning by employing digital technology as a tool for youth-based evaluations of existing built environments. Using the pilot project #OurChangingClimate as a case study, this paper presents an alternative model for engaging youth with an understanding of their communities and its resilience or vulnerability to climate change. It draws from international precedents in youth-based participatory planning and climate engagement work. In particular, it draws from methodologies such as photovoice and digital storytelling to engage youth in seeing, recording, and sharing their own perceptions of their communities. The paper details the use of social media as a tool for participatory resilience planning and presents some of the preliminary content generated in four youth workshops held from 2015–2017. Lastly, implications of youth-generated content on contemporary community resilience planning efforts are discussed.

2. Background

2.1. Youth Perspectives on Climate Change

Connecting youth to a sense of urgency represents one of the largest hurdles to effectively engaging them in climate resilience planning. According to recent polls from the Yale Program on Climate Change Communication, 70% of adult Americans believe climate change is happening, and 58% are worried; however, only 40% believe it will harm them personally. In contrast, 70% of adult Americans believe that climate change will harm future generations (Marlon, Howe, Mildenberger, & Leiserowitz, 2016). This belief of the inevitable, but not immediate, impact of global environmental change is reflected in the timeframes that national and international climate mitigation policies are determined with decarbonization targets focused for 2030, 2040, 2050 or beyond. Climate scientists similarly describe impacts on decadal time scales in ranges from 2020 to 2100, as do regional and local resilience planning. Climate impacts, carbon targets, and adaptation strategies frequently establish a timescale that will play out for a generation of youth that are simultaneously the best positioned to define our societal responses to, while being the most vulnerable to, climate change (Corner et al., 2015). Despite this, current notions of climate change among U.S. youth appear consistent with adult conceptualizations: it is rarely the top priority. Only 9% of Americans aged 18–34 were worried about climate change, and only 21% believe that people are currently experiencing harmful effects of climate change (Feldman, Nisbet, Leiserowitz, & Maibach, 2010). And while youth between 10–25 years of age tend to have high levels of acceptance of anthropogenic climate change, climate literacy appears to be particularly low. In the United States, only 7% of youth aged 18–34 accurately identified 2 degrees Celsius as the correct amount of global temperature rise to be dangerous (McSweeney, 2015).

Another barrier to meaningful youth engagement includes the 'psychological distance' of climate change, as perceived by the general public and by youth in the U.S.

(Spence, Poortinga, Pidgeon, & Lorenzoni, 2010). The psychological distance of climate change is manifested both geographically and temporally: long time frames of projected impacts, and the physical distance between many Americans and the sites of some of the more catastrophic climate-related events, are often too great to make the issues feel relevant (Gilbert, 2006). Furthermore, international surveys suggest that the general public believe taking action on climate change is primarily the responsibility of governments, whilst simultaneously expressing low levels of trust in them (Corner et al., 2015). Finally, fear tactics that characterize climate change as 'a terrible, immense, and apocalyptic problem' are successful at capturing people's attention, and thus often utilized by popular media as a result; however, such an approach also leaves people feeling hopeless and unable to see their own relationship to the issue (Lorenzoni, Nicholson-Cole, & Whitmarsh; O'Neill & Nicholson-Cole, 2009).

Despite these challenges, there is growing body of literature that suggests new opportunities and alternative approaches for improving youth (and the broader public) perspectives on climate change. In O'Neill and Nicholson-Cole's study of public responses to climate-related imagery, they noted that communication approaches that "…take account of individuals' personal points of reference (e.g., based on an understanding and appreciation of their values, attitudes, beliefs, local environment, and experiences) are more likely to meaningfully engage individuals with climate change" (2009, p. 375). Ojala's work on perceptions of climate change in Swedish high school students revealed similar results: constructive hope, one that is "future-oriented, positive, and solution-oriented" is more powerful in engaging students than denial-based hope (2015, p. 133). This suggests new modes of engaging youth in climate action are needed beyond globally-scaled climate science perspectives or the 'gloom and doom' approach represented in popular media.

2.2. Youth Participation in Planning

As mentioned prior, the participation of young people in urban planning processes is well-established as a beneficiary practice to both urban environments and youth development (Derr et al., 2013; Francis & Lorenzo, 2002; Hart, 1997). Engaging youth in planning processes must extend beyond the traditional and institutionalized means of public participation, as noted by the work of Derr et al.: "[Youth] have sometimes resisted more conventional methods of participation, such as attending public meetings, interviewing and writing" (2013, p. 487). Their review of alternative methods for engaging youth in Boulder, Colorado includes the use of action groups, digital storytelling, child and youth bill of rights, civic area planning, and photovoice. Photovoice in particular proves to be a useful tool for engaging "...on youths' terms, with methods that they find exciting and relevant" (Derr et al., 2013; p. 499). The photovoice technique was first introduced by Wang and Burris (1997), and prompts youth to photograph their environments and to write brief commentaries about their lives and the places they select. "As a practice based in the production of knowledge, photovoice has three main goals: (1) to enable people to record and reflect their community's strengths and concerns, (2) to promote critical dialogue and knowledge about important issues through large and small group discussion of photographs, and (3) to reach policymakers." (Wang & Burris, 1997, p. 369). Seen as a kind of storytelling, photovoice has been applied to engage diverse individuals and topics, including aging populations' perspectives on public space (Hou, 2005) and youth perspectives on health (Strack, Magill, & McDonagh, 2004). In Hou's work with elderly immigrants in Seattle, photovoice was shown to "…empower participants to define and address their concerns, and shift the authority and authorship of design and analysis from experts to the participants" (Hou, 2005, p. 1). Digital storytelling allows for the development of longer format narratives than photovoice, using imagery with narration or written text; the roots of this technique lie in community arts and oral history (Meadows, 2003). Both photovoice and digital storytelling methodologies suggest opportunities for integration with emerging digital and social media—tools and techniques that are increasingly popular among American youth.

Participatory methods are also being applied to engage youth specifically with issues related to climate change with efforts to improve climate literacy and action and to limit disaster risks. They employ techniques such as narrative, social media, and filmmaking to connect youth with climate issues and build resilience. Corner and Robert's analysis of climate-related youth narrative workshops in the United Kingdom provides a list of key strategies for successful engagement: (1) Frame messages as a "contemporary concern requiring immediate response"; (2) Identify climate action as necessary to protect "the things they love"; (3) Focus on "'social' as well as 'scientific' consensus"; and (4) Employ "trusted messengers," such as peer-to-peer communications (2014, p. 528). Other youth-based climate engagement work conducted in Australia, Europe, and North America supports this framework (Arnold, Cohen, & Warner; De Vreede, Warner, & Pitter, 2014; Hickman, 2012; Reinfried, Rottermann, Aeschbacher, & Huber, 2010), and in particular, the importance of localized, solutions-based approaches with positive messaging (Percy-Smith & Burns, 2012). The works of Paschen and Ison (2013) and Walker et al. (2012) on climate narrative demonstrate similar opportunities for engagement to provide new knowledge with regard to vulnerability and resilience as experienced by local community members, as does the work of Haynes and Tanner (2015) which explores the role of participatory video as an alternative methodology for community generated digital storytelling that shares youth experiences of climate-related disasters. Collectively, these engagement techniques suggest a powerful opportunity in

the employment of digital and social media: social media enables the sharing of personal narratives, supports experiential learning, engages with existing online social activity of today's youth, and promotes peer-to-peer interaction (Corner & Roberts, 2014a, 2014b; Senbel, Ngo, & Blair, 2014).

3. Case Study: #OurChangingClimate

#OurChangingClimate is a participatory design project that engages youth in the exploration, documentation, and sharing of the local effects and experiences of climate change. The project aims to make the impacts of climate change more comprehensible on the neighborhood scale, particularly for youth within vulnerable communities and with limited access to political engagement. #OurChangingClimate addresses the need for local perspectives by utilizing digital tools to establish a community-driven network that (1) Provides participants with the ability to better visualize the direct impacts of climate change within their surrounding landscapes; (2) Creates opportunities to contribute images and narratives to community-generated neighborhood resilience mapping; and, (3) Encourages youth and other community-members to participate in on-going local conversations about climate change resilience. This is consistent with key strategies for youth engagement detailed in the literature review: re-scaling climate conversations to local impacts, re-framing impacts within participant existing concerns, encouraging youth-led engagement, and finally building a sense of capacity to respond to threats (Corner et al., 2015).

The project began as a pilot in collaboration with the Oakland-based community organization, Institute for Sustainable Economic, Education, and Environmental Design (I-SEEED). In the pilot phase, researchers conducted two half-day workshops with youth groups affiliated with I-SEEED in the spring of 2015. The project expanded in 2015 to include alternative workshop formats, integrated with other Northern California and out-of-state community groups (including adult participants), and diversified the tools used for engagement (including analogue options). A summary of workshop formats, locations, dates, and collaborating organizations is listed in Table 1. This paper will focus specifically on content generated from four youth-based workshops held between 2015 and 2017: the 2-day pilot workshop in Oakland, California; a half-day workshop held in Milwaukee, Wisconsin in collaboration with the National Organization for Minority Architecture Students (NOMAS) as part of the Imagining America National Conference in October 2016; a 10-week workshop held at the University of California, Davis as part of a first-year seminar offered January through March 2017; and a half-day workshop held in Santa Barbara, California as part of the California Higher Education Sustainability Conference (CHESC) in June 2017.

4. Methodology: Hashtags & Digital Narratives

The four workshops from which content is examined in this paper followed a similar format, despite variations in meeting lengths and frequencies. Led by project team members in coordination with non-profit/community collaborators, workshops began with an introduction to the project team and ice-breaker exercises. Facilitators then introduced participants to the localized projected impacts of climate change through regional vulnerability maps, aerial photographs, and street view imagery and engaged participants in an exercise to discuss, challenge, and revise these representations of local built environments (see Figure 1). Following project and participant introductions, youth were then asked to contribute their imagery and brief narratives using their personal social media accounts. Workshop facilitators requested participants to record evidence of vulnerability and resilience in their communities; they encouraged participants to consider social as well as environmental indicators, and to include conditions of interest to them. Nearly all participants engaged regularly with social media, Instagram and Twitter being the primary networks and several using Facebook. The image and descriptive text contributions to social media models the technique of photovoice, with the added benefit of allowing sharing between a much broader network that includes participants' families and peers. It also allowed the project team to meet participants 'where they are' with tools they already engage with and enjoy (Corner et al., 2015; Senbel et al., 2014).

Participants contributed posts for a span of time that varied in length from ninety minutes to six weeks, depending on the duration of the workshop(s). For Oakland-based workshops, participants met for two half-day workshops and contributed posts from their own communities during the six-week timeframe between each workshop. Posts from the pilot workshop helped develop the preliminary themes that were utilized in subsequent workshops. Scavenger hunt cards were developed for latter workshops to facilitate student observations of their communities and experiences. Themes were printed on 3.5 inch by 5 inch index cards, describing a social or environmental condition; one side described the condition as resilient (white), the other side as vulnerable (magenta), see Figure 2. Blank cards were also provided to encourage the introduction of new themes by participants. Participants in the Milwaukee and Santa Barbara workshops posted for ninety minutes midway through a half-day workshop from sites surrounding University of Wisconsin, Milwaukee and University of California, Santa Barbara campuses. Students participating in the Davis workshop met weekly for two hours during a ten-week period, and contributed posts weekly for the first six weeks of the seminar. Posts from Davis workshops included observations around the University of California, Davis campus and from students' hometowns (which included international locations).

Table 1. #OurChangingClimate workshop locations, dates, formats, and collaborating partners.

Workshop Location	Date	Format	Participants	Collaborating Partners
Oakland, California*	March–May, 2015	(2) Half-Day Workshops	San Francisco Bay Area youths affiliated with I-SEEED	Institute for Sustainable Economic, Educational, and Environmental Design (I-SEEED)
San Francisco, California	November, 2015	Half-Day Workshop	San Francisco Bay Area professional and student environmental designers	OpenIDEO
Davis, California	March 2016	Half-Day Workshop	University of California, Davis staff	University of California, Davis, Office of Sustainability and Carbon Neutrality Effort
Davis, California	May 2016	Half-Day Workshop	University of California, Davis faculty	University of California, Davis, Faculty Climate Working Group
San Francisco, California	September 2016	Half-Day Workshop	San Francisco Bay Area professional architects	San Francisco Bay Area Chapter of the American Institute for Architects (AIA)
Davis, California	September–December 2016	(10) 2-Hour Workshops	University of California, Davis undergraduate students	University of California, Davis First Year Seminar program
Milwaukee, Wisconsin*	October 2016	Half-Day Workshop	Environmental Design students from University of Wisconsin, Milwaukee and University of California, Davis; attendants of the Imagining America Annual Conference	University of Wisconsin, Milwaukee's National Organization of Minority Architecture Students (NOMAS) and Imagining America
Davis, California*	January–March 2017	(10) 2-Hour Workshops	University of California, Davis undergraduate students	University of California, Davis First Year Seminar program
Santa Barbara, California*	June 2017	Half-Day Workshop	Youth and adult attendants of the CHESC Conference	California Higher Education Sustainability Conference
Plymouth, United Kingdom	August 2017	Half-Day Workshop	Sustainable Earth Institute students and attendants of the Balance/Unbalance Conference	University of Plymouth, Sustainable Earth Institute and the Balance/Unbalance Conference

Note: * indicates workshop content inclusion in paper.

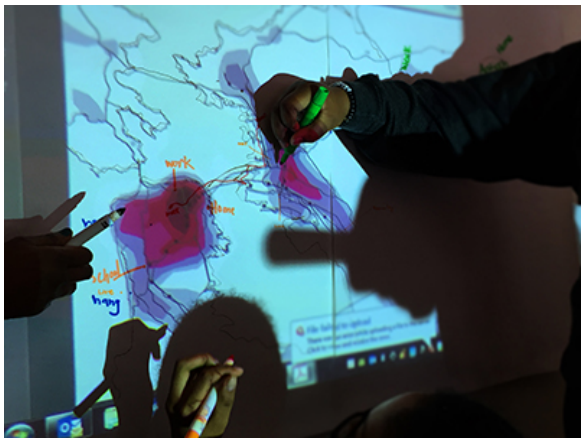


Figure 1. #OurChangingClimate pilot workshop held in Oakland, California in 2015.

Posts were aggregated using the hashtag 'OurChangingClimate,' and participants often tagged their posts with additional hashtags, such as 'Drought,' 'Community' or other keywords related to their posts. Contributed content was also geo-tagged through the social media posting process, enabling the project team to connect imagery and text with a specific location. When participants and the project team reconvened, content and major themes were discussed. Participants presented their imagery and short narratives, comparing their experiences with fellow participants and, in the case of latter workshops, with prior workshop content. During the latter part of the Oakland and Davis workshops, participants developed a longer narrative based off a theme of their choosing. Youth participants curated from posts aggregated to tell a personal story of their experience of cli-

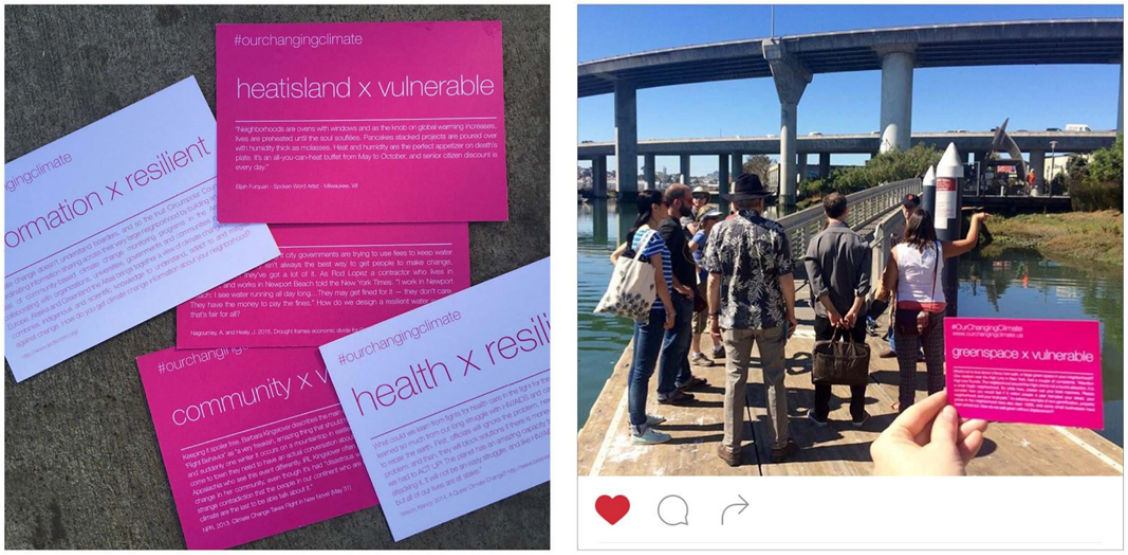


Figure 2. Thematic scavenger hunt cards.

mate change: how they were experiencing vulnerability or resilience to its impacts in their own lives. Limited time prevented Milwaukee and Santa Barbara workshop participants from developing longer narratives. Participants from Oakland and Davis workshops utilized either Storify or Wordpress to create their digital narratives—both free and easy-to-use programs that integrate with existing social media networks.

5. Youth Content on Climate Change

Instead of images of polar bears, glaciers, or hurricanes (some of the more popularized imagery associated with climate change), workshop participants contributed more localized and personal images that reflected their own concerns, experiences, and interests. The common themes that arose in youth observations of their communities included: food, transportation, severe weather, community, green space, and health. Each of these themes provides a clear relationship to climate vulnerability or resilience. Many participants also contributed speculative posts, using the prompt 'WhatIf' to project alternative futures of their communities. Lastly, posts that explored the identity of youth participants' communities was also common, often tagged with the hashtag 'TheView.' Below is a list of the four key findings distilled from the youth content. They suggest important techniques for engaging youth in adaptation planning, and new approaches for urban planners to meaningfully plan for community resilience to the socio-ecological challenges of climate change.

5.1. Food is a Gateway to Youth Engagement with Climate Resilience Planning

The most common theme in all workshops was food; youth participants were very interested in linking climate change to issues related to personal food choices and habits, food security, sustainable food systems, and management of food waste. This suggests an important opportunity for urban planners to think about food and food systems as an integral part of community resilience planning. There is already increasing interest in connecting food systems planning with urban sustainability efforts in many North American cities (Mendes, Balmer, Kaethler, & Rhoads, 2008; Napawan, 2014; Pothukuchi & Kaufman, 2000). Interest in linking climate change to issues related to food suggests a further opportunity to engage youth in community resilience planning. Photographing and talking about food in their social media posts helped many youth connect their own lives to the issues related to climate change: On the one hand, they were able to see how their food choices had an impact on food miles, greenhouse gas emissions, and thus mitigation efforts. Participants were also able to consider how the future impacts of climate change might impact the affordability of some of their favorite foods such as avocados, chocolate, and coffee (see Figure 3).

5.2. Focus on the Social Dimensions of Climate Vulnerability and Resilience

Another important trend in posts was the predominant focus on social aspects of climate vulnerability and resilience, as opposed to the environmental aspects. This emerged in the themes such as food insecurity, public health, and an interest in building community (see Figures 4 and 5). Even when exploring environmental conditions, such as green infrastructure or transportation, youth often approached this content through the lens of how green space can build community, or who has access to transportation (Figures 6 and 7). Nearly all longer format digital narratives from the Oakland and Davis workshops focused on social characteristics of resilience or vulnerability within a community. Narratives explored participant interests in food security, public health, envi-

"How far has your produce traveled? #ourchangingclimate #mexicotosf #avocado" via Instagram, Oakland workshop participant

"I'm concerned about #ourchangingclimate because of its potential impact to my need for caffeine!" via Instagram, Santa Barbara workshop participant

"Foodwaste in the trash bin?! #ourchangingclimate via Instagram, Milwaukee workshop participant

"Village bakery bread makes for a great midnight snack! #foodwaste #dumpster diving #freegan via Instagram, Davis workshop participant

Figure 3. Food-related posts.

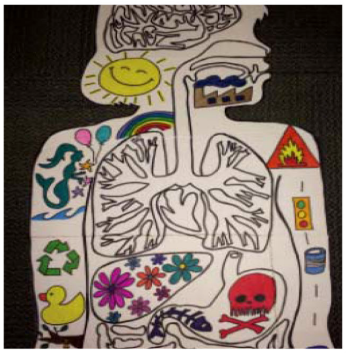
"SFSU. Green space makes opportunity to unite with community, If only, if only... #ourchangingclimate #climatechange" via Instagram, Oakland workshop participant

"Elevated public spaces and student gardens help create campus community. #ourchangingclimate" via Twitter, Milwaukee workshop participant

"Davis Farmer's Market builds community. #ourchangingclimate" via Twitter, Davis workshop participant

Figure 4. Community-related posts.

"I live near a field of dead grass that is across the street from my neighborhood. It has caught on fire the last two years... The fire left burnt patches of grass that would eventually fade- not nice to look at. It would create a very smoke atmosphere and smell bad when you step outside. Dangerous for me because I could enconter this scene when I leave the neighborhood or walk home from school." via Wordpress, Davis workshop participant



"This is the profile of a little girl and her main organs... The left side of her body is the happy and healthy life. The life this child was to live if humans recycled, took care of the ocean, or cut down less tress so children can have a swing. The right side of her body is the polluted and impure life. A life full of inhaling too much smog from forest fires due to droughts, or not being able to enjoy a sunny day out on the beach." via Wordpress, Davis workshop participant

"Allergies, in general, are increasing throughout the westernized world", Dr. David Rosenstreich, chief of the division of the allergy and immunology at the Albert Einstein College of Medicine and Montefiore Medical Center in New York, told CBS News. "Because of global warming and CO_2 levels in the air, they're making more pollen. The pollen seasons tend to begin earlier, last longer and are more severe."

"my allergies are ruining my sleep #cbsnewsarticle #allergyseason #ourchangingclimate" via Instagram, Oakland workshop participant

Figure 5. Health-related posts.

"Waited 20 minutes for the 122. It came and was full so I'll be waiting another 30 minutes for the next one… #publictransportation #busriderlife #ourchangingclimate" via Instagram, Oakland workshop participant

"#IA2016MKE #ourchangingclimate covered bike racks protect resilient transportation" via Twitter, Milwaukee workshop participant

"From my middle school to high school in Beijing, I used to ride bike every day to school. I felt that most streets in Beijing are not friendly to cyclits. Most streets don't have bike path. I usually ride bike among the noisy beep and exhaust of cars. Terrible." via Wordpress, Davis workshop participant

Figure 6. Transportation-related posts.

"Lower Haight in San Francisco. My neighbors make the most of the sidewalk! #ourchangingclimate #greenspace" via Instagram, Oakland workshop participant

"Lots of impervious surfaces! Neighborhood could use some #greenspace #ourchangingclimate" via Instagram, Oakland workshop participant

"Campuses are adorned with greenery that often don't exit in low-income spaces. #ourchangingclimate" via Twitter, Milwaukee workshop participant

Figure 7. Green space-related posts.

ronmental justice, and connecting personal habits (such as diet or commute) to climate change. This finding is consistent with the results of Haynes and Tanner's (2015) participatory video work with youth in the Philippines. Their youth videos reflected the "…social and political root causes of vulnerability…Through this vulnerability emphasis, participants have developed their capacities to reduce risk based not only on physical aspects on the hazard, but also on the human causes of risk that require behavioural and policy change [sic]" (Haynes & Tanner, 2015, p. 369). The results of our youth content suggest a similar approach to climate resilience, one with a greater emphasis on addressing the social issues related to the complexities of climate vulnerability.

5.3. Rescale Environmental Conditions to Local and Regional Scales

When environmental conditions surfaced in youth content, it tended to be weather-related and reflect the hyper-localized concerns related to climate vulnerability or resilience; for example, the presence of street trees or pervious pavement and the impact to urban heat island or flooding. Participants also focused on the regional-scaled weather impacts over global-scale: California workshop participants focused on drought, while Wisconsin participants focused on severe storms and extreme temperatures (see Figure 8). Although longer format narratives predominantly focused on social issues, the handful of narratives with an environmental focus also explored localized weather conditions, such as the California Drought or urban heat island impacts within a participant's community. This finding is consistent with many of the key points reviewed in related literature. Again, it suggests rejecting popularized media depictions of climate change that focus primarily on global-scale environmental impacts, and instead rescaling climate resilience planning to address regional, local, and hyper-local concerns. It is also consistent with literature that stresses the importance of locally-scaled adaptation approaches over regional, national, and global scales (Adger, Arnell, & Tompkins, 2005; Hallegatte & Corfee-

"The rain came down and the floods came up? The storm drains in South SF may need to be looked at. #flooding #southsanfrancisco #suburbs #ourchangingclimate" via Instagram, Oakland workshop participant

"Stonestown Mall. Thank goodness it cooled down I'm sure a #heatisland blazed a many of folks today! #ourchangingclimate #climatechange" via Instgram, Oakland workshop participant

"Trees with deep roots keep water in the soil. Let California dought fade away #ourchangingclimate" via Twitter, Davis workshop participant

"How far is your shelter from extreme weather? #ourchangingclimate #ia2016mke" via Instagram, Milwaukee workshop participant

Figure 8. Weather-related posts.

Morlot, 2011) and place-based approaches to resilience efforts (Berkes & Folke, 1998; Berkes & Jolly, 2001).

5.4. Enable Youth to Consider Alternative Futures While Embracing Current Identities

Speculative and community identity posts were also common, and encompassed the most unexpected themes that developed for the project team. Youth from all workshops felt compelled to suggest new ideas about the places within their community unprompted—proposing new green spaces and improvements to public transportation, or depicting absurd scenarios of projected climate impacts (see Figure 9). This outcome has the clearest implications for urban planning professionals seeking to engage youth in re-imagining new and resilient communities, and reinforces the findings from Derr, et al. on their youth participatory planning workshops: "When youth were invited to reimagine…they became more engaged" (2013, p. 500). These posts point to the need to engage youth in projecting speculative futures for their community as part of an engaged climate resilient planning process, and the important opportunity that social media can play in supporting this process. Alongside the speculative posts, youth also contributed a range of images that suggested the importance of the visual identity of their communities. Using the tag 'TheView,' many youth participants captured the environmental conditions typically associated with climate vulnerability (shorelines and streetscapes), portraying them as places significant to their community's identity (see Figure 10). This illustrates the ways that youth value existing visual elements within their built environment—regardless of their vulnerability to climate change. It also suggests the importance of maintaining community identity within the resilience planning process. By definition, community resilience includes maintaining its identity, alongside its general structure, functions, and form (Allen & Bryant, 2011; Amundsen, 2012).

"Daly City construction means community gardens and access to green space right? #IHopeSo #climatechange #ourchangingclimate" via Instagram, Oakland workshop participant

"Water City Scuba Tours, Found in ever major port city by 2050 #changingclimate" via Twitter, Davis workshop participant

"One day, will people look back at our time in history, and realize we were all foolish not to have a career in taking care of our home? #ourchangingclimate" via Instagram, Santa Barbara workshop participant

"Hey @Oaklçand, why don't we build a park with this lot? #ourchangingclimate @sd_opencity" via Twitter, Oakland workshop participant

Figure 9. Speculative posts.

"Damn SF, you're looking fine this morning #ourchangingclimate" via Instagram, Oakland workshop participant

"My view this morning #ourchangingclimate" via Instagram, Oakland workshop participant

"a reason to put more benches around the lake #peace #theview #ourchangingclimate #sf" via Instagram, Oakland workshop participant

"View from our apartment. #ourchangingclimate Impervious surface, unused land, shoreline." via Instagram, Oakland workshop participant

Figure 10. View-related posts.

6. Conclusions

Community resilience planning requires defining climate change as a socio-ecological problem and must connect the physical and spatial attributes of community vulnerability with the experiences and perceptions of these characteristics (Berkes & Folke, 1998; Berkes & Jolly, 2001). Current adaptation planning approaches often privilege environmental considerations, but precedents in participatory planning methodologies suggest new approaches for integrating community conceptualizations of built environments into the process. In particular, narrative-based approaches offer an alternative approach to adaptation planning: "[It] offers an innovative, holistic approach to a better understanding of socio-ecological systems and the improved, participatory design of local adaptation policies… it can significantly inform public engagement, deliberation and learning strategies—features of systemic adaptive governance" (Paschen & Ison, 2013, p. 1083). Youth engagement in these strategies has already revealed new paradigms for understanding vulnerability and resilience within a community (Haynes & Tanner, 2015; Peek, 2008; Tanner et al., 2009), and new digital technologies are diversifying and broadening strategies for that engagement (Corner et al., 2015; Senbel et al., 2014).

#OurChangingClimate represents an alternative approach to engaging youth in climate resilience planning, exposing the nuanced and personal ways in which youth experience their built environments and understand vulnerability to climate change. As a place-specific case study that employs participatory methodologies, the project exposes the critical connections between the social and environmental conditions of climate change and addresses many of the challenges of sustainability science: "Because of the nonlinearity, complexity, and long time lags, sustainability science will need to use new methodologies, build upon lessons provided by case studies, and work with the local people to produce knowledge" (Berkes & Jolly, 2001). Preliminary project content reveals important implications for community resilience planning efforts. The four main points being: (1) Food is an important gateway for engaging youth in climate resilience planning; (2) Focus on the social dimensions of climate resilience and vulnerability; (3) Rescale environmental conditions of vulnerability and resilience to address the specifics of a location; and (4) Create opportunities for youth to imagine alternative futures, while addressing the identity of their existing communities. Employing these techniques supports youth engagement in adaptation planning efforts. Moreover, engaging youth in a better understanding of their communities and their vulnerabilities, in it of itself, can help build resilience to the socio-ecological complexities of climate change.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

The Social Dimension of Sustainable Neighborhood Design: Comparing Two Neighborhoods in Freiburg, Germany

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Abstract
The study presented in this article adds to the body of research on the socio-cultural dimension of sustainable cities by looking at the efforts of the City of Freiburg, Germany to create neighborhoods that acknowledge the importance of the social dimension of sustainable development. The research in this article is centered on evaluating the social responses of living in Freiburg's two recognized sustainable neighborhoods Rieselfeld and Vauban. The study focuses on the motivational factors that prompted todays residents of the two neighborhoods to move there in the first place, their level of satisfaction living there now, and their perceived social interactions and level of community engagement. Results show that satisfaction with living in a place and reinforcing its assets through social resiliency or livability can result in long-term community staying power. In general, there were few differences in preference ratings of physical and social assets between the two communities. The levels of importance of social factors contributing to place satisfaction and staying power were not significantly different in both neighborhoods. Having a "cluster" of social factors present that were important to residents contributed significantly to place satisfaction. In fact, survey results showed that it was these social factors that were seen as more important to place satisfaction than the physical attributes of sustainable developments.

Keywords
Freiburg; social dimensions; social equity; survey research; sustainable community

Issue
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1. Introduction

The study presented in this article adds to the body of research on the socio-cultural dimension of sustainable cities by looking at the efforts of the City of Freiburg, Germany to create neighborhoods or communities that acknowledge the social dimensions of sustainable development and strengthening social ecology by building robust social systems that ultimately lead to stronger and more resilient communities (Wheeler, 2012). The City of Freiburg is located in the Southwest corner of Germany, at the edge of the Black Forest, and very close to the borders of Switzerland and France. The city (population of approximately 225,000) is today a hub for regional ecotourism and center for academia and research (City of Freiburg, 2017a). Over the last few decades, Freiburg focused heavily on becoming a recognized "green" and sustainable city and has won various national and international environmental awards for their policies and developments. Freiburg is especially well known as a green city or eco-city for its efforts in public transportation, alternative energy systems, and sustainable place-making (Newman, Beatley, & Heather, 2009). The city administration emphasizes other sectors as well to increase the level of sustainability such as land conservation and the promotion of a green economy. The term eco-city represents

a relatively new planning paradigm combining different societal aspects of urban development into a holistic political strategy built on consensus (Mössner, 2016). According to Roseland, the aim of eco-cities is "to secure the means to survival, improve the quality of community life, protect the environment and make inclusive and participatory decisions" (2012, p. 3).

Motivated by growing concerns over climate threats, environmental deterioration, social justice issues, and lack of economic opportunities, there are increased efforts worldwide to engage in more sustainable development practices, especially at the city level. Sustainable developments can be understood as efforts to increase the standard of living and thus quality of life, protect and enhance the natural environment, and preserve local culture and history (Deakin, 2001). Because of increased and ongoing efforts of city governments to find solutions to today's sustainability challenges (Luederitz, Lang, & Von Wehrden, 2013), the concept of sustainable community development (Van der Ryn & Calthorpe, 1986) has attracted attention by policymakers and academics alike, acknowledging the local community as an important unit of social organization and implementation of sustainability strategies (Dempsey, Bramley, Power, & Brown, 2011). Communities are also beginning to employ sustainability officials to help them track their efforts and inform sustainable development. Even though many cities, such as Seattle, San Francisco, and Boston in the United States, have launched significant sustainability programs, there is often a lack of focus on social justice and equity concerns. Instead, sustainable development projects often pay less attention to the social dimension relative to the environmental and economic side of sustainability (Murphy, 2012). This may be because social well-being within the context of sustainability is often ambiguous and multifaceted with major methodological and theoretical complexities.

The Rieselfeld and Vauban developments stand out in public discussion and academic literature on Freiburg's efforts to become a more sustainable city. They are considered "eco-neighborhoods" (Scheurer & Newman, 2009) with different interpretations and ideologies of sustainable community development as well as size and planning approaches. Both are highly regarded for their holistic sustainability planning with a strong focus on social aspects during the development process. Furthermore, both were planned and built during the 1990s and early 2000s, when Freiburg was experiencing a substantial housing shortage resulting in increased costs of living within the city and rapid suburbanization. The research presented in this paper is centered on evaluating the nature of social responses of living in the two neighborhoods. In both cases, the neighborhood development process was not exclusively guided by design, transportation, and ecological concepts, but also by a social concept acknowledging the need for "community" and social engagement.

In the wake of an increased focus on climate and environmental quality in the sustainable planning literature, Dixon (2012) points to the real danger that the social dimension of sustainability will receive even less attention in the future. Already, decision-makers too often focus only on technical aspects such as energy reduction and efficiency, sustainable building materials, or compact settlement structures without acknowledging the importance of building social capital or social networks (Mössner, 2016). However, as research in the United Kingdom shows (Social Analysis and Reporting Division Office for National Statistics, 2001; Woodcraft, Hackett, & Caistor-Arendar, 2011), social sustainability and its focus on community issues should be a central concern of all neighborhood developments. Without increasing social capital and well-being, successful sustainability policy may not be possible. For example, social well-being policies require enhanced public participation, acceptance, and support for mitigating and adapting to environmental threats such as climate change and other hazards (Hagen, Middel, & Pijawka, 2016). Thus, social support and engagement is important in establishing sustainable practices. Unfortunately, much of the literature has focused primarily on environmental and economic issues, in part due to the "conceptual chaos" undermining the utility of the term "social" (Vallance, Perkins, & Dixon, 2011), how to measure it, and a perceived trade-off at a global scale between social progress and environmental concerns (Colantonio & Dixon, 2011; Holden, 2012).

Thus, adding to the social dimension and building social capital or social networks have become recognized as important factors in sustainable developments and community plans. This paper provides insights on the importance of the social dimensions of sustainable places and experiences based on visits to the two neighborhoods; interviews with architects, city planners, and community leaders in 2014; and surveys of the residents of Vauban and Rieselfeld in early 2017. Research was guided by the following underlying questions:

- How did the city of Freiburg establish social dimensions of neighborhood development into the planning process of Rieselfeld and Vauban to achieve sustainable communities?
- How do the residents perceive the level of social engagement in the two neighborhoods, why did they move there, and are they satisfied with their decision?

The article first discusses important literature in the area of sustainable social development. This is followed by a description of Freiburg's approach of becoming a more sustainable city and of the two neighborhoods of Rieselfeld and Vauban which are the focal point of this study. The third part introduces the methodology of this study, particularly the survey instrument, data collection process, and the applied statistical analysis. Section four presents the analysis of the survey data focusing on the motivational factors that prompted todays residents of Rieselfeld and Vauban to move there in the first

place, their level of satisfaction living there now, and their perceived social interactions and level of community engagement.

2. Literature Review

2.1. Theoretical Background

The idea of sustainable development was conceptualized in the 1980s in a time of increasing awareness of ecological issues and an ongoing "retreat from social concerns" (Dempsey et al., 2011). Ecological devastation and the lack of social equity concerns manifested itself in many parts of the world in forms of poverty, deprivation, and urban dereliction (Carley & Kirk, 1998). Today, the most accepted definition of sustainable development was provided in 1987 by the World Commission on Environment and Development (1987) in its report 'Our Common Future'. Often referred to as the Brundtland Report, the definition emphasizes our responsibility to future generations and describes sustainable development as balancing economic, environmental, and social concerns. However, the balancing of the underlying aspects of sustainable development are not without conflicts and have led to different urban forms that claim to be sustainable (Giddings, Hopwood, & O'Brien, 2002; Jenks & Dempsey, 2005). Generally speaking, the preferred urban form from a sustainability urban planning perspective is characterized by high degrees of compactness and density as well as mixed use with public transportation and use of sustainable materials. However, many argue that the sustainability benefits of compact forms are still contested and robust data that supports the claims are deficient (Bramley & Power, 2009).

Nonetheless, since the conceptualization of sustainable development, different approaches have emerged that highlight distinctive aspects of a sustainable urban neighborhood. For example, the work by Ahmed (2012) presents the efforts of neighborhoods in the United Arab Emirates to excel in social aspects and Li, Wang, Paulussen and Liu (2005) discuss Beijing's strategy to improve urban greening while considering ecological principles. Other approaches focus on the cultural dimension (Joubert, 2004), economic stability (Jones, Leishman, & MacDonald, 2009), or determining thresholds and barriers to achieving sustainable neighborhoods. (Galster, Quercia, & Cortes, 2000). Given the fact that current definitions of sustainable development place responsibility on humans (Hopwood, Mellor, & O'Brien, 2005), it is surprising how little attention has been placed on clearly defining social sustainability and its relationship to the built environment. As mentioned before, there is a relatively small body of literature that focuses specifically on social sustainability.

Similar to the concept of sustainable development, social sustainability is not an absolute or a constant (Dempsey et al., 2011). Instead it is a dynamic and multidimensional concept that changes over time and holds various theoretical constructs. However, the underlying question of what social goals of sustainable development are and a clear understanding of how to meet those goals is still up for debate (Hopwood et al., 2005; Littig & Griessler, 2005). Even though the social dimension of sustainability is widely accepted as a key aspect of sustainable development, it has not been clearly conceptualized and only a few efforts to define social sustainability exist (Bramley & Power, 2009; McKenzie, 2004; Stren & Polèse, 2000; Yiftachel & Hedgcock, 1993). Little attention has been given to the social sustainability factors at the community level. This lack of a clear definition and meaning of social dimensions everybody can agree on is happening despite recent efforts in Europe through the 'Bristol Accords' (UK Presidency, 2005) and 'Leipzig Charter' (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, 2007) which outline a common approach to and characteristics of sustainable neighborhoods for all European Union (EU) members including social-livability factors. The work on social dimensions of sustainability presented is this paper is based on a definition provided by Stren and Polèse (2000, pp. 16–17) who defined the social dimensions of sustainable development in an urban planning context as "development (and/or growth) that is compatible with the harmonious evolution of civil society, fostering an environment conducive to the compatible cohabitation of culturally and socially diverse groups while at the same time encouraging social integration, with improvements in the quality of life for all segments of the population."

In the context of this study's focus on the sociocultural dimensions of sustainable urban development, we understand social sustainability as the means to create strong, vibrant, and healthy communities that enhance the quality of life and the overall resiliency of the neighborhood and its population. Establishing a built environment of high quality provides accessible local services that contributes to the overall physical, social, and cultural well-being. It is important to gain a practical understanding of social sustainability and operationalize it, especially in times of rapid urbanization with increased housing needs and declining public resources to ensure strong and resilient communities (Department for Communities and Local Government, 2012; Woodcraft, 2012).

A key component of social sustainability is the concept of social justice and equity with different approaches (Agyeman, 2005; Harvey, 2010; Fainstein, 2010) to fair allocation of resources, inclusiveness, as well as full and equal accessibility to all aspects of society (Dempsey et al., 2012). The level of accessibility to local amenities plays a key role in establishing a socially just community (Barton, 2000a; Burton, 2000). Ensuring residents' ability to access services and opportunities such as parks within the community assigns physical neighborhood planning an important role. A thoughtfully planned settlement structure can shorten travel distances, improve walkability and, improve access to pub-

lic transit which allows all income classes access to economic opportunities as well as other local amenities that improve the quality of life (Hamiduddin, 2015). Local amenities can affect the well-being and increase social cohesion by covering daily functional needs, enabling incidental encounters between residents which in turn can improve social relations (Bridger & Luloff, 1999). Moreover, social sustainability also implies local empowerment in decision-making and inclusivity in participation.

Among the important features residents need in terms of equitable access to everyday life are facilities for education and employment training, decent housing, public services, social infrastructure, green spaces, and cultural and recreational services (Dempsey et al., 2011). Some of these are directly linked to the built environment, whereas others are more indirect. Directly linked features are those that provide services and facilities or the means of accessing them, such as public transport. Indirectly linked features are those that are more abstract or intangible such as decent housing and social infrastructure.

A sustainable community is also strongly related to social cohesion and capital, which in turn is based on trust and social relationships among residents, public participation in community institutions, community stability and safety, and sense of community identity and belonging (Forrest & Kearns, 2001; Hamiduddin, 2015). Currently, there is an increasing belief among policymakers and scholars alike that a large amount of social capital present in a community will allow the implementation of voluntarist solutions to problems that market mechanisms as well as government programs or legislation cannot address adequately (Flora, 1998). However, this hypothesis has not been tested sufficiently and conceptual issues remain that present a barrier to fully linking the successful development of a sustainable community to social capital.

Finally, a study by Bramley and Power (2009b) shows that sustainable urban forms can result in trade-offs between social equity and sustainable community elements, which need to be considered by policy-makers and urban planners. For example, the study shows that compact neighborhoods can exacerbate existing problems and dissatisfaction within the community, while simultaneously improving access to services. Social cohesion and capital within a community improves its adaptive capacities regarding threats such as crime and environmental disasters (Seidman, 2013). In turn, overcoming threats to a community further improves social ties, sense of place, and overall happiness. However, the relationship between resiliency and social well-being needs further examination.

To better understand how urban form impacts social well-being, one needs to take a closer look at specific services and facilities at the neighborhood scale. An empirical study by Winter and Farthing (1997) points to eight services and facilities that, if locally available, are used most often and therefore represent important aspects to improve social relations and equity among the residents. These services and facilities are food shops, newsstands, open spaces, post offices, primary schools, bars, supermarkets, and secondary schools. Other theoretical studies argue that it is important that residents also have local access to doctors, restaurants and cafes, banks, and a community center (Aldous, 1992; Burton, 2000; Barton; 2000b). Finally, Dempsey et al. (2011) identified vital non-physical and physical factors that contribute to socially sustainable communities (Table 1).

The work of Dempsey et al. (2011, 2012) and this paper's underlying general definition of social sustainability by Stren and Polèse (2000) led to the development of a new framework to examine different elements of urban form on different factors of social sustainability. This framework identifies social justice and equity as core principles underlying social sustainability (Bramley, Dempsey, Power, & Brown, 2009; Hamiduddin, 2015). The study presented in this paper does not address all factors outlined in Table 1. Instead it focuses on factors that can be captured and discussed based on data provided by the study's survey instruments, site visits to Freiburg including the Rieselfeld and Vauban neighborhoods, and conducted interviews. These factors include: 1) social-capital, -networks, and -interactions; 2) participation and active community organization; 3) quality of life and well-being; 4) sense of community and belonging; 5) accessibility; 6) sustainable urban design (i.e. energy efficiency, car-free zones) and 7) walkability.

Table 1. Contributing factors to urban social sustainability.

Non-physical factors	Predominantly physical factors
• Education, training, & cultural traditions	• Urbanity
• Social-justice, -inclusion, -capital, -order, -cohesion, -networks, -interaction	• Attractive public realm
	• Decent housing
• Participation, local democracy, & active community organization	• Local environmental quality and amenity
• Health, quality of life, & well-being	• Accessibility
• Community, community cohesion, sense of community and belonging	• Sustainable urban design
• Safety, employment, residential stability, mixed tenure, fair distribution of income	• Neighborhood
	• Walkability

Note: Adapted from Dempsey et al. (2011).

2.2. City of Freiburg

Much has been written about Freiburg's efforts to become a green or eco-city. This article does not go into the details due to the vast amount of literature already available (Crowhurst Lennard, von Ungern-Sternberg, & Lennard, 1997; Drilling & Schnur, 2012; Frey, 2013; Medearis & Daseking, 2012). Instead the following will provide a brief history of the city efforts to become more sustainable with a focus on factors contributing to the social dimensions of sustainability. First, it is important to understand the city's environmental history and how that has led to strong public support for sustainable development initiatives today.

Due to a large academic community in the city, Freiburg became a center for the country's green movement in the 1970s. In 1975, a proposed nuclear power plant close to the city sparked significant citizen protest and Freiburg citizens successfully defeated the project (Nössler & de Witt, 1976). Many protest leaders and other people involved in Freiburg's green movement remained in the area after obtaining their educational degrees and became involved in local and regional politics, found employment in educational or research activities, or founded environmentally-based companies. Although critics point out the lack of evidence for a direct connection between the protests in the 1970s and today's strong focus on sustainable development and clean energy in Freiburg (Mössner, 2015), according to Thomas Dresel from Freiburg's Environmental Protections Agency "the mid 1970s is when it all started" (Dresel, personal communication, July 2014). This is echoed by the literature (Medearis & Daseking, 2012; Rohracher & Späth, 2014) that describe this time period as an important milestone in Freiburg's history as an eco-city, impacting the political landscape of the city and allowing city officials to commit to long-term sustainable development goals, especially in regards to increasing the city's renewable energy portfolio. The history of the green movement in Freiburg with a strong citizen participation as well as the city's early focus on clean energy and improving public transit has also contributed to the social dimension of sustainability in the city, fostering contributing factors such as social-capital, participation and active community organization, and sustainable urban design.

In the following years, Freiburg became increasingly more environmentally active and acknowledged the need to engage in sustainable development before the term gained popularity after the 1992 UN Earth Summit in Rio de Janeiro, Brazil. By 1986, Freiburg became one of the first cities in Germany to establish an Environmental Protection Agency. The City also passed a local energy supply concept to promote energy conservation, climate protection and a withdrawal from nuclear energy the same year. Another key year was 1996, in which the city drafted its own local Agenda 21, setting the framework and goals for various sustainability activities and projects (City of Freiburg, 2017b). In 2006, Freiburg signed the Aalborg Commitments which provides a common format for the promotion of energy conservation, climate protection, sustainable urban development and an expanded public awareness of environmental issues in European cities (Frey, 2013). In addition, the City developed its own climate action plan in 2007.

According to the mayor Dieter Salomon, Freiburg's success in moving towards an eco-city is a result of a long-term and strategic approach to urban planning, the advancing of environmentally friendly businesses, strong public participation and support for sustainable policies, and a proactive city government (Frey, 2013). Public participation in the decision-making process is identified as a key component for the success of a sustainable community development project and is also an important non-physical factor to urban social sustainability, as outlined in Table 1. Often, successful interventions due to sustainability concerns or new approaches to community development result from public engagement that are not possible from traditional top-down strategies (Bridger & Luloff, 2001). Instead, the knowledge and efforts of people familiar with local circumstances is essential. In addition, Thomas Dresel points to the "five big Cs" that are preconditions for successful sustainable policy implementation and urban development in Freiburg (Dresel, personal communication, July 2014). The five Cs stand for "cost, comfort, control, consensus, and cooperation" which also relate to several contributing factors to the social dimensions of sustainability, such as sense of community and belonging, quality of life and well-being, participation, or social interaction. From a citizen perspective, sustainable policies are more likely to be supported if extra costs are reasonable and do not increase beyond 10% (i.e. energy or building material); they do not decrease the comfort of living and acknowledge current lifestyles; and they are implemented in a very transparent form providing the public with a sense of control over costs and spending. From a municipal policy perspective, it is crucial that policies are based on a broad consensus and cooperation within the city government as well as between the government and the public.

Because of careful planning, transparency in the decision-making process, and comprehensive public outreach, a considerable number of Freiburg's residents support the city's approach towards designing and implementing sustainable development strategies (Hopwood, 2007). Thus, it is not surprising that the current mayor, who has been in office since 2002, is a member of the Green Party. The Green Party also holds the most seats in the city government with 11 out of 48 seats (City of Freiburg, 2017c). Work by Mössner suggests that Freiburg successfully "arranged a whole 'eco-system' of techniques, markets and politics that set new standards for implementing sustainability at the local level and in all societal fields, seemingly including all parts of society" (2016, p. 973).

Parallel to the environmental movement in Freiburg, a housing-related social movement developed as well

in the early 1980s. Ongoing population migration to Freiburg and other cities sparked a housing crisis, pricing especially younger residents out of the market and forcing them to occupy vacant houses do to the lack of affordable housing stock. This led political decision-makers to focus more on affordable housing throughout the city, emphasizing affordable housing and other social equity objectives in their initial planning and early construction phases. This focus was very apparent in the development phases of both Rieselfeld and Vauban.

2.3. Rieselfeld and Vauban

Of these two recent neighborhood developments in Freiburg, Rieselfeld can be considered the result of a long-term planning approach by the city to provide new housing, whereas Vauban was the outcome of an unexpected availability of land in the form of an abandoned French army barracks. Rieselfeld can be characterized as an exurban scheme designed with greater self-containment in mind, with a full range of schools and community infrastructure, compared to the smaller Vauban neighborhood. Construction of Rieselfeld began in 1994 and was completed in 2010. The first residents moved there in 1996 and today Rieselfeld's 4,500 housing units can house up to 12,000 people (Frey, 2013). The development phase of Vauban also began in 1994 with its first residents moving into the neighborhood in 1998. By 2006, the neighborhood was fully developed and today is home to about 5,500 people (Forum Vauban, 2017).

The built environment is similar in both neighborhoods. As shown in Figures 1 and 2, Rieselfeld and Vauban have significant car free areas, green infrastructure and networks, and a superblock pattern with low mobility needs and high walkability supporting social interactions and health among residents. Both neighborhoods were also connected to light rail and bus networks early on, linking the new developments to the downtown and commercial districts of Freiburg. Both communities were designed to reduce the use of the private automobile, but Vauban implemented more stringent measures. Whereas parking is available throughout Rieselfeld, Vauban established car-park-free housing requiring car owners to purchase a parking spot in structures located on the edges of the neighborhood. Car owners also had to cover the costs for building the parking structures, amounting to approximately €18,000 per car.

In both cases, the design of the neighborhoods has been profoundly impacted by public participation and strong city government involvement that controlled the development process from the outset rather than private developers (Hamiduddin & Daseking, 2014). Instead of selling an entire site to a developer, the local government favored an alternative approach, making individual parcels available for collaborative self-build development, so called "Baugruppen", or co-operative building. Within an overall framework of design codes and with the help of an assigned architect, the cooperative housing approach allowed future residents of Vauban and Rieselfeld to collaborate on financial and design aspects of an apartment building and ensure that the requirements of all households were met. Proponents of this approach emphasize its benefits, including meaningful public input into the design and construction process, fostering social bonds from the onset of a project, and significant cost savings compared to traditional and developer-driven individual housing projects (Barlow, Jackson, & Meikle, 2001).

Figure 1. Vauban housing court in 2011 (Payton Chung, Flickr).

Figure 2. Aerial view of Rieselfeld neighborhood in 2012.

Rieselfeld also applied a "responsive" planning approach to the neighborhood development under the leadership of Klaus Siegel, the head of the city-appointed Rieselfeld Development Committee from 1992 to 2010 (Siegel, personal communication, July 2014). Development was split into four distinct property segments with each development starting 2 years after the previous section. This allowed a flexible planning approach that could learn from mistakes and adapt to changes in the demographics and needs of households interested in living in Rieselfeld.

Regarding the social dimension of neighborhood design and the first research question of this paper, the work done in Rieselfeld and Vauban emphasizes two factors that strongly contribute to sustainable and socially just communities (Hamiduddin, 2015). First, neighborhood development allows for a co-operative housing development model as well as easy accessibility to a comprehensive public transit system that makes it easier for young families as well as lower income groups to relocate there. Second, neighborhood design favors pedestrians and cyclists over the car as well as provides ample green space and a high-quality public realm for children to play and adults to interact with each other. These factors enhance social relations among the residents.

In addition, both neighborhoods established citizen organizations early on, such as K.I.O.S.K (Contact, Information, Organization, Self-Help, and Culture) and BIV (Citizens Association) in Rieselfeld, and the Stadteilverein Vauban e.V. (Neighborhood Citizen Club) in Vauban. According to Andreas Rössler (president of BIV and long-term resident of Rieselfeld) and Almut Schuster (member of Stadteilverein Vauban e.V and long-term resident of Vauban), the early installment of citizens' organizations was crucial in the overall success of both neighborhoods and building up a strong sense of place and community as well as a robust and diverse social fabric (Rössler & Schuster, personal communication, July 2014). These institutions provided an opportunity for residents to provide feedback on proposed designs and policies, and encouraged social interaction early on. Fostering citizen involvement from the beginning created a strong sense of identity and responsibility among today's residents. People who live in in either of two neighborhoods generally care about the environment and value the social infrastructure and networks they helped to put in place so many years ago.

3. Methodology

The data presented and discussed in the following section were gathered through surveys conducted in the two neighborhoods over a three-week period in January 2017. Rieselfeld and Vauban residents were asked to fill out a survey instrument containing 27 questions. In total, 200 completed surveys were collected, 103 in Vauban and 97 in Rieselfeld. The two neighborhoods were chosen because of the present social sustainability conditions discussed. All streets and homes were selected at random, and responses were collected on a voluntary basis with complete anonymity. The surveys were either filled out with the collector present or distributed and collected later. The researcher conducting the fieldwork underwent training prior to the fieldwork to ensure that participants were not influenced, were at least 18 years of age, and that privacy rights were protected. Table 2 shows the characteristics of the two neighborhood survey samples with respect to gender, age group, children per household, time of residency, and living situation.

Randomization techniques were used in the collection of the survey data. Participants were approached on the street or at home and asked to participate in the

Table 2. Characteristics of surveyed population.

Gender	**Female**	**Male**	**No Answer**				
Rieselfeld	51.6%	44.3%	4.1%				
Vauban	53.4%	44.7%	1.9%				
Age Groups	**18 to 24**	**25 to 34**	**35 to 44**	**45 to 54**	**55 to 64**	**65+**	**No Answer**
Rieselfeld	8.2%	4.1%	10.3%	50.5%	19.6%	5.2%	2.1%
Vauban	14.6%	1.9%	5.8%	43.7%	21.4%	7.8%	4.6%
Children per household	**0**	**1**	**2**	**3**	**4+**	**Mean**	
Rieselfeld	33.0%	24.7%	27.8%	11.3%	3.1%	1.3	
Vauban	46.6%	20.4%	23.3%	8.7%	1.0%	1.0	
Time living in…	**1< years**	**1–3 years**	**4–6 years**	**7–9 years**	**10+ years**		
Rieselfeld	5.2%	5.2%	5.2%	15.5%	69.1%		
Vauban	4.9%	9.7%	7.8%	5.8%	71.8%		
Living Situation	**Rent**	**Own**	**No Answer**				
Rieselfeld	12.4%	85.5%	3.1%				
Vauban	24.3%	68.9%	7.0%				

Note: In total, 200 completed surveys were collected, 103 in Vauban and 97 in Rieselfeld.

15-minute survey. It is important to acknowledge here that several factors may have influenced the survey data. The researcher administering the survey and collecting data was not a native German speaker. Potential survey participants were approached in English, but were provided with a survey instrument and information sheet about the study in German to reduce survey bias. Although translations were provided and younger generations learn English in school, language barriers between the researcher and elderly people may have affected survey response rates among this age group. However, enough household responses were obtained from the two neighborhoods to be able to scientifically generalize for each neighborhood.

Originally developed for risk perception research, the survey research presented in this paper is based on a psychometric paradigm (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, Fischhoff, & Lichtenstein, 1984), which assumes that through appropriate survey design, different scaling methods, and multivariate analysis of public attitudinal, motivational and behavioral factors important to this study can be captured. The survey questions and response items are based on previous studies in public perceptions and community research (McMillan & Chavis, 1986; Nasar & Julian, 1995; Sander, 2002; Schwaller, 2012). The majority of questions in the survey were closed-ended, multiple-choice questions, allowing easy coding and comprehensive statistical analysis (Henerson, Morris, & Fitz-Gibbon, 1987). The questions asked were predominantly focused on the motivating factors of moving to either Rieselfeld or Vauban, the level of satisfaction of living in the two neighborhoods, and social engagement factors as well as socio-economic information shown in Table 2. The survey questions were designed with the seven contributing factors of social sustainability outlined in section 2.1 in mind.

The questions mainly consisted of ''Likert-type scaling'' and answers were balanced equally. This means that the number of favorable and unfavorable answer categories are equal to prevent statistical biases. The Likert-scales used in the survey instrument were mostly 5- to 7-point scales. The answers ranged, for example, from strongly disagree to strongly agree or from unimportant to very important with a neutral answer possibility. The survey instrument was tested and reviewed by national researchers experienced in survey research, public engagement, and community planning to ensure the validity of the Likert-scales and other multiple-choice questions. The total sample size of 103 households for Vauban and 97 for Rieselfeld is large enough to generalize results with a 95% confidence level at ±4% margin of error for both neighborhoods. This study applied basic statistical methods such as frequency distributions and descriptive statistics.

4. Data Analysis

4.1. Motivational Factors for Moving to Rieselfeld and Vauban

To understand why people decided to move to Rieselfeld or Vauban, one set of survey questions targeted the underlying motivation and reasons to relocate to either neighborhood. Our hypothesis was that potential residents of the two neighborhoods were motivated by sustainability as they were provided with plenty of information on how the communities would be centered on sustainable design, including social infrastructure acknowl-

edging the social dimension of sustainability. The study was interested in 1) discerning what factors were important in the decision to purchase a home in either of the neighborhoods and the relative weights of those factors; and 2) were these factors aligned with the prevailing literature on social sustainability and neighborhood social well-being factors leading to happiness (Choi, 2013; Cloutier & Pfeiffer, 2015). Data collected also allows us to examine if the motivational factors to relocate were aligned with the advertised amenities of the communities during the planning and development process as well as to determine whether today's level of satisfaction of living in the two neighborhoods can be accounted for by the reasons prompting the move in the first place.

The survey asked respondents how important a set of nine factors were in deciding to move to a neighborhood designed along new urbanism and sustainable design principles. These factors were Safety, Peace & Quiet, Affordability of Housing, Quality of Schools, Sense of Community, Walkability, Energy Efficiency Households, Public Amenities, and Environmentally Friendly Design. The nine factors were chosen based on the work by Sander (2002) and Schwaller (2012) to permit data comparison of similar neighborhoods at a later stage of this project. In addition, the chosen factors address various indicators of social sustainability in an urban environment discussed in section 2.1 such as sense of community, sustainable urban design, accessibility, quality of life, and walkability. Table 3 shows the mean scores and percentages for each factor by neighborhood.

The results show that the top two factors for relocation are the same for both neighborhoods. The prospect for "Peace & Quiet" was the most important factor for relocation with a mean score of 5.4 in Rieselfeld and a 5.7 in Vauban. This was followed by "Environmentally Friendly Design" with mean scores of 5.3 and 5.6, respectively. Both these factors include sub-factors such as utilization of solar technology, high density dwellings, green open space, pedestrianism, and nearby schools. "Energy Efficient Households" was ranked third by Rieselfeld participants with a mean score of 5.2. In Vauban, this was ranked fourth, with a mean score of 5.4, behind "Walkability" with a mean score of 5.5.

In reviewing the data, a couple of interesting trends emerge. First, nearly all factors received points on the higher side of the scale, meaning that all factors had some importance in the decision to relocate. However, environmental factors dominated. Second, we hypothesized that household composition and number of children account for relatively large differences between neighborhood rankings for "Public Amenities" and the "Quality of Schools" factors when compared to the other seven aspects. Almost 50% of all households in Vauban do not have children compared to only one-third in Rieselfeld. Furthermore, each household in Rieselfeld has on average 1.3 children; in Vauban, the number is 1.0. In addition to "Public Amenities" and "Quality of Schools", "Walkability" mean scores ranked differently as factors for moving to Rieselfeld or Vauban. For all three factors t-tests show a statistically significant difference between the two samples with $p \leq 0.05$.

"Public Amenities" was the factor with the largest difference in mean scores. It averaged 5.0 in Rieselfeld (ranking 5th) and 4.3 in Vauban (ranking 6th). In other

Table 3. Level of importance of different factors for moving to Rieselfeld or Vauban

Rieselfeld	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Mean**	**Rank**
Safety	20.6%	12.4%	10.3%	20.6%	16.5%	11.3%	8.2%	3.7	9
Peace & Quiet	3.1%	3.1%	7.2%	6.2%	23.7%	33.0%	23.7%	5.4	1
Affordability of Housing	8.2%	11.3%	13.4%	22.7%	12.4%	18.6%	13.4%	4.3	8
Quality of Schools	16.5%	7.2%	9.3%	8.2%	19.6%	17.5%	21.6%	4.4	7
Sense of Community	3.1%	11.3%	9.3%	9.3%	23.7%	20.6%	22.7%	4.9	6
Walkability	3.1%	13.4%	6.2%	9.3%	19.6%	26.8%	21.6%	5.0	5
Energy Efficient Households	4.1%	6.2%	5.2%	12.4%	24.7%	21.6%	25.8%	5.2	3
Public Amenities	2.1%	6.2%	7.2%	20.6%	13.4%	35.1%	15.5%	5.0	4
Environmental Friendly Design	5.2%	3.1%	4.1%	13.4%	17.5%	35.1%	21.6%	5.3	2
Vauban	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Mean**	**Rank**
Safety	19.4%	19.4%	12.6%	13.6%	17.5%	5.8%	11.7%	3.5	9
Peace & Quiet	2.9%	3.9%	1.0%	10.7%	13.6%	35.0%	33.0%	5.7	1
Affordability of Housing	17.5%	13.6%	11.7%	8.7%	23.3%	9.7%	15.5%	4.0	7
Quality of Schools	26.2%	9.7%	4.9%	16.5%	19.4%	12.6%	10.7%	3.7	8
Sense of Community	3.9%	1.0%	11.7%	16.5%	21.4%	35.0%	10.7%	5.0	5
Walkability	4.9%	4.9%	4.9%	5.8%	12.6%	30.1%	36.9%	5.5	3
Energy Efficient Households	6.8%	1.0%	4.9%	11.7%	12.6%	35.0%	28.2%	5.4	4
Public Amenities	10.7%	6.8%	11.7%	20.4%	15.5%	30.1%	4.9%	4.3	6
Environmental Friendly Design	5.8%	1.0%	5.8%	4.9%	16.5%	35.9%	30.1%	5.6	2

Note: Survey respondents were asked "On a scale from 1 to 7, how important were each of the following items in your decision to live in Vauban/Rieselfeld, with 1 being 'not important at all' and 7 being 'you would not have relocated without it'?".

words, public amenities were seen as more important in Rieselfeld. Less than 51% of respondents in Vauban identified them as an important relocation factor (4.9%) compared to almost 65% in Rieselfeld (15.5%), who identified them as essential to their decision to move to Rieselfeld. The second factor 'Quality of Schools' was also more important to residents in Rieselfeld than Vauban. Overall, it was one of the less important factors motivating people to move. However, the percentage of respondents indicating that without quality schools they would not have relocated is twice as high in Rieselfeld (21.6%) compared to Vauban (10.7%). The third factor "Walkability" was considered more important to the residents in Vauban compared to Rieselfeld. We hypothesize that Vauban's strong focus on car free living, compared to Rieselfeld that allows private cars at all times in its interior, is an important aspect that contributed to the difference between the two places regarding this factor.

Another set of questions asked about the relative importance of environmental and social factors in deciding whether or not to move into the neighborhood (Table 4). Overall, the response percentages show environmental factors were seen as "Somewhat important" to "Important" in both of the neighborhoods. In Vauban, this was 68.9%; in Rieselfeld, it was 72.16%. Environmental factors were significantly less important than social factors. For example, environmental factors averaged 12.9% as being 'very important' while social factors averaged 37.5%. Social factors were seen as 'Somewhat important' to 'Important' in both of the neighborhoods with 69.9% of residents in Vauban and 73.2% of residents in Rieselfeld expressing this opinion.

It is important to note that the major relocation factors identified were also key points of the underlying concepts of the two neighborhoods developed by the city government with the help of planners, architects, and involved citizens (Frey, 2013) Moreover, major reasons for relocation such as Peace & Quiet, Environment Friendly Design, Walkability, or Energy Efficient Households fall within the contributing factors of social sustainable neighborhood design identified in the literature and discussed in section 2 of this article. This suggests that early marketing campaigns were successful in attracting potential residents that were supportive of the underlying neighborhood concepts. However, a very important factor for the city of Freiburg in developing the two neighborhoods, "Affordability of Housing", ranked in the lower third (8th in Rieselfeld and 7th in Vauban) among all possible motivational factors for moving into either of the two neighborhoods. This is not totally unsurprising given the recent critiques of Freiburg's housing market as being not affordable (Hamiduddin, 2015; Mössner & Miller, 2015).

Although providing affordable housing was one the key goals of Vauban and Rieselfeld, the overall success of Freiburg to become more sustainable has led to a considerable uptake in people wanting to move there and has led to lower income groups being priced out of the housing market. Due to the bidding mechanism of the open market, especially for residents in Vauban and Rieselfeld who were not among the original co-operative building groups, affordable housing was not an option and thus not a motivating factor in moving. Instead, critics argue that Rieselfeld and Vauban with their initial focus on social diversity have transformed over time into a relatively well to-do, homogeneous, ethnically German neighborhoods (Freytag, Gössling, & Mössner, 2014). What does stand out as important are the motivational variables and physical features in terms of sustainable urban design and the social, mostly participatory, dimensions of the development process.

4.2. Level of Satisfaction Living in Rieselfeld and Vauban

Another group of questions focused on how satisfied residents are in living in Vauban or Rieselfeld. Since both neighborhoods have been completed for several years now, it is important to understand if today's residents are satisfied with the living conditions, social interactions, and public amenities. This will help inform similar future developments. The literature discussed in section 2 pointed out that several key factors—quality of schools, safety, local governance, social contacts, environmental quality, and housing conditions—are influential in creating neighborhood satisfaction or high levels of quality of life in neighborhoods. Survey questions were developed to measure the importance of several of these factors in determining the level of satisfaction in living in the two communities.

One question asked about the overall level of satisfaction of living in the two neighborhoods. As shown

Table 4. Importance of environmental and social factors for moving to Rieselfeld/Vauban.

Environmental Factors	**Not at all important**	**Somewhat important**	**Important**	**Very Important**	**No Answer**
Rieselfeld	15.5%	38.1%	34.0%	9.3%	3.1%
Vauban	13.6%	35.9%	33.0%	16.5%	1.0%
Social Factors	**Not at all important**	**Somewhat important**	**Important**	**Very Important**	**No Answer**
Rieselfeld	2.1%	13.4%	35.1%	38.1%	2.6%
Vauban	1.9%	11.7%	33.0%	36.9%	1.9%

Note: Survey respondents were asked "On a scale from 1 to 4 to what degree did the following factors enter into your decision to move to Vauban/Rieselfeld, with 1 being 'not at all important' and 4 being 'very important'?".

in Table 5, the results indicate similar levels of satisfaction between both Vauban and Rieselfeld residents. In Vauban, 83.5% of responses were "satisfied" and "very satisfied"; in Rieselfeld, 86.7%. For both places, dissatisfaction levels in living in the two neighborhoods were between 10 and 15 percent, respectively with Rieselfeld showing around a 5% lower dissatisfaction level.

Another corroborating question asked respondents about their "level of satisfaction with their decision" to move into these two neighborhoods (Table 6). The sum of the percentages in the 5, 6, and 7 ratings indicate a generally high level of satisfaction with the decision to move into each of the two neighborhoods with similar response percentages between the two neighborhoods—86.4% for residences in Vauban and 85.4% for Rieselfeld. Both questions on residential satisfaction, one on living there and one on their decision to move there, show very high levels of satisfaction. These data are still at the aggregate level and do not tell us the critical social factors experienced in community satisfaction.

4.3. Level of Social Engagement in Rieselfeld and Vauban

Besides improving the understanding of why people moved to Rieselfeld or Vauban and their level of satisfaction with living there now, the study was also interested in residents' perceptions regarding the level of social engagement in the two neighborhoods (Table 7). We considered three factors as social engagement factors: the amount of social contact, influence on local decision-making processes, and participation in local organizations. Respondents in each of the neighborhoods were asked to rate the level of social contact (friendliness), the ability to influence local decisions (governance), and participation in local organizations (civic involvement).

The analysis looked at the responses in the top two ratings, 6 and 7 on the Likert scale for both communities. For social contacts, the combined average percentages in the 6 and 7 categories were 38.8 percent in Vauban. The combined percentage was much higher at 55.6 percent In Rieselfeld. If we include the mid-level rating (5), social contacts for Vauban rank over 50% (59.2) and 70% for Rieselfeld, we can deduce that the very high levels of satisfaction living in the two neighborhoods are not significantly influenced by knowledge of neighbors in Vauban but may be a contributing factor in Rieselfeld.

We also wanted to determine if governance or community involvement made a difference. To answer this question, respondents were asked to rate the statement "I feel I can influence decisions that affect my neighborhood" on a 1- to 7-point Likert scale. The combined scores of 6 and 7 were assessed. Results showed that

Table 5. Overall level of satisfaction with living in Rieselfeld/Vauban.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied	No answer
Rieselfeld	10.3%	0.0%	2.1%	30.9%	55.7%	1.0%
Vauban	15.5%	0.0%	1.0%	35.0%	48.5%	—

Note: Survey respondents were asked "On a scale from 1 to 5, with 1 being 'very dissatisfied' and 5 being 'very satisfied', how satisfied overall are you with living in Vauban/Rieselfeld?".

Table 6. Level of satisfaction with moving to Rieselfeld/Vauban.

Satisfied with moving to…	1 Very dissatisfied	2	3	4 Undecided	5	6	7 Very satisfied	No answer
Rieselfeld	2.1%	1.0%	2.1%	4.1%	11.3%	16.5%	57.7%	2.1%
Vauban	4.9%	1.9%	1.0%	4.9%	8.7%	28.2%	49.5%	4.9%

Note: Survey respondents were asked "On a scale from 1 o 8, with 1 being 'very dissatisfied' and 7 being 'very satisfied', how satisfied overall are you with your decision to move to Rieselfeld/Vauban?"

Table 7. Level of social engagement in Rieselfeld/Vauban.

Rieselfeld	1	2	3	4	5	6	7	No answer
Social contacts	3.1%	4.1%	8.2%	13.4%	14.4%	17.5%	38.1%	1.0%
Ability to influence local decisions	7.2%	14.4%	21.6%	28.9%	11.3%	11.3%	2.1%	3.1%
Participation in local organizations	21.6%	16.5%	10.3%	21.6%	9.3%	6.2%	9.3%	5.2%
Vauban	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**No answer**
Social contacts	1.9%	3.9%	14.6%	19.4%	20.4%	26.2%	12.6%	1.0%
Ability to influence local decisions	5.8%	19.4%	19.4%	15.5%	25.2%	8.7%	1.0%	4.9%
Participation in local organizations	30.1%	15.5%	9.7%	16.5%	5.8%	9.7%	4.9%	7.8%

Note: Survey respondents were asked "Please rate the following statements using a scale from 1 to 7, a) I know my neighbors on my street; b) I feel I can influence decisions that affect my neighborhood; c) Members of my household participate in formal or informal neighborhood associations or groups."

not many residents of the two neighborhoods, 9.7% in Vauban and 13.4% in Rieselfeld, felt that they could influence decisions that would impact their neighborhood. This factor was not strong enough to explain high satisfaction rates for either neighborhood. The third factor, household participation in local community associations, was found to be lower than expected given the literature on the two neighborhoods and the interviews on the social aspects of planning the two communities. Only 14.6% of households participate actively in Vauban (ratings of 6 & 7) and only 15.6% in Rieselfeld rated their involvement with local organizations.

The results for satisfaction with living in the two neighborhoods were expected given the increasing values of homes and the relatively long periods of time that residents stay. The high levels of social contact suggest a significant level of trust among neighbors, which is a most important feature of social capital, increasing the likelihood of cooperation that further increases trust (Dempsey, 2008, 2011). But in the two other social engagement areas, local decision-making processes and participation in local organizations, activities did not meet our expectations. At the higher end of the Likert scale (ratings 6 and 7), percentages were less than expected. While these percentages were lower than we anticipated, they may be higher than the rate of these activities in communities elsewhere in the world (Beatley, 2004; Head, 2008; Putnam, 2000). Our study did not compare findings to external communities. This is a future research area that will provide greater insight into what makes these communities good places to live.

5. Conclusion

This paper first addresses the question "How did the city of Freiburg establish the social dimension of sustainable neighborhood development into the planning process of Rieselfeld and Vauban" in section 2. As pointed out by the vast amount of available literature and city officials, Freiburg took advantage of local circumstances, such as early interest in the green movement among its citizens, to engage in environmentally friendly and socially just policies building up social capital and fostering social sustainability. This resulted in long-term commitments outlined in the city's local Agenda 21 in 1996 and the signing of the Aalborg Commitments in 2006.

When looking at the social dimension of sustainable development practices specifically, the city's long-term approach to planning as well as inclusion of the five big Cs—cost, comfort, control, consensus, and cooperation—for successful sustainable policy implementation and urban development were found to be a vital part of Freiburg's success. The city's focus on public outreach and citizen participation also was a decisive factor in directly establishing the social dimension of sustainable neighborhood development into the planning process of Rieselfeld and Vauban. As pointed out in section 2, the citizen organizations established early on build a strong sense of place and community as well as a robust and diverse social fabric. Although, some circumstances are unique to Freiburg and cannot be replicated easily in other cities, other aspects of the City's approach are transferable to other municipalities looking for ways to increase not only the environmental but also social dimensions of sustainable urban development.

The analysis of the survey data in section 4 focuses on the second underlying research question "How do residents perceive the level of social engagement in the two neighborhoods, why did they move there, and are they satisfied with their decision?" The analysis first addresses the question of what drew people to Vauban and Rieselfeld. The results show positive responses to all the locational factors—Safety, Peace & Quiet, Affordability of Housing, Quality of Schools, Sense of Community, Walkability, Energy Efficiency Households, Public Amenities, and Environmentally Friendly Design—defined in the surveys given to neighborhood residents. These factors were taken from the social dimensions' literature on sustainable urbanism and relate to the seven contributing factors to urban social sustainably this study focuses on and discussed in section 2.1. All nine of the variables are within or above the medium scale of importance to persons looking for a place to settle and live sustainably. The factors range from 4.5 to 6.0 on a 1 to 7-point rating scale where 1 is "not at all important" to 7 which means "very important" in people's decisions to move into a neighborhood.

None of the elements stands out as exceptionally or critically important for adopting the neighborhood. It is the plethora of physical and social elements that come together to create a place. This "clustering effect" highlights the consistency and reliability of all variables. A few variables do rank at the highest levels of importance within the cluster, however. Our results show "Peace & Quiet" and "Environmentally Friendly Design" at the top of the cluster. But in what context do these two factors lead in importance? Certainly, significant pedestrianism, lack of automobiles, housing with courtyards and gardens, as well as high levels of walkability are among the factors that contribute to both peace and quiet, and environmentally friendly design.

Interestingly, a few of the nine factors are not as important to the neighborhood homebuyers as the literature would have us think. For example, safety, housing affordability, quality of schools and overall sense of community show less importance than anticipated. Despite attempts to reduce housing costs through cooperative participation in designing multiple-housing units as entry into these neighborhoods, it did not apply everywhere and was not deemed a factor of high importance. Similarly, with a population of over 50% of households in Vauban without children, the quality of schools did not emerge as an important social factor for relocation into the neighborhood.

"Environmental Friendly Design" as a factor for purchasing homes and residing in the two neighborhoods

were words that we used to characterize the neighborhoods, but the data suggests that survey respondents did not link that term to energy efficiency or technologies, but concepts of space and place and form of the neighborhoods as well as social engagement. This is most likely due to the way the term was translated into German for the survey instrument. Only 46.6% of residents indicated that environmental factors were important to them when they purchased or rented their home. Surprisingly, 71.5% of respondents identified social factors as a principal reason for moving into the neighborhoods. These factors were generally clustered together indicating consistency across respondents.

The second half of section 4 focused on the level of satisfaction of living in either of the two neighborhoods followed by a discussion of the level of social engagement among the residents. The data show high levels of satisfaction with the decision to move into the neighborhoods and with the current quality of life in Vauban and Rieselfeld. There was congruence in attitudes between what was important to residents moving into the community and satisfaction with living there, meaning that the attributes of space and place that were important were met by living there. This congruence resulted in an average "livability satisfaction" rating of 85.2% for "satisfied" and "very satisfied" for living in the two communities.

Lastly, tested responses to measure the level of social and community engagement tell us that both communities experienced fairly solid community engagement levels if we take the percentages in the 5, 6, and 7 ratings on a 1 to 7 scale of involvement or engagement. This indicates a strong social sustainability in both neighborhoods. In terms of social cohesion or level of neighborliness, Rieselfeld residents had 70% knowledge of their neighbors while Vauban had 58.4%. Using the same rating categories (5, 6, and 7), average scores for political involvement in local organizations and the ability to influence decisions were in the mid-20s. We argue that compared to other cities around the world, especially in the United States, these percentages of people engaged in sociopolitical organizations remains relatively good.

What did we learn from this case study of two neighborhoods that can provide insights to research on the social ecology of urban areas that impacts sustainable development? Satisfaction with living in a place and reinforcing its assets through social resiliency or livability can result in long-term community staying power. In both neighborhoods studied around 70 percent of residents had lived in the two neighborhoods for over ten years and continued to express high levels of "satisfaction". In general, there were few differences in preferences ratings of physical and social assets between the two communities. The key factors identified in the literature on social sustainability were also seen as important factors in these neighborhoods, and we mention these as a "cluster" of social factors explaining "satisfaction" with living there. Some factors received less influence in importance such as quality of schools in one neighborhood. In this case demographics were a key explanatory variable based on a much lower number of children. Overall, the levels of importance of social factors contributing to place satisfaction and staying power were not significantly different in both neighborhoods. Having a "cluster" of social factors present that were important to residents contributed significantly to place satisfaction. In fact, the survey results showed that it was these social factors that were seen as more important to place satisfaction than the physical attributes of sustainable developments.

From the findings, we surmise that residents' satisfaction levels with living in the neighborhoods are derived from environmentally friendly designs, maintaining social capital, and community engagement and participation. Importantly, these factors were developed and sought after by the original designers of the two communities. Thus, we can hypothesize that intentional, participatory design can result in both highly sustainable and livable urban areas. This hypothesis points to future research opportunities. The current study is limited in scope, focusing on two neighborhoods. Future research should also look at the relationship of Rieselfeld and Vauban with the city of Freiburg. For the two neighborhoods, the city of Freiburg, provides added value in the larger social ecology for sustainability—food markets, social interaction, education, shopping, and services. It is also the cultural hub of the region. In addition, it is likely that the survey instrument does not capture all factors that can explain what drove people to relocate as well as how satisfied and socially engaged they are nor does it cover all contributing factors to urban social sustainability outlined in Table 1. Therefore, this study should function as a benchmark for different follow-up studies from an empirical perspective, for example by expanding the survey instrument and comparing Freiburg and its two neighborhoods to other cities.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Expanding the Scope of Sustainability Planning: Lessons from Stockholm's Congestion Charging Policy

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Abstract
In 2007, after years of unresolved debate, the Swedish parliament approved a congestion charge for Stockholm applied to cars crossing the city's inner boundary. Since its introduction, congestion charging has led to an even more lasting reduction of car trips to the city center, in part because the policy generates revenues for financing new subway extensions and uses these same resources as the basis for negotiating new transit oriented housing in subway extension areas. As such, congestion charging is arguably as much a sustainable housing solution as it is a narrowly defined transit policy for reducing automobile congestion or pollution. This article investigates how and why Stockholm, despite considerable political conflict, technical complexity and negative public opinion, was able to turn a long-standing and controversial debate over moderating automobile traffic via tolls into widespread support for a national congestion tax, which itself laid the groundwork for a more expansive sustainability agenda. It further suggests that only when congestion charging was strategically reframed and widely recognized as addressing the concerns of multiple and competing constituencies, did efforts for its adoption translate into larger sustainability gains.

Keywords
congestion charging; innovation; land-use policy; planning; politics; transport; urban sustainability

Issue
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1. Introduction

In June 2007, Stockholm introduced a congestion charge for vehicles crossing the city's inner boundary to reduce traffic flows into central city areas and fund badly needed new capital investments. The decision followed a seven-month trial and a public referendum. Today, Stockholm is known world-wide for the successes of its congestion-charging program and its early adoption of a policy which has contributed to its reputation as one of the most sustainable cities in Europe. Congestion charging is now accepted by a broad group of stakeholders, including those who ardently fought the introduction of such measures for close to forty years. Moreover, the revenue generated by the charge is now funding subway extensions by negotiating with local communities, who in return for these investments in infrastructure agree to provide transit oriented new housing. Thus, congestion charging has increased local authorities' political capacity to link housing and transportation planning to support sustainable growth.

This case study investigates how, why, and in what ways governing authorities in Stockholm reversed four decades of opposition to congestion charging, bringing

Green Party advocates, Moderate, Social Democratic, and Liberal Party protagonists together to support this policy despite years of political conflict, considerable technical complexity, and initially negative public opinion. The narrative presented here is based on a review of historical documents, plans and reports, complementary date on historical population and income trends, and interviews with leading politicians, civil servants and NGO representatives, both active and retired. Of 21 total interviews, 14 were undertaken in 2014 based on an interview guide. Other individuals were interviewed as part of the process of determining relevant transportation decisions. During a return visit in 2015 nine additional interviews were conducted, several new actors were interviewed, and some additional contacts were re-interviewed (a full list is available upon request).

In this article we investigate the historical evolution of political support for and against congestion charging in the context of institutional relationships at the municipal, regional and national levels. Our aim is neither to evaluate the transit implications of congestion charging nor offer a new interpretation of the operation of the trial experiment that led up to the public referendum and its electoral success, two topics already well addressed in the literature (Eliasson, Hultkrantz, & Rosqvist, 2014; Gullberg & Isaksson, 2009). Rather, we are interested in the temporal and strategic process through which the policy was ultimately recast as contributing to more than transit priorities, as well as what role planners, politicians, and even the private sector played in crafting a reframing which effectively linked congestion charging to other urban challenges such as housing and environmental protection.

Recent work in the transport field has investigated the intra- and inter-bureaucratic conversations that produce policy change within institutions and in particular a shift in focus from transit to mobility. For instance, Hull (2007) explores the organizational and institutional dimensions of policy change and how they are marshaled to produce more sustainable transport policy. Battilana, Leca, and Boxenbaum (2009) have likewise argued that "institutional entrepreneurship" is key to changing the policy mandates within governing institutions. Along the same lines, the international NGO responsible for much of the policy agenda setting in the field of transport, ITDP (International Transport and Development Policy), has recently enshrined a similar rhetorical shift by turning attention away from mobility and more towards access.

We build on this thread in the literature but also move beyond it. In addition to expanding our understanding of congestion charging as having urban sustainability implications beyond mobility because of its impact on land-use, we examine the ways in which a negotiated reframing of the benefits of congestion charging by stakeholders both outside and inside bureaucratic institutions and across various political parties has played a critical role in effectively recasting the housing-transport nexus. All this leads us to suggest that the analysis and evaluation of congestion charging must be understood not merely in terms of its mobility impacts but also in the context of larger, more politically and strategically coordinated infrastructural imperatives necessary for producing sustainable cities.[1] Furthermore, by showing that the reframing of congestion charging involved both national and city leaders and their constituencies, a fact reinforced by the designation of congestion charging as a national tax, we are able to move beyond the biases in much of the policy analysis literature—transport or otherwise—that assumes that the jurisdictional domains of policymaking are *either* local or national. In this instance,[2] it was the shared responsibility across governance scales that set into motion an alternative framing of the value of congestion charging, and that ultimately led to its more expanded and transformative impacts with respect to urban sustainability.

2. Background: The Swedish and Stockholm Context

Sweden is a Western parliamentary multiparty democracy, with universal suffrage and elections at the national, regional and municipal levels on the same day every four years. It is often said that Swedish voters choose a party rather than an individual candidate, though dynamic and charismatic politicians have boosted political parties in Sweden as elsewhere. In contrast to nations with presidential rule and/or Anglo-Saxon traditions, Swedish politics reflects collective decision-making at all levels; leading Swedish decision-makers to not have the status of say the governor of a US state or the Mayor of London. Accordingly, the decisions described in this case were made by the 101-member Stockholm City Council, the county council assembly and the national parliament. The congestion charge decision in 2006 was a national level tax which required a formal decision of the Swedish parliament.

Many associate the Swedish brand of social welfare policy with the long period of Social Democratic Party-led government for several decades starting in the mid 1920's. In fact, in Stockholm the balance of power between the left and right party blocks has shifted back and forth several times. However, shifts between governing coalitions have in general not paralyzed efforts to adopt new policies and implement major new investments. Part of the reason for this may be that the pe-

[1] For more on the importance of conceiving of integrated urban infrastructures as the key to building sustainable cities, see Bonilla and Zapparoli (2017).

[2] In an article by Brian Holland (2015, p. 125), the argument is made that scholarly research on policy design rarely "reflect(s) a discussion of the impact of *where* programs or initiatives are implemented," and that only institutional analysis will yield possible answers to the "where" question. He further argues the importance of understanding the reasons why different scales of government might prioritize people versus place, economic versus social, or publicly versus privately led dimensions of policy. Such claims are interesting for our analysis here, because a reframing of congestion charging through local and national collaboration allowed a discussion of all of these dimensions simultaneously.

riod between about 1930 and the mid 1960's was one in which there was consensus between the Social Democratic Party and the Liberal party regarding priorities for social welfare achieved through the redevelopment of the built environment based on modernist and functionalist principles. Another explanation for Stockholm's ability to achieve transformative urban development despite differences in political opinion may be the Swedish culture of compromise. Although this is often equated with cultural values favoring consensus, it may be more closely linked to a pragmatic approach to political decision making.

Both functionalism and pragmatism contributed to a Swedish approach to urban development that during certain historical periods has seen transportation and land use for housing and commercial use as intertwined. It was also reinforced by institutions such as multiparty and multi-sector national evaluations and committees at both the national level and in Stockholm (and later, at the metropolitan level). The national evaluations and local and regional plans analyzed for this study all reflect an understanding of functional links among geographies and sectors and are typically the joint responsibility of politicians, civil servants and experts in planning, transport, real estate, public works and finance.

Stockholm's extensive and high quality public transit system, including the metro (*tunnelbana*) built and extended since the 1940's, emerged from precisely this logic. Since its construction, the subway has contributed to a high share of public transport trips even before the congestion charge was introduced; currently over 70 percent of all trips within the city, 60–65 percent to and from the city centre and about 35 percent of trips within the region as a whole, suggest a high share of transit in total trips by international standards (for current statistics from the City of Stockholm see Stockholms Stad, 2016).

As a consequence of the various driving forces influencing land-use, the population of the inner city started falling in the 1940´s and the population of the city in the 1960´s. The fraction of Stockholm´s population living in the inner city fell from 78 to 35 percent between 1940 and 1980 and the fraction living in the city, decreased from 67 per cent in 1950 to 42 percent in 1980 whereupon the ratio stabilized. In 2017 slightly more than 41 percent of the region's population lived within the City of Stockholm (Statistics Sweden, 2017).

The expansion of the subway system offered superior, low cost accessibility to a much larger geographic area and as such greatly increased the size and spread of the functional metropolitan region (Börjesson, Jonsson, & Lundberg, 2013). In Stockholm this tendency was arguably reinforced by policies that provided families of average income with larger dwellings of a higher standard while simultaneously safe-guarding the inner city from high-rise apartment blocks (see Gullberg & Kaijser, 2004; Malmsten & Carle, 2007; Sidenbladh, 1981).

3. Congestion Charging in Stockholm

Against this backdrop, the introduction of congestion charging both revealed some of the same financial dilemmas and political tensions that marked early debate over the expansion of the subway system, even as it connected the fate of congestion charging to yet another politically contentious transportation conflict emerging in later decades: what to do about growing automobile expansion. The sections that follow describe the decision to introduce congestion charges in Stockholm in light of these historically specific dilemmas; first as a means of expanding an original proposal for toll roads; second as a full-scale experiment (decision 2002; trial 2005–2006) intended to reduce automobile traffic and enhance the use of public transportation, including the subway; and finally as a permanent national tax (decision 2007; extended 2013) that laid the foundation for connecting transport to urban land-use in ways not that dissimilar from decades earlier discussions surrounding the subway.

3.1. Precedents and Forerunners

Road charges—not congestion charges—had been discussed for years and were thoroughly analyzed and proposed in national reviews of metropolitan policy in the late 1980's (Swedish Government Official Reports SOU 1989:67–70, SOU 1989:109–112, SOU 1990:20 and SOU 1990:32–36). When the national government opened negotiations with the leading political parties at the local and regional authorities in the Stockholm region for a comprehensive investment package in road and rail, road tolls were formally introduced.[3] Several of the parties participating in the first round of negotiations were positive to the idea of road charges (Social Democrats, Liberals, Green Party, Stockholm Party, Center Party) but the powerful Moderate Party was firmly against the charges unless they were earmarked for new roads. In Spring 1992 the majority parties remaining in the negotiation leading to the so-called Dennis Agreement (Social Democrats, Moderates, Liberals) said yes to the road charges, contingent on the idea that the revenue would be used exclusively to fund the new roads. "One reason for that the moderates' hesitancy was overcome was surely that they did not see any alternative to financing the road projects they most prized." (Malmsten & Carle, 2007, p. 55, author's translation). Although this was a road toll and not a congestion charge per se, the effect of a new toll to reduce total vehicle miles travelled and to achieve a better spread of traffic to avoid congestion peaks was discussed early on.

When the national government tore up the Dennis Agreement in 1997, plans to introduce road charges in Stockholm were once again tabled. Yet interest in road charges and congestion charges remained. During the

[3] This negotiation is popularly known as the Dennis negotiations, named for national negotiator Bengt Dennis.

15 years from the late 1990's Sweden noticed international experiments with charges in Oslo, Singapore and London which were cited by many of those interviewed as important predecessors to Stockholm's experience that gave the idea legitimacy in political circles and, eventually, for the population as a whole. Foreign examples affected public opinion, but also helped individual leaders hone their strategies. Åsa Romson of the Green Party notes that a study trip to Edinburgh during this period was influential; she realized that road charges had only been understood by the public as an economic burden and this prompted her to think about how to communicate the benefits of improved accessibility and economic savings (from e. g. not needing more road space) (interview, May 28, 2014). The Dennis Agreement describes road charges to finance the unbuilt sections of the Ring and for the outer bypass (*Västerleden*).[4] This had always been an uneasy and brittle compromise since the Moderates were basically against road charges in all forms, the Social Democrats were against the eastern section of the Ring and the Liberals were against the outer bypass. So when the national government withdrew its support for the package, all bets were off. Yet ten years later a fairly advanced congestion charging tax had been made permanent and by all accounts has received broad (if grudging) acceptance from a wide range of constituencies. How this happened a lot to do with a changed political context in the early 2000's.

3.2. The 2002 Elections

During the 2002 election campaign, the environmental lobby had become more organized and was able to highlight the role of road charges in reducing congestion, improving local air quality, reducing carbon emissions, and potentially avoiding the cost and effort to build a western bypass (whose estimated budget increased with every new evaluation and showed no signs of plateauing). On the other hand, there was still considerable support for building new roads as the best way to provide a lasting solution to congestion in the central parts of the city. Even among parties positive to using road charges as a demand management policy, the focus of the argument was somewhat different. Stockholm's environmental director Gunnar Söderholm notes that "The Social Democrats underlined the air quality improvement more than congestion (relief), and the Green Party underlined the decrease in congestion more than the air quality. But this is quite logical. To the Social Democrats, this was not an alternative to new roads but rather a complement. But for the Green party the main issue was, if we can reduce congestion we can avoid new roads, the present capacity will be enough to handle the traffic. They wanted to minimize the number of cars, fossil fuel driven but also the car itself. That was not the case for the Social Democrats—the car has always been a symbol of social welfare and economic growth." (Gunnar Söderholm, interview).

The 2002 election campaign was in full swing in Summer 2002 and the Social Democrats in Stockholm were eager to regain power from the right-wing coalition, as were their party colleagues at the county and national levels. Leading Stockholm Social Democrat Annika Billström was interested in the potential of congestion charging but advocated postponing implementation of a congestion charge. During the election campaign of 2002, she swore not to introduce congestion charges during the next term if elected. However, directly after the Social Democrats won the election (local, county, and national) Billström was more or less ordered to introduce a full-scale charging experiment by her national government party colleagues. Billström faced a storm of criticism for having broken her promise and according to many of those interviewed, her ability to lead the city was compromised. On the other hand, it was the only way for her to form a majority in the city council and assume leadership (Bosse Ringholm, interview, 2014). Billström used the opportunity to ask the national government for co-funding for a congestion charge trial. She also demanded a secretariat for the "environmental charge" (*Miljöavgiftskansli*) to be created directly under her to manage the trial.

The Social Democrats were after the 2002 elections the largest party in the national parliament and were eager to maintain power by forming a multi-party coalition government, but this required the active support of the Greens, who, with 17 seats, now had swing vote power. The Green Party representatives demanded a promise to test a full-scale congestion charging scheme in Stockholm—comprising (almost) all access roads to Stockholm but with a strictly defined trial period—noted by many of those interviewed as critical to its eventual success.

The 2002 elections had also given the Greens swing vote power within the Stockholm City Council and the County Council. This made local approval of a congestion charging trial essentially unavoidable, even for the most avid opponents, who nevertheless turned their attention to efforts to delay tactics, including legal appeals of the many details as part of the decision. In the end, it was a seven-month trial instead of a multi-year trial. Much of the legal controversy had to do with whether or not it was possible to introduce a local fee, which would require a change to the Swedish Constitution.[5] Taxis and other commercial vehicles were exempt from the tax as were alternatively fueled vehicles—a selling point for green cars that had such dramatic effect on sales of ethanol bi-fueled vehicles in particular that it has

[4] When the national government finally approved the congestion charging scheme the revenues were (informally) promised (though not formally earmarked) for building the western bypass, the part of the road transportation package in which the national government arguably had the strongest national interest because it facilitated both metro area accessibility as well as national corridors linking Northern and Southern Sweden.

[5] Such a change was made seven years later.

since been revoked to ensure that revenues can remain high and congestion low.

3.3. The First Trial

To the surprise of many, the chaos predicted by congestion charging opponents did not materialize. On its first day, the traffic volumes on the gateways to the city decreased by 20–25%. Despite the shortened trial period, the years of planning paid off and the trial itself was relatively smooth. However, issues regarding its form, function and timing remained unresolved. Tax or fee? Locally or nationally determined and administered? Who pays, and to whom would the revenues accrue? How would they be used? The national government and the parliament held firm; according to the Swedish Constitution a congestion charge is a national tax over which the parliament has decision-making authority and indeed, did not have the legal authority to delegate to the government or to a municipality.[6] This means that strictly speaking, the Stockholm region can make no claims on the revenues from the congestion charge. However, all those interviewed reported a common understanding of charge revenues as financing transportation improvements in Stockholm. This is strengthened by public statements from national government politicians noting the tax as an important national contribution to Stockholm's transportation infrastructure.

Congestion charging in Stockholm was, however, not a matter where every party leader could count upon unanimous support among party members. On the contrary, there were deep splits within some parties at the city and county levels. Interviews (e.g., Bo Malmsten, Klas Thorén, and Bosse Ringholm) indicate that the Social Democrats at the city level were positive to congestion charges but those in Stockholm's suburbs were opposed. Some of this had to do with actual uncertainty regarding effects on economic growth and the distribution of costs and benefits. Some uncertainty was more tactical in nature. Would cooperation and compromise with other parties strengthen their position, or would they "give away the store" in the process? A similar type of uncertainty had to do with signals between the local and national levels. Would an acceptance of congestion charges free up additional resources for Stockholm's road infrastructure, or give the national government an excuse to reduce the annual transportation subsidy—essentially using the congestion charging revenues for other national priorities? Interviews, as well as reviews of public statements during the 2002–2007 period indicate that many political leaders were attempting to both calm their base constituencies (that may or may not want the tax, or may or may not want revenues from the tax to facilitate the approval of new motorways) but also leave the door open for compromises with other parties and other political levels.

3.4. A Political Gamble: The Referendum in Stockholm

The move from mandated large-scale experiment to potentially permanent national tax was bound up with promises from both the national and local governments to hold a local referendum on the issue of a congestion tax.[7] In the City Hall, the Moderates and Liberals were opposed to the congestion tax and found popular support against road charges in any form. Annika Billström (Commissioner of Finance) and the rest of the city leadership, including representatives of the Green party, accepted the idea of holding a referendum, but not the timing. They decided that the referendum would not be held until Stockholm had the benefit of experiencing a full-scale experiment. The referendum was therefore held simultaneously with the general election in 2006. Billström promised that although the referendum was formally still only advisory, the city would respect the decision of the electorate—within the City borders.

This proved important in several respects and provides a clue to the aspects of leadership in Stockholm that may be essential to understanding this case. Agreeing to respect the results of a referendum was politically risky—polls at the time showed that a majority of Stockholmers were clearly against the charge.[8] Nevertheless, Billström reasoned that agreeing to a referendum would dampen the powerful criticism she was subject to from other parties, from the press and indeed from some of her own constituency. She had been compelled to break a promise to wait with a full-scale test—but now demanded that a referendum be held once the voters had a clear sense of how it affected them, both positively and negatively. This also gave transportation planners and administrators time to focus on the immediate improvements that could be made in other areas, such as significantly expanded bus service and new subway cars—that showed that voters were "getting something" from the charge—even if this was strictly speaking not the case. So, promising to hold a referendum was relatively unproblematic, and promising to follow its result was risky but could effectively counteract arguments that she was unresponsive to her constituency. Only the results of the referendum held in the municipality of Stockholm would count. Results from surrounding communities would be considered, but not allowed to determine what the City of Stockholm would propose to the national government and parliament to make the charge permanent.

[6] This paragraph of the Constitution has since been modified. Since 2011, the Swedish parliament may delegate such decisions to the government or to a municipality but it is stated that such a delegation right should be used restrictively.

[7] Referenda have always been advisory, i.e. non-binding, in Sweden. If a minimum of 5% of eligible voters demand a referendum, local governments are compelled to administer it.

[8] Polls taken when the congestion charge trial had been announced, but was not yet underway, showed 52% percent in favor in late 2004, but only 43% by late 2005. However, towards the end of the trial public support had increased to 54%, a remarkable shift that underscores the importance of helping users experience actual effects of such a policy (Hårsman & Quigley, 2010).

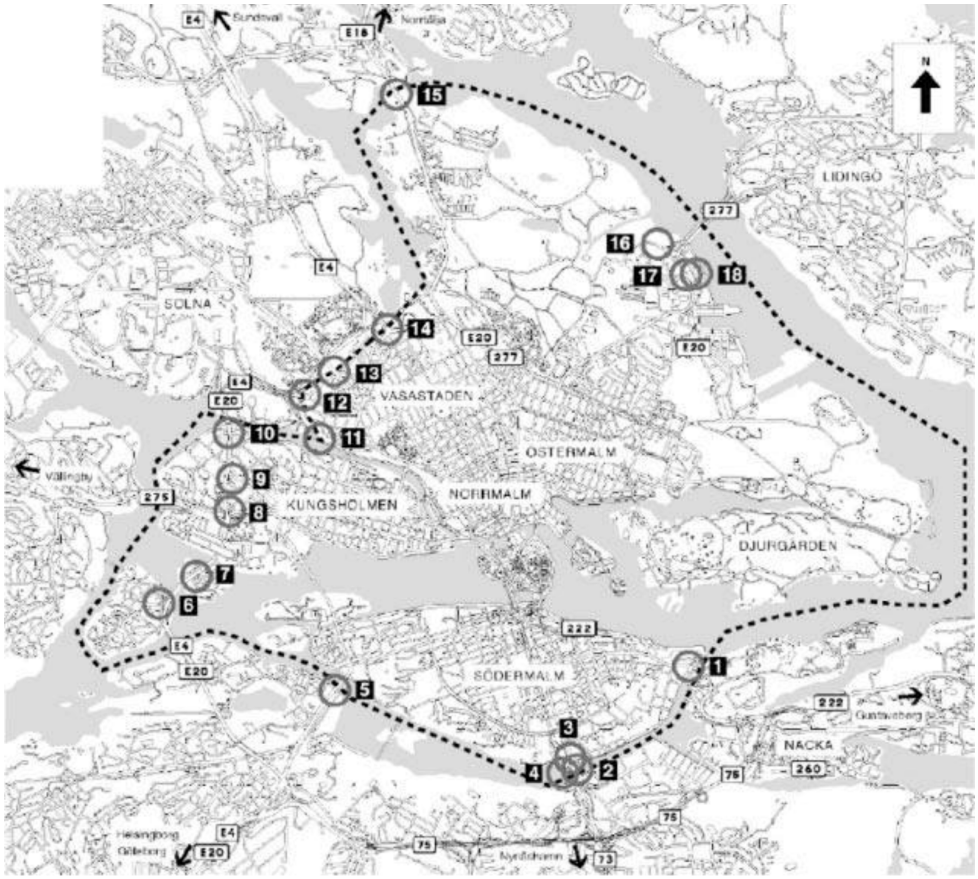

Figure 1. The congestion charge zone and electronic payment gateways. Many gateways have several hundred years of history as tolled entry points for goods into the city. It is also no accident that all of the actual charging points (including the physical infrastructure itself) are on Stockholm City land. To site gateways in other municipalities would have required negotiating land use rights with additional communities and it was feared that surrounding municipalities could use land use monopoly power to block the trial (Hårsman & Quigley, 2010; Swedish Road Administration, 2005).

The gamble paid off. The referendum in Stockholm showed a clear majority in favor of continued congestion taxes, with support strongest in the inner city. Perhaps predictably, among those in the surrounding communities that held a vote, a clear majority remained against. Yet because the decision whether or not to move forward was contingent on the municipality vote, these results did not undermine the mayor's efforts to move forward with congestion charging. This is not to say that the negative results of the referendum outside the city were inconsequential. Not too long after the referendum, the 2006 election put the right bloc[9] back in power—in the parliament, the county council and in Stockholm with enough of a majority that they could build a coalition government without the Green Party. The left bloc had won the referendum regarding congestion charging, but lost its seats at all levels of government. Whether or not this was related to congestion charging more than other electoral issues is hard to say, but as a single-issue, the political impact of prior support for or opposition to congestion charging was not entirely obvious with respect to the newly established electoral power balance. As suggested by Hårsman and Quigley (2010) the causation goes in two directions: those with strong opinions about congestion charging might have voted for a party sharing their opinion and those having strong preferences for a political party may have disregarded their opinion about the charging system.

The City Council´s new Moderate majority leadership was now faced with a tricky situation, described by party colleague Carl Cederschiöld this way: "the voters gave the right bloc a clear majority; and although the moderates and liberals (*Folkpartiet*) were clearly against the congestion tax, they now had control of the city hall. At the same time, while Stockholmers voted 54% for the congestion charge, 80% of the people that had voted in surrounding communities were against.[10] Furthermore, within the alliance (Moderates, Liberals, Christian Democrats, Center) we had a split, the Center party wanted the tax. We needed to unravel that knot, so we came up with a clever solution. We four parties wrote a guest editorial in DN (*Dagens Nyheter*, Stockholm's

[9] Moderate, Liberal, Center and Christian Democratic parties.

[10] This is important because the local, regional and national representatives of the same parties were not necessarily in agreement and neither were those that voted for them.

largest daily newspaper) about a week before we were scheduled to assume governance of the city and announced that there would be a permanent congestion tax from July 1 2007. We had to do it before we assumed power, we had to pre-empt the discussion before it completely got out of hand."

The text to which Cederschiöld is referring (Reinfeldt, Olofsson, Leijonborg, & Hägglund, 2006) was an important strategic move for the incoming coalition government. First of all, the editorial was signed by the leaders of the four parties that called themselves the "alliance" at the national level: incoming prime minister Fredrik Reinfeldt, (Moderate), Maud Olofsson (Center), Lars Leijonborg (Liberal *Folkpartiet*) and Göran Hägglund (Christian Democrat). This is an example of the importance of ongoing communication among party members at the local, regional and national levels. It is also a clear signal from the new national government that they intended to set the agenda for future decisions regarding congestion charging in Stockholm rather than facilitating an independent local decision, notwithstanding the reference to a future decentralization of charging authority to local or regional authorities.[11] Perhaps even more importantly, the alliance parties re-coupled the congestion charging issue with decisions regarding other major transportation investments, announcing that congestion taxes would be introduced as part of a major transportation policy package negotiated between the local, regional and national levels. This put the western bypass back on the bargaining table, opening negotiation space with more auto-dependent communities surrounding Stockholm for the incoming minister of finance Anders Borg. With one stroke congestion taxes were positioned as a funding mechanism for new roads, the solution with which the right bloc (and the Moderates in particular) had always been most comfortable with. And with this compromise, congestion charging had moved beyond its pilot status into the realm of reality, promoted and institutionalized now by some of the very same political forces that had raised questions about its appropriateness under previous Mayor Billström.

3.5. Congestion Charges to Fund Subways—And Facilitate Housing

The discussion about using congestion taxes to fund a range of transport infrastructures made sense to a wide range of political actors, given that Stockholm's population growth had continued unabated since 1981. By the mid-2000's, Stockholm's labor and housing market had outgrown both city and county administrative limits; while economic growth has been even more rapid than population growth, notwithstanding economic downturns and the global economic crisis. Given its expansion,

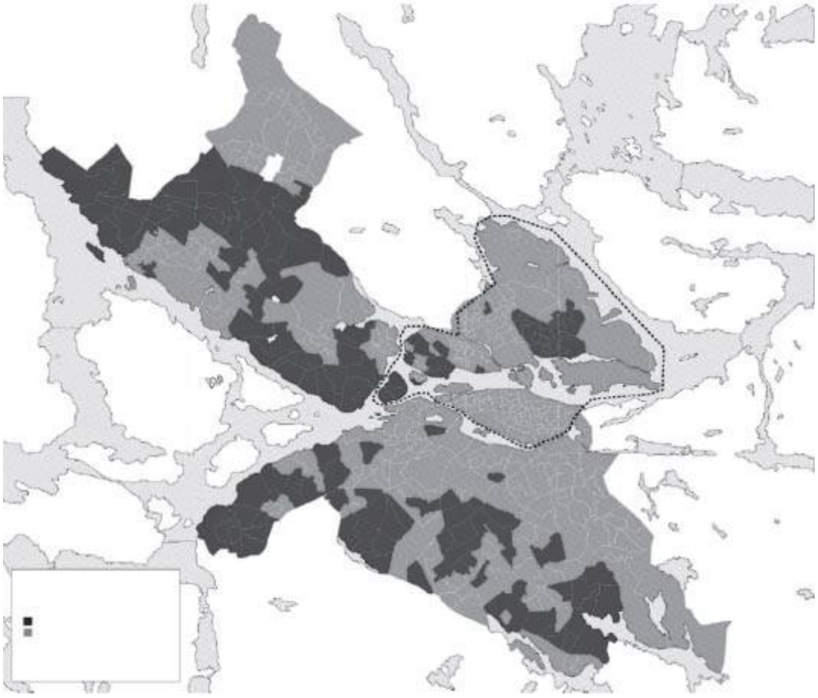

Figure 2. Results from the Stockholm referendum on congestion charging in 2006, 52% for and 48% against. Note: City of Stockholm residents only; charging cordon noted as a dotted line. "No" districts noted in the darker shade. Those within the cordon were in general far more favorable to the charge than those outside the cordon. Roughly half of the revenues come from residents within the cordon (Hårsman & Quigley, 2010).

[10] As of 2017 this has not transpired although several respondents argue that it is "understood" that revenues should in some way remit to the Stockholm region.

many were arguing that Scandinavia's largest city could position itself as a successful model for a European capital city built on innovation, sustainable growth and diversity. This was an argument dear to many in the right-wing bloc. But it would be hard to realize such aims without public investments to facilitate such goals. Among the greatest barriers, as described in a number of reports, including OECD Territorial Review for Stockholm (Organisation for Economic Co-operation and Development, 1999), were those related to housing and transport.

The housing market had both too low a rate of new buildings and a range of institutional factors hindering turnover. The structural problems affecting Stockholm's housing market included the effects of continued rent control policies, tax policies affecting turnover, and low rates of new developments were often attributed to confusing national laws and sometimes local policies. A number of improvements had long been proposed by interest groups and opinion leaders, and there had been some reforms to housing policy and regulation, but many were seen as too politically charged and had not yet been implemented. In the post-2006 electoral environment, however, Moderates saw an opportunity to put these issues back on the agenda when considering whether to proceed with congestion charging, using these issues to widen their coalition of support. By highlighting the importance of explicitly linking extensions of the subway to new housing developments in station areas, advocates of transportation expansion were able to produce broad approval across political blocs in the parliament, county council, and municipalities for more forceful action.[12] The Moderate Party was, as noted above, in favor of using revenues from congestion charging taxes for building new motorways, but now they changed their strategy. The national government negotiated an agreement regarding both housing and subway extensions including the division of responsibility and regulatory authority among the national government, County Council and municipalities (Stockholmsförhandlingen, 2007). Since that agreement, the congestion charge revenues have increased, due partly to higher charges and partly to the inclusion of additional crossings (Swedish Transport Agency, 2016).

About half of the additional revenues generated from the expanded and raised congestion charges will fund the new subway expansion. The Stockholm County Council will build nine new subway stations and associated rail infrastructure in Stockholm and three neighboring municipalities (Järfälla, Nacka and Solna) during the period 2018–2025. Stockholm and these three municipalities promise that 78,000 new apartments will be built in the station areas (either by municipally owned development companies or by private developers) over a 16-year period. This is roughly twice the number of new apartments built in the entire region in past six years; in other words, it is a major breakthrough in the seemingly intractable "chicken and egg" problem plaguing the building of new transport infrastructure (in hope that housing will be built) and new housing (in hope that transport infrastructure will be built).

To the extent that congestion charge revenues are regarded as national level contributions to Stockholm's infrastructure (the charges legally are national taxes), the national level is thus contributing about 70 percent of the cost for the subway extensions and the county council and municipalities for the balance of the capital costs plus some marginal costs for new subway cars and associated infrastructure. If we instead regard congestion charges as a regional contribution (aggregated from individual contributions of which roughly half are Stockholmers and half from the rest of the region), then the proportion of national/local financing is basically the opposite. But either way, the point is that congestion charging is far from a localized policy whose impacts are felt only by Stockholm residents or those driving into the city. Rather, congestion charging has become a transport policy initiative capable of uniting multiple scales of governance around a range of spatial planning and sustainability aims.

4. Insights from the Stockholm Congestion Charging Experience

Building on Metzger and Rader Olsson's account of Stockholm's experience with sustainable urban development over the past century (2013), we argue that the contributions of congestion charging to larger urban sustainability goals are the result of critical decisions that laid the pathway for addressing a wide range of infrastructure concerns, ultimately leading to the successful adoption of congestion charging and to a more robust planning process capable of integrating multiple sustainability aims.

4.1. Linking the What and the Why to Build Support

Information and awareness-building about sustainability is important, but this case has suggested that such goals must be supported by concrete interventions that directly impact everyday life in the city. Likewise, action without awareness-building can fail if those affected do not understand their purpose. The congestion charging policy in Stockholm tests this hypothesis and suggests a slightly modified formulation, building on recognition of the ways that initial transport policy discussions established strong political positions that ultimately created limits as well as opportunities for consensus.

The idea of road charges in some form had been evaluated, packaged, spun, wrangled and debated by all parties, in Stockholm and at the regional and national levels. Repeatedly, congestion charging failed to win support as purely a revenue source for motorways, or as a demand

[12] This is essentially a reaffirmation of the principles of the 1952 City plan and the regional plans that followed it. Even the routes of the proposed subway extensions are essentially inspired from proposals and arguments in the 1965 Subway plan, which were not implemented.

management measure. Eliasson (2014) argues that the reframing of congestion pricing as an environmental policy was important to its eventual political and public acceptance. We support this idea but propose that it was a rather longer and more complex process of coupling, decoupling and re-coupling congestion charges with a range of goals such as environmental protection, revenue generation, and even solving acute housing shortages that finally succeeded in breaking political logjams and building local support. A potential consequence of this strategy was that over time, identically articulated congestion charge policies could become different things to different constituencies. This allowed competing interests to agree on one policy but for varied reasons.

For example, the Stockholm Party (locally) and the Green party (nationally, later also locally) chose the single issue of a congestion charging trial as their condition for support and used this to court both the left and the right from the middle. They found a vacuum in local (and later national) politics that could be called "environmental urbanists." In contrast to the "green wave" of decades earlier that equated environmental ideology with living off the land and eschewing capitalism, these new urbanists celebrated the city. The Stockholm Party was focused on both the natural environment and the built environment, and chose niche issues that appealed to the new urban professionals. They attracted voters from the right bloc that were market oriented but wanted more explicit focus on the natural environment, and from the left bloc that were interested in exploring the potential of privatization, support for small businesses and innovation as sustainable development strategies. The Green and Stockholm parties led by cleverly decoupling and recoupling issues. They found a new party platform that appealed to a growing niche in Stockholm's electorate, the environmentally aware urbanite. They decoupled congestion charging from the grandiose and highly interdependent giant transport packages that were moving two steps forward and one step back. They also recognized that their ultimatum should be the demand for a congestion charging trial, full scale but limited, and followed by a public referendum (Romson notes that a 7-month full scale trial was seen as an absolute minimum and that it was important that she rejected a last-minute proposal to limit the trial to only a few parts of the city).

The Green Party (which by the end of the trial had more or less incorporated what was left of the Stockholm Party) hoped that demonstrating that congestion charges would provide lasting congestion reduction without jeopardizing continued economic growth would finally take the motorway plans off the table. Instead, the other major parties set out to "recouple" the increasingly accepted charging scheme back to their old priorities. The right bloc's pre-emptive strike following the 2006 elections, accepting the charges but firmly repositioning them as a funding source for the new roads seems to have been effective. The fact that the national government and Stockholm's municipalities are now using the opportunity to finally make concrete plans for new housing is testament to the importance of re-coupling the congestion charges to development plans for public and private transport, housing and accessibility.

This continuing reframing of the "what and why" of congestion charging may hold lessons for approaching sustainability policy in other cities. The inclusion of road charges in the Dennis package negotiations was an important strategy to build support for a comprehensive transportation package, because it allowed diverse political constituencies to agree on the same package for different reasons. However, it may have also had the effect of reinforcing the idea that road charges (including congestion charges) are a transportation investment and demand management policy as opposed to a sustainable urban development policy. When considered primarily a transportation policy, road/congestion charges are negotiated in relation to other transportation priorities, and local and regional authorities that lack the resources for large capital transportation infrastructure investments are in a difficult negotiating position with powerful national authorities. But when congestion charging is imbued with a dual revenue generation/demand management role, linked more strongly to urban sustainability goals and in particular to housing provision, policy space is opened for more balanced negotiation between the local and national levels. Congestion charging linked not only the "what" and the "why" more clearly, but also the "who".

4.2. Build consensus or forge ahead?

Marquis W. Childs' book Sweden: The Middle Way (1936) characterized Swedish politics has been as focused on cooperation and compromise across party lines or as pragmatic and driven by common sense or an engineering attitude to problem-solving. Childs has many followers that underscore the Swedish capacity for consensus and compromise (See e.g., Möller, 2011; Kelman, 2012). The political culture of consensus-seeking and pragmatism has never meant an absence of political differences and political fights. However, fights have more often than not resulted in going "back to the drawing board" for further evaluations and have eventually led to compromises rather than stalemates blocking further actions. Broad consensus can lead to "watered down" sustainability policies that are ineffective as tools for change. In the congestion charging case, however, Stockholm managed to make bold policy and investment decisions without losing sight of the need for compromise and at least some kind of consensus—at least regarding the attractiveness of congestion charges, albeit with different motives and revenue priorities.

Earlier studies of Stockholm's congestion charging experience have suggested that the acceptance of congestion charges can be explained at least in part by the city's high share of public transport users, with median voters in favor of congestion charges due to their potential to

benefit transit and reduce urban congestion (Armelius & Hultkrantz, 2006). However, this does not explain why charges were not imposed far earlier. It may be argued that willingness over time to bundle congestion charges with transportation investments that would appeal to inner city transit users as well as regional motorists (in particular by funding the western bypass) demonstrates the importance of compromise and of compensating "losing" constituencies.[13] This is logical, but does not explain the political courage to announce the full-scale pilot before determining exactly where revenues would be spent. This may illustrate the importance of timing open and closed negotiations; an open announcement of the congestion charge pilot, with simultaneous closed discussions regarding revenues and more comprehensive transportation investment packages.

It is difficult to attribute innovative transport decisions to an individual or a single organization or party; rather, this case reflects the contribution of key individuals—leaders—in achieving support their proposals in the City Council and the national parliament respectively in a specific economic, social and political context. Throughout the process they also needed to convince influential subordinate authorities and associated bureaucrats, and these processes were time-consuming and demanding. Effective leaders had ambitious and visionary goals but also remarkable patience and tenacity. By contrast, when leading politicians and parties sought to force decisions, disable the opposition or set ultimatums they were either typically sent "back to the drawing board" to be re-evaluated, discussed again, tested, and—in the case of the congestion charge—re-legitimized by a popular vote.

From studying these differences and the processes that preceded them, we can conclude with some other additional takeaways on the subject of political strategies and tactics necessary to achieve policy success:

- *Open and closed negotiations* are both useful, but the order of these matters. From this case study, it appears that starting with an open discussion to build consensus and public support and then moving to a closed negotiation to negotiate specific terms can be effective;
- *Setting limits on the scope of the negotiation* is key. Without limits or trade-offs from the outset, the negotiations run the risk of spiraling out of control. Some of these imposed limits might include *Elections or electoral timing, Legislation, Finances, Early commitment to other infrastructure projects*, and *Physical realities* (i.e. Stockholm being surrounded by water);
- *Perseverance* through periods of uncertainty and divergent opinions is as or more important as perseverance during times of cooperation. Conflict is just as important as consensus, and both are to be expected in an effective negotiation;
- *Language* is key in building political support. Calling the congestion *tax* a *toll* was much less favorable, and the phrasing of the referenda in the surrounding municipalities likely affected how it was perceived. In addition, continuity in language can be similarly important (e.g. the use of the words "negotiation" and "package");
- *Piloting* or other large-scale experiments can reduce uncertainty regarding effects and therefore allow policymakers to craft compensatory policies within the context of political negotiations.

In policy circles, decisions are often made based on expectations that both physical infrastructure and policy commitment will endure. This is critical in helping individuals evaluate the costs and benefits of a particular policy. However, the long-term impacts of novel, as-yet unrealized policies may be difficult to gauge. This case shows that the city's "full scale experiment" in congestion charging, built on a pilot tested at a scale large enough to reduce various types of uncertainty and build acceptance, but small enough to be dismantled if proven ineffective, was a key determinant of policy success. The congestion charging pilot led to a dramatic reversal of public opinion from strongly negative to positive. It anticipated broader applications of policy and expansions, but took an incremental approach. Congestion charging is now an accepted part of the policy portfolio in Stockholm; it remains to be seen if it will be as successful in other Swedish areas. This follows Eliasson (2014) but adds the idea that the individual experience of voters related to public acceptance is not identical to the political experience of politicians experimenting with various policy incarnations over time and in changing political contexts. But in this case, the positive experience of voters helped change the policy calculation of politicians, thus leading to widespread embrace of congestion charging.

5. Conclusions

Although the congestion charging decision played out in a distinctively Swedish context, it involved a complex process of reframing both the problem of congestion and the aims of transport policy in ways that required strategic diplomacy and tactical mediation. Only when it was recast as simultaneously a traffic restriction and a revenue generation measure did it become widely recognized as addressing the concerns of multiple and competing constituencies, thus breaking the long-standing political impasse.

[13] It may be worth noting that another argument for building the western bypass was to reduce the isolation of the rich north and less wealthy southern parts of the metro region (a long-standing priority for the left leaning parties) and help working families access jobs, schools and local services. It bears underscoring that the working class, generally a strong share of the left bloc's constituency, have in recent decades moved further and further out in the Stockholm region as the processes of gentrification in Stockholm and the near suburbs proceeded. For many residents within the City of Stockholm, the idea of charging the cars coming into the city so as to reduce inner city congestion was attractive, not least if revenues could be used to improve public transportation (either directly, or as a result of not having to use as high a share of national transport allocations for roads).

Through the introduction of congestion charging, Stockholm has experienced major transformations in revenue/financing sources, institutions and the institutionalization of the housing-transport nexus, communication and coordination between the different levels of government, and a certain willingness on the part of both politicians and citizens to make sacrifices on behalf of overall sustainability goals. Just as importantly, the policy's successes have produced a transformation in the ways that transportation policies are now being perceived, far from being seen solely as an enabler of mobility they are now also viewed as a complement to housing (i.e. a mode of infrastructural servicing) and a basis for an integrated regional planning system, the latter of which is perceived as crucial to the achievement of larger urban and national development aims. Likewise, the intensified focus on dense urban living in Stockholm has been made possible by congestion charging, but is also now connected to many other agendas, including economic competitiveness and environmental sustainability. The process followed to arrive at this outcome was marked by successes and failures, not to mention conflict and consensus, all revolving around congestion pricing as a policy as well as over who would get political "credit" for introducing or rejecting this policy.

If we accept that the process is as important as the outcome, knowing exactly which process to follow to keep the idea of congestion charging alive, knowing at what point in time a new framing is necessary, and understanding which organizational or political tactics will help achieve both, will be critical to sustainability outcomes. One might say that after decades of struggle, there is now enhanced planning capacity to have a healthy conversation about urban sustainability in Stockholm, including but certainly not limited to the role of transportation. Hands-down, the capacity to leverage multiple sustainability goals must be considered one of the most important contributions of congestion charging to the field of urban planning, and the reason that other cities should take it seriously.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Evolving the Evolving: Infrastructure, Place and Rewilding in the California Delta

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Abstract
Current planning and legislation in California's Sacramento-San Joaquin Delta call for the large-scale ecological restoration of aquatic and terrestrial habitats. These ecological mandates have emerged in response to the region's infrastructural transformation and the Delta's predominant use as the central logistical hub in the state's vast water conveyance network. Restoration is an attempt to recover what was externalized by the logic and abstractions of this logistical infrastructure. However, based on findings from our research, which examined how people are using restored and naturalized landscapes in the Delta and how these landscapes are currently planned for, we argue that as mitigatory response, restoration planning continues some of the same spatial abstractions and inequities by failing to account for the Delta as an urbanized, cultural and unique place. In interpreting how these conditions have come to be, we give attention to a pluralistic landscape approach and a coevolutionary reading of planning, policy, science and landscapes to discuss the conservation challenges presented by "Delta as an Evolving Place". We suggest that for rewilding efforts to be successful in the Delta, a range of proactive, opportunistic, grounded and participatory tactics will be required to shift towards a more socio-ecological approach.

Keywords
California Delta; coevolution; complexity; conservation; infrastructure; landscape approach; logistics landscape; place; scenario planning; water

Issue
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1. Introduction

Current legislation and state plans for the California's Sacramento-San Joaquin Delta (Delta) call for large-scale ecological restoration, which will require significant changes in current land uses and cultural patterns (Figures 1 and 2). Restoration mandates in the Delta are heavily driven by the detrimental effects of water exports and the reengineering of the Delta as logistical infrastructure for its conveyance. Our research project, *The Human Use of Restored and Naturalized Delta Landscapes*, examined how human presence and uses can and will continue after restoration, and considered how these uses could be reconciled with ecological and adaptive management goals (Milligan & Kraus-Polk, 2016, 2017). The main finding from that research that we selectively focus on in this article is the lack of effective planning and consideration of socio-cultural and place-based values within this transformative effort. Utilizing a pluralistic and co-evolutionary landscape approach, we suggest how this situation has come to be, introduce the predominant challenges faced, and discuss potential solutions and strategies for working effectively with the Delta as a rapidly evolving place. Broadly, we ask: how might ur-

ban environmental planning in this contested and complex region best lead toward socially transformative ecological recovery?

1.1. The Delta

The Delta is a cultural landscape that humans have inhabited and modified for up to 4,300 years in tandem with its ecogeomorphic formation (Pierce, 1988). During the last four millennia of the Holocene, as glaciers retreated and sea levels rose, the Delta began to assume its deltaic and estuarine features, and human communities adapted to these changes, modifying the landscape to meet their needs. This feedback loop exerted pressures, determining future possibilities of socio-ecological systems (SES). Post-contact adaptations and modifications built upon this coevolution. Beginning with the passage of the Federal Swampland Act of 1850, the concerted work of "reclamation" eliminated the complex web of sloughs and seasonal wetlands that characterized the Delta, replacing them with fewer, straighter and much deeper channels running through manufactured agricultural land

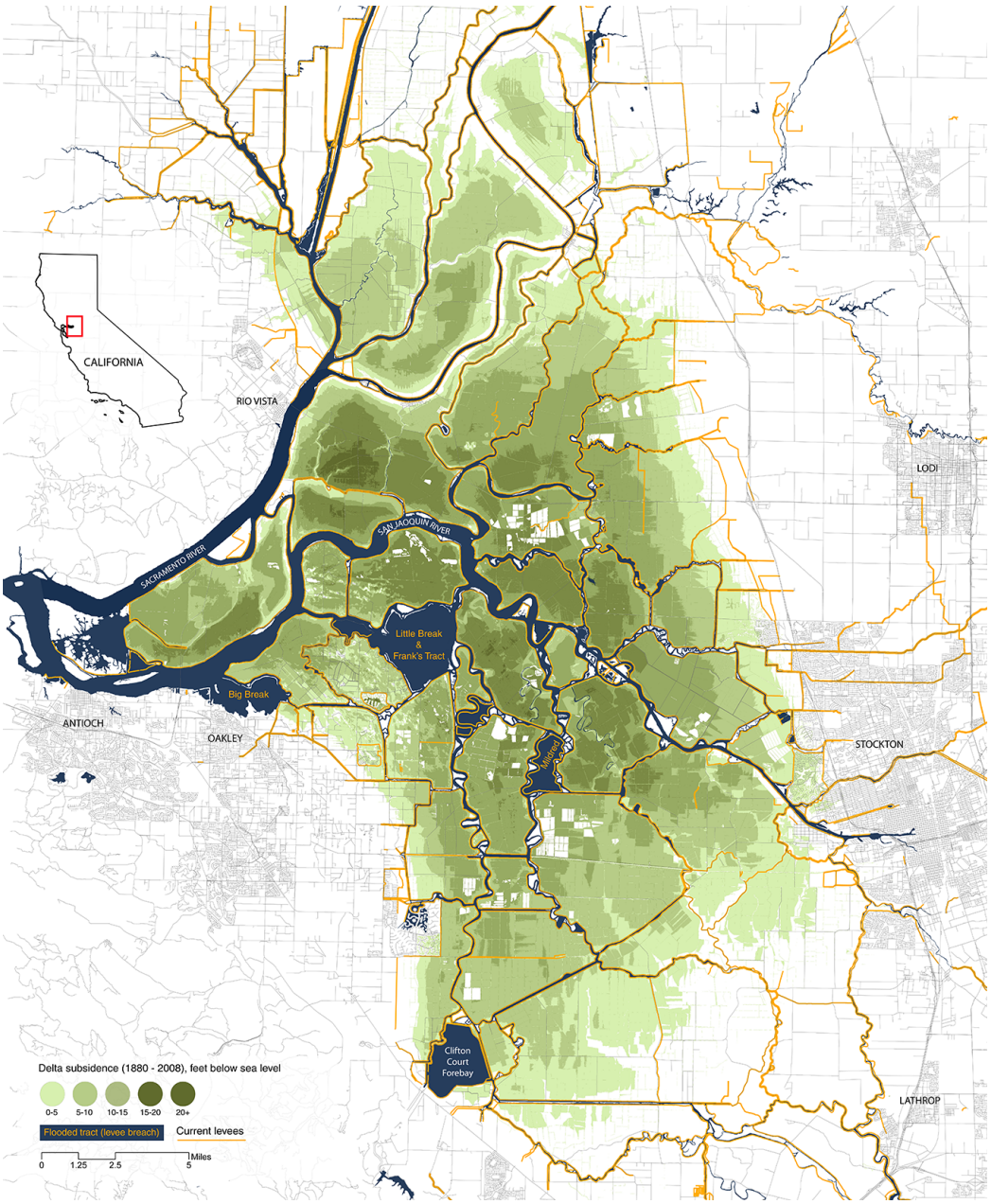

Figure 1. Delta levees, subsidence, and urbanization: once exposed to air through reclamation and the construction of an extensive network of levees (over 1,100 miles), the Delta's peat soils have oxidized and subsided up to 30 feet below sea level, which in turn places greater stress on levees. The Delta is surrounded and encroached upon by expanding urbanization from multiple cities and population centers (Data generated by 2008 Lidar from the California Department of Water Resources). Map by Brett Milligan.

(Robinson et al., 2014). An extensive network of engineered levees prevents waterways and floods from migrating across the former massive floodplain of the Delta (except when they fail). These alterations radically transformed the Delta, eradicating 95–98% of dynamic wetland and riparian habitats (Robinson et al., 2014).

In turn, this reclamation infrastructure of dredged channels and levees was conscripted in the latter half of the twentieth century to serve as the central logistical hub in California's State and Federal water projects, a controversial role it plays to this day with respect to ecological, infrastructural and socio-political crisis. One could say that there is no problem in the Delta, rather there are multiple interrelated complex problems, which suggest multiple or unknown solution paths (Rittel & Webber, 1973). Following Rittel and Webber, planners, scientists and others working in the Delta have described it as a wicked problem (Luoma, Dahm, Healey, & Moore, 2015; Shigley, 2012).

> If the problem were just about allocating freshwater flows, it might be solvable. Add in the complexity of moving water through a hydrologically and hydrodynamically complex Delta and it becomes complicated. Add the uncertainty of ecological responses and the institutional complexity of many actors with many visions and the problem becomes wicked. Then add the ever-changing water supply and ecological and economic contexts within which decisions must be made, and the problem becomes devilishly wicked (Luoma et al., 2015).

Adding to these problems is the vulnerability of the levee infrastructure itself, which is subject to sudden failure due to floods and seismic events, or the slower, increasing threat posed by rising sea level surrounding heavily subsided islands as much as thirty feet below sea level (Deverel et al., 2016; Deverel & Leighton, 2010; Mount & Twiss, 2005). The contemporary Delta is an anthropogenic landscape. Human engineering and colonization has moved it "beyond recognition and resulted in irrevocable impacts" (Renaud et al., 2013; van Staveren & van Tatenhove, 2016). Sparsely populated and pastoral, the legal Delta is often considered a rural place (Thompson, 1957). Yet in terms of systematic land alteration and its infrastructural role in maintaining a globalized economy and cities, the Delta is thoroughly urbanized (Brenner & Schmid, 2015). The ring of urban centers surrounding the Delta keeps encroaching into it through various forms of development within the floodplain (Norgaard, Kallis, & Kiparsky, 2009; Shigley, 2012). The resultant landscape is both a novel ecosystem and culturally enigmatic and it is within this urbanized "hydraulic society" (Worster, 1982, 1985) that ecological restoration occurs. These conditions, found both here and in other urbanized deltas around the world, will require recalibration of hydraulic and infrastructural interventions received from the past to "long-term sustainable delta pathways" (van Staveren & van Tatenhove, 2016); pathways that consider the complex interaction of environmental dynamics, technology, and socio-political processes.

1.2. Current Conflicts and Planning Challenges

The Delta of today is, to greater and lesser degrees, a product of planning. Over the last 150 years, local plans have been eclipsed by state plans, which were in turn warily usurped by Federal plans as the scope, scale and controversies of its planning arenas have expanded. Today, no single entity is in charge (Shigley, 2012). Current collaborative and cross scalar planning processes include local, regional, state and Federal agencies whose primary planning concern for the present and future Delta is where, and how much export of Delta waters should occur for urban and agricultural uses (Lund, Hanak, Fleenor, Bennett, & Howitt, 2010).

Given the compound infrastructural character of the Delta, meaning the wholesale remaking of it through infrastructural means (dredging and levee building), followed by the "reclaiming" of that infrastructure to serve a larger globalized constituency as the state's water delivery hub, we can confidently describe the Delta as an infrastructural landscape. More specifically, it is a space of flows (Castells, 2001); an emerging breed of neoliberal "logistics landscapes" with "distribution and delivery" of water as its primary function (Waldheim & Berger, 2008). As Waldheim, Berger and others note, the contemporary expansion of infrastructural and logistics landscapes has given rise to some of the most significant transformations and systemic spread of urbanized and globally networked environments, which often exhibit social and ecological disparities (Brenner & Schmid, 2015; Graham & Marvin, 2001; Lyster, 2016; Waldheim & Berger, 2008). In the Delta, the "rule" or "disposition" of logistics (Easterling, 2014; LeCavalier, 2016) has manifested as the globalized agricultural economy of California's Southern San Joaquin Valley and facilitated the rise of the San Francisco Bay Area and Southern California's metropolises. Within this "deadly life of logistics" (Cowen, 2014) we see the near total ecological transformation of the Delta (Robinson et al. 2014; Wiens, Grenier, Grossinger, & Healey, 2016).

Logistical landscapes operate on an abstract and economic math of distribution and delivery efficiencies. They mediate between abstracted goals—profit margins, movement of commodities—and the physical and material realities of the landscapes they must use and traverse to provide services (Davis, Holmes, & Milligan, 2015). This creates inherent friction, as landscapes exceed and impinge upon those economic abstractions through social, cultural and ecological parameters that are not accounted for in logistics' math (Davis et al., 2015). In the Delta this friction manifests in multiple ways. The most obvious are the precipitous decline in Delta native fishes, fisheries and other species as a result of water exports, resulting in an ecological crisis or "regime shift" (Laćan

& Resh, 2016; Moyle et al., 2012). Since the 1980s, this has defined a much publicized and polarized controversy of "fish vs. farms". Biological opinions and scientific mandates now place restrictions on when and how much water can be pumped out of the Delta based on state and Federal endangered species act (ESA) criteria.

To reconcile these competing interests, the state has established the "coequal goals" of water reliability and ecosystem recovery (CA Water Code §85054), which it is aggressively pursuing through "California Waterfix" and "EcoRestore". Waterfix is a massive infrastructural retrofit to the state's water delivery projects, which would construct two 40 feet diameter tunnels to convey water thirty miles 150 feet beneath the Delta, rather than through it (California Natural Resources Agency [CNRA], 2017). EcoRestore (Figure 2) is a plan to fast track the

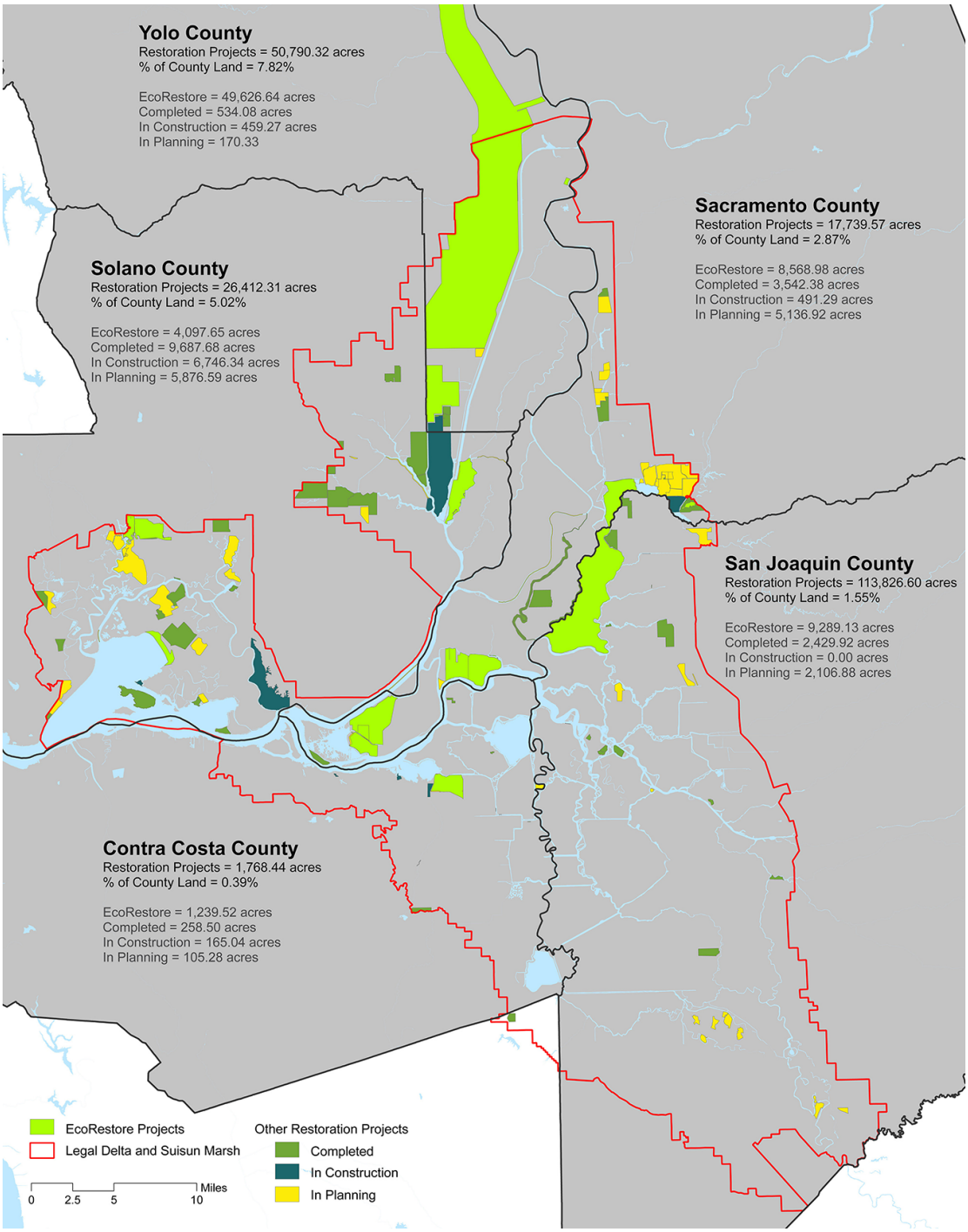

Figure 2. Restored landscapes in the California Delta: current and planned, as of 2016. Map shows proposed EcoRestore projects and all other restoration projects that are completed, in progress or in planning. Total acreages within the Delta are divided up by county. Data from the California Department of Water Resources and EcoAtlas. Map by Brett Milligan and Prashant Hedao.

restoration of over 30,000 acres of habitat as mitigation for infrastructural side effects described above (CNRA, 2017). Within these plans is a continuation of abstractions, a "scientization" (Laćan & Resh, 2016; Sarewitz, 2004) that is largely blind to the local and cultural realities of what restoration and ecological land conversion actually entails in the Delta as a dynamic, cultural place subsumed within global logistics. This is the focus of our research.

1.3. Restoration and Human Uses

Given the imminent expansion of restored and naturalized landscapes in the Delta, our research investigated how such landscapes are used, occupied and culturally valued, as well as how they are planned for. In a year of empirical study of in the Delta, we found that human uses of these lands are widespread, plentiful and highly diverse. These landscapes consist of waterways, levees, and tracts (reclaimed lands similar to polders in the Netherlands) (Milligan & Kraus-Polk, 2016). We make a distinction between *naturalized* landscapes or those which have been unintentionally rewilded, often by a levee breach that went unrepaired (Figures 3 and 4) and *restored* landscapes, areas where the transition to environmental habitat for other species and ecosystem services is intentional and laboriously designed. This distinction serves to emphasize how human activity arises in these environments, as planned or unplanned, sanctioned or unsanctioned. Human uses range from land management, to scientific research and monitoring, to recreation, to a variety of unsanctioned uses and law

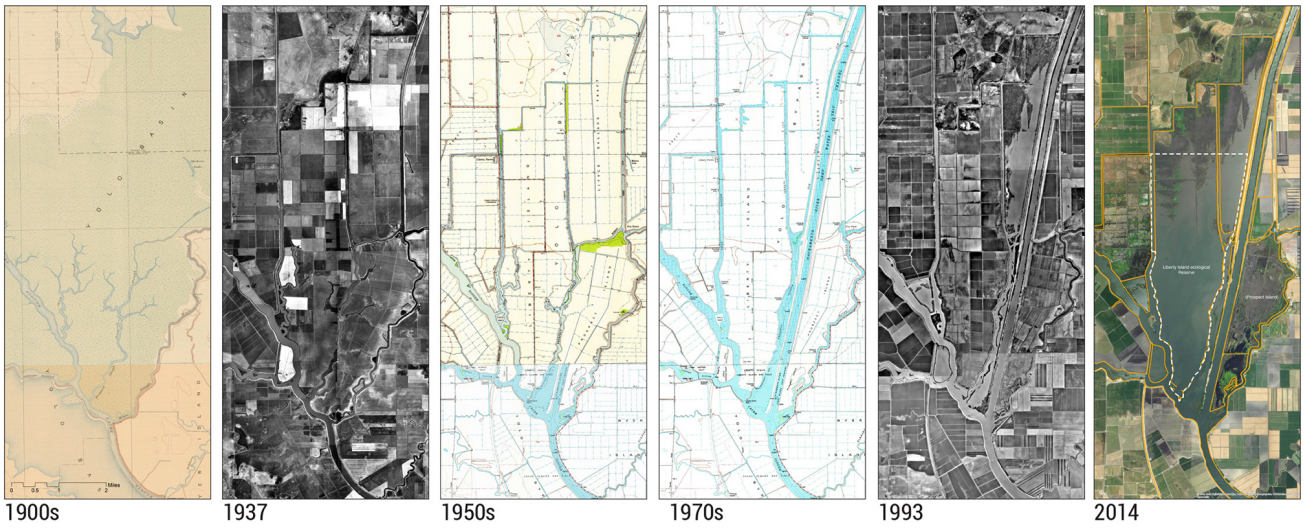

Figure 3. Evolution of the North Delta and Liberty Island: 1900–2014. The sequential series of maps show Liberty Island and the North Delta's transformation from marshland and sloughs, to reclaimed agricultural fields, to the dredging of the Sacramento Deep Water Shipping channel, to re-naturalized landscape "reclaimed" as an ecological reserve. Historic survey data and 1937 ortho imagery from the San Francisco Estuary Institute. Image by Brett Milligan.

Figure 4. Ground view of tidal marsh formation on what was formerly the Liberty Island Tract, 2015. Prior to a final levee breach in 1997, all of this naturalized landscape was farmland. Image by Brett Milligan.

enforcement efforts. We encountered situations where human uses are perceived as compatible and beneficial to restoration efforts and others where uses conflict with management efforts and ecological performance. In most cases, a range of specific contextual factors could be identified as contributing to these conditions, including management and planning decisions.

Despite what we found in the field, talking with land managers, law enforcement personnel, and scientific researchers, most Delta restoration planning literature lacks depth and consideration of human uses of these landscapes, or avoids Delta cultural concerns alltogether, given the mitigatory and regulatory basis of the work. Based on our findings, this is a culturally and socio-ecologically unrealistic approach. Many past efforts at ecological land transformation in the Delta have experienced limited success due to compartmentalized planning approaches that separate the ecological, the social and the technological, when in fact all of these complex and interconnected strands need to be considered cohesively within infrastructural landscapes (Grabowski et al., 2017).

In the following sections, we outline our approach and methods for engaging with socio-ecological complexity in infrastructural landscapes like the Delta. We deploy a pluralistic and coevolutionary method of understanding Delta planning, policy, science and landscapes to specifically explain how ecological restoration is performed to shed light on why "Delta as an Evolving Place"—the official legislative title and mandate bestowed on the region—has remained elusive and marginalized in planning at nearly all scales. Based on our empirical research findings, we take Delta as Evolving Place head on; defining three pervasive challenges it presents to the transformative goals of rewilding an urbanized Delta. We close with discussing planning and design strategies that show promise in working with these challenges.

2. Approach

Given the uncertainty, complexity and accelerated change that characterize the Delta, reductive and sectoral approaches to understanding it are less than useful. A multitude of competing factors and actor networks are implicated in the evolution and current status of restoration in the Delta. Thus we subscribe to the need for more pluralistic, pragmatic and expanded epistemologies for encountering complex, evolving phenomena (Mitchell, 2009). Pluralism entails the "integration of multiple explanations and models at many levels [and scales] of analysis instead of always expecting a single, bottom-level reductive explanation" (Mitchell, 2009, p. 113). In this way pragmatism replaces absolutism, recognizing that there are many ways to "accurately, if partially" represent and interpret reality, each with its own values, specificities, and levels of abstraction (Mitchell, 2009). Different disciplines, epistemologies and the world itself organizes in a plurality of context-specific ways, and our knowledge should strive to integrate that diversity (Bennett & Zurek, 2006). This is not meant to imply that methodologically "anything goes", rather pragmatic pluralism serves as a basis for comparative evaluation of approach and methods according to how well they address specific concerns. A pragmatic approach to inquiry is one that is cognizant of the particular interests and goals it is trying to achieve, knowing that the methods and knowledge gained are themselves provisional, dynamic, value-laden, and evolving through practice and feedback.

Our pragmatic approach draws from two modes of pluralistic explanation, the landscape approach and coevolution. Landscape approaches can be defined as transdisciplinary planning frameworks that seek to integrate multiple competing land uses, with the goal of creating more equitable, adaptable and multifunctional landscapes (Milligan & Kraus Polk, 2017; Reed, Deakin, & Sunderland, 2015). Landscape approaches have emerged in response to the inadequacy of single sectoral approaches to planning that fail to accommodate a diversity of stakeholder perspectives. Generally speaking, landscape approaches tend to assess what currently is (such as policies, economic regimes, competing uses and perspectives) as a basis for action and reconciliation. Coevolution is also a multifaceted approach, but in contrast, gives more attention to how such composite conditions have come to be. Coevolution implies that evolving (changing) structures and things mutually influence the evolution of each other, rather than transforming in isolation (Norgaard & Kallis, 2011). Coevolution is propelled by feedback loops that become selection pressures that provoke adaption from other systems and assemblages, which include the political, cultural, economic and biogeophysical (Gerrits & Teisman, 2016). Coevolutionary approaches to planning have received growing attention (Boelens & de Roo, 2016; Gerrits, 2010; Gerrits & Teisman, 2016; Mees, Tempels, Crabbé, & Boelens, 2016; Rydin, 2014; Schipper & Gerrits, 2014; Tempels & Hartmann, 2014), building off of the work of Richard Norgaard (Gual & Norgaard, 2010; Norgaard, 1984, 1988, 1994). Specifically, the Delta's recent history can be seen as a "coevolutionary process between science, governance and ecosystems" (Norgaard et al., 2009). Under such an understanding, humans—including planners—are not simply ecological "stressors" or "externalized beneficiaries of the ecosystem's services" (Ogden, 2011, p. 4); rather humans are integral to the design, habitation and evolution of what these landscapes are and will become. A coevolutionary planning approach can be particularly useful in the Delta, which clearly exhibits path dependencies, feedbacks, mutual adaptation, and reciprocal selection (Gerrits & Teisman, 2016; Norgaard & Kallis, 2011).

Generally speaking, both landscape approaches and coevolution posit a relational understanding of spatial change in which planners work under conditions of complexity and spatial agency is indeterminately distributed

among diverse and changing constituencies, including the more-than-human (Bryant, 2014; Rydin, 2014). Thus in efforts to manifest change, planners "become an integrated part of these specific, ongoing actor networks, and co-evolve with them in order to bend them to more sustainable futures" (Boelens & de Roo, 2016).

The challenge with complexity, pluralism and coevolution lies in the contradictory ways in which we parse complex and interrelated webs of agency to explain changes, mobilize people, and impel action. This work bounds problems, which goes against the openness of coevolution itself. Norgaard and Kallis suggest that we face this contradiction by making explicit choices about, "what coevolves and how" (2011). In our work we approach landscape and coevolutionary approaches as complementary, together offering a historical framework for understanding current conditions, combined with an instrumental and integrative approach for dealing with current matters of concern (Latour, 2004a). Specifically, we attempt to identify what actors appear to play a predominant or infrastructural role in generating change or stasis in landscapes (Milligan, 2015). By identifying where and how stronger selective agency appears to reside, planning and design may begin the work of guiding these landscape assemblies towards more equitable and inclusive developmental trajectories.

3. Research Methods

Our study of human uses of restored and naturalized Delta landscapes utilized and tested a landscape approach that consisted of a unique combination of six overlapping and mutually informing methods (Milligan & Kraus-Polk, 2017). Consistent with emerging landscape approach literature, this mixed methodology was customized to the specifics of the landscapes and region of study, as well as to our research concerns and goals. These methods included a planning and governance review specific to the Delta, a survey questionnaire, interviews, landscape case studies, GIS mapping, and field work. These methods, how they were applied, and how they collectively led to our results are depicted in the methods diagram shown in Figure 5. We briefly describe each of these methods below (adapted from Milligan & Kraus-Polk, 2017).

The planning and governance review served to categorize and distill a complex set of protocols and plans that influence the Delta's rewilded landscapes. Planning infrastructure is dense and prolific in the region, with more than 230 Federal, state and local agencies, institutions and stakeholders defining, envisioning and regulating the Delta (Luoma et al., 2015). Our review covered both current and historic protocols and was vital to understanding how the Delta is officially defined and managed and how those definitions and schemata evolve over time. Generally, this research component provided a background that allowed us to analyze all other applied research methods for their adherence or deviation from these protocols. Given our emphasis in this article, we focus specifically on the results of this method in the following section.

The survey consisted of a standard set of questions that we asked of individuals with direct physical experience in these landscapes. The survey assessed perceptions of human uses and landscape boundary conditions. The approach here was one of landscape ecology but focused on human habitation; investigating patterns of use and occupation across a mosaic of heterogeneous landscapes. We had a total of 35 survey participants, which though relatively small, includes most land managers in the region. Overall response rate was likely less than 30%. However, the exact survey response rate is unknown, given that we enrolled agency and organization leads to voluntarily disseminate the survey to their personnel. A diverse array of landscape types were represented in the survey, including Federal and state lands, regional parks, mitigation banks and other private conservation lands. Respondents included personnel from state and Federal agencies as well as for-profit and nonprofit entities. The survey was conducted between March of 2015 and April of 2016.[1] See Figure 6 for a sample of survey results.

In addition to the survey, we conducted in-person interviews with land managers, resource enforcement personnel, restoration ecologists, environmental planners, Delta agency staff, and field researchers working in these environments. These voluntary interviews, nearly 50 in total varied in length and content. Unlike the survey, interviews allowed for more flexible and in-depth conversations. Many were conducted in the field during tours of landscape case studies (below), and the interview questions were modified as new information emerged. We also had opportunities to follow up with interviewees later in the study with new questions or to clarify previous information. The interviews helped address questions that emerged in survey results and inconsistencies observed in the planning and governance review. The perspectives gathered from our interviews informed all of our recommendations.

Nine case studies allowed for a detailed, comparative study of existing restored and naturalized landscapes in the Delta. Through them we could examine how site-specific conditions influence human uses, as well as how official planning, management and law enforcement protocols are implemented and to what effect. Multiple ecosystems and management regimes were deliberately selected, including naturalized open water "lakes", tidal marshes; floodplains, and oak woodlands. Ownership included Federal, state, private and nonprofit, with both single owner and multiple owner partnerships and memorandums of understanding represented. For each case study, we looked closely at how the landscape culturally and ecologically evolved to its current state. Each was assembled through a review of printed and online

[1] A full list of all survey questions is available in our report appendices (see Milligan & Kraus-Polk, 2016).

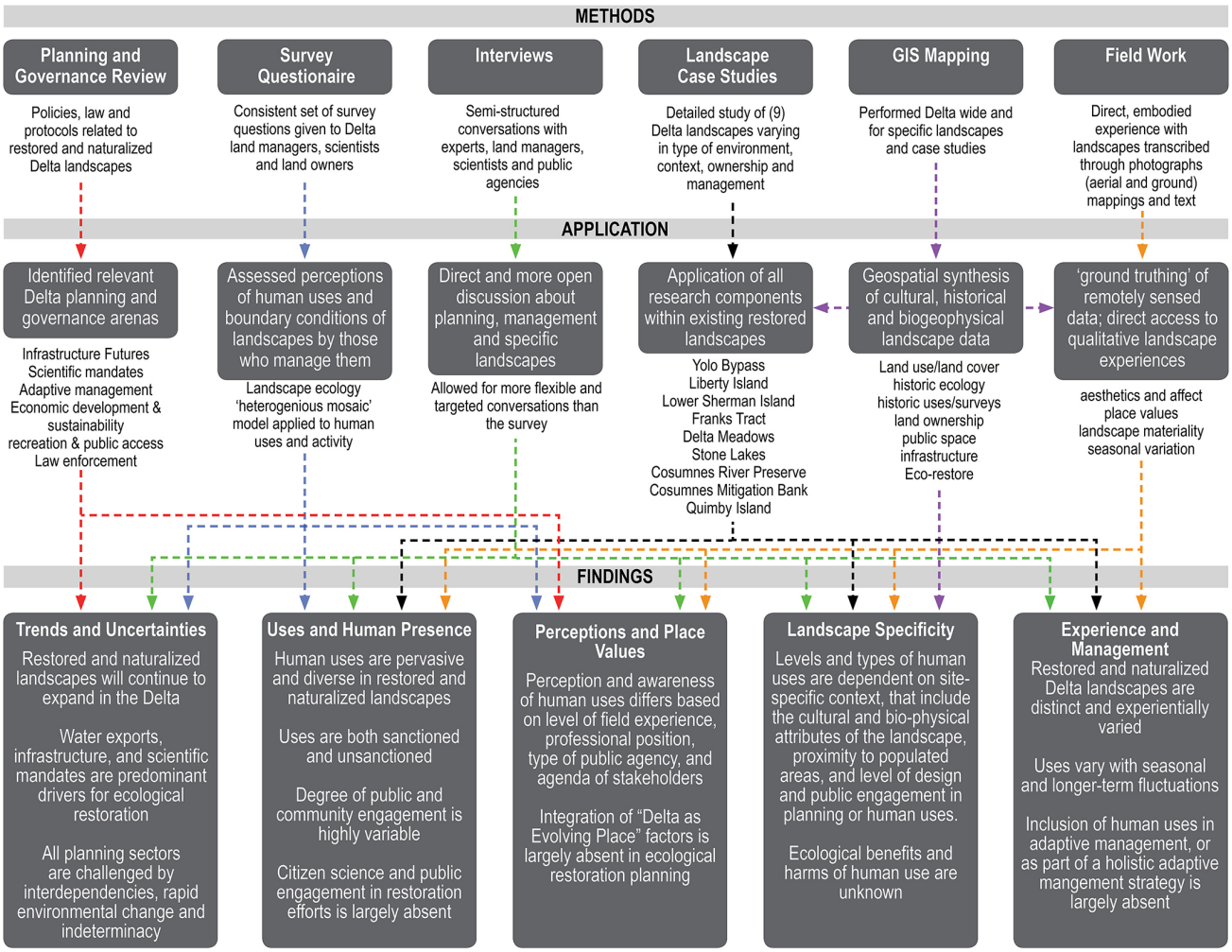

Figure 5. Research Methods Diagram deployed in the *Human use of Restored and Naturalized Delta Landscapes* study (from Milligan & Kraus-Polk, 2017). The diagram depicts six different methods, how they were applied and how each method contributed to the study's findings.

resources, participant interviews, extensive field work, on-site photography (both ground and aerial) and GIS mapping. Generally speaking, GIS mapping was used to provide remotely-sensed historical and current geospatial analysis of landscape and ecological transformations (pre- and post-reclamation), shifting ownership and jurisdictions, land use, management, and infrastructure. This was applied to the case studies, as well as to Delta wide spatial analysis (for example see Figure 2).

Field work was essential to "ground truth" the research by offering encounters with the materiality of the environments that we wanted to understand and influence (Rydin, 2014). It included both the interpersonal (micro) and, "macro-influences which trigger transitions, co-evolution and structure-functional change" (Boelens & de Roo, 2016; Latour, 2004a). Field work consisted of guided tours of landscapes and our own excursions on land and water and was documented through photographs and text. The direct and embodied experience of the field work fed back into the questions we asked during subsequent interviews and augmented the GIS-based mapping of our case study sites. We saw these combined methods as constructing a form of "landscape ethnography" attentive to embodied experiences and relationships with specific places and their temporalities, processes and politics (Ogden, 2011, p. 28).

In our study's report, we detail our findings across each of these research methods (Milligan & Kraus-Polk, 2016) and provide a more distilled telling of those same results in an open-access article (Milligan & Kraus-Polk, 2017), demonstrating why we concluded that these landscapes are heavily and diversely used by a wide range of users, with significant desirable and undesirable effects, all of which is not adequately factored into current planning efforts. Given our stated planning emphasis here, in the following section we focus specifically on how restoration planning in the Delta has coevolved with other planning arenas (our planning and governance review) to provide perspective as to why socio-cultural concerns and "Delta as Evolving Place" factors have been detrimentally side-lined in these efforts. We then present what we see as the main "Evolving Place"

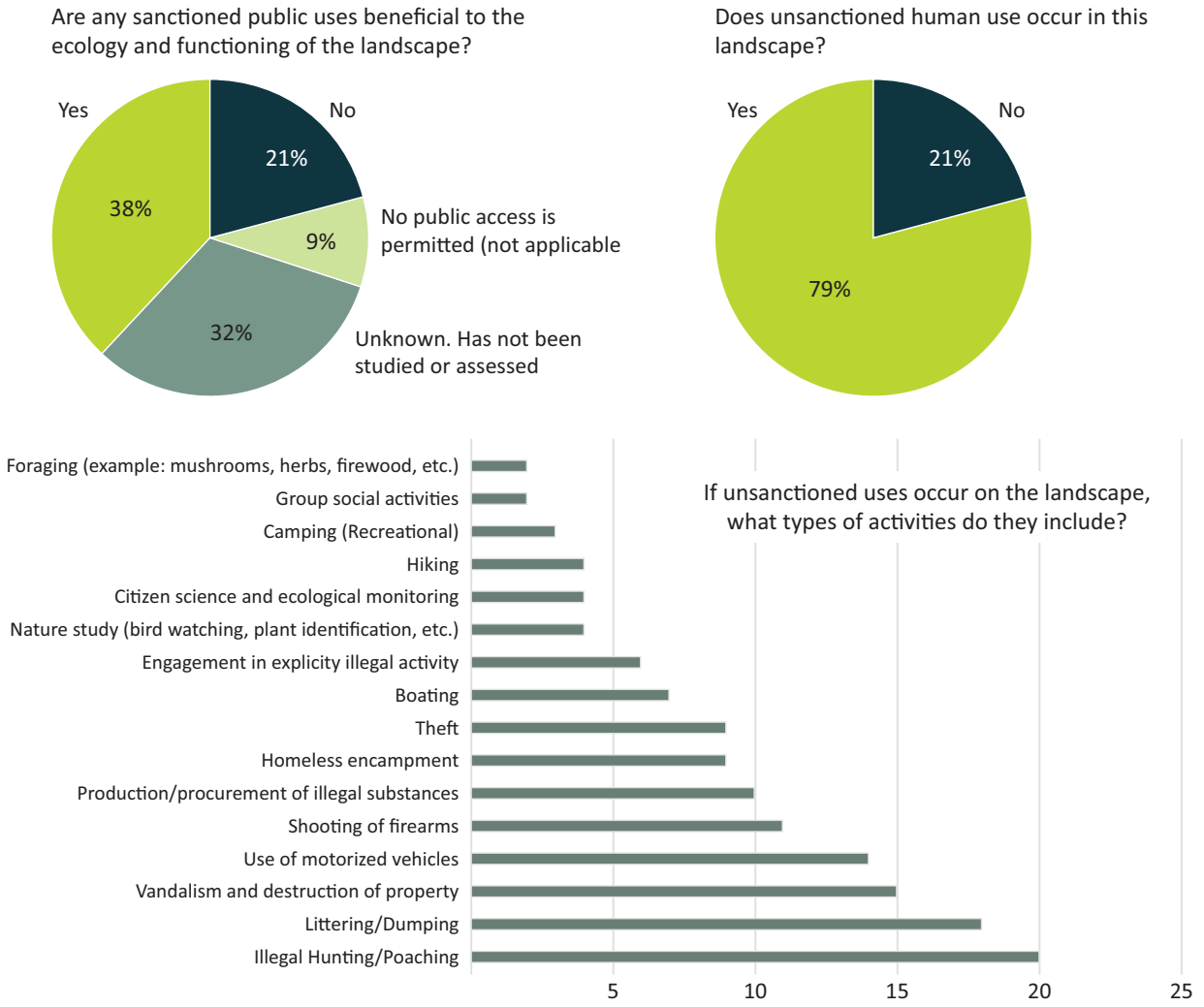

Figure 6. Selection of results from the project survey assessing perceptions of human uses and landscape boundary conditions. The complete survey results are available in the project report (Milligan & Kraus-Polk, 2016).

challenges that urban environmental planning needs to embrace to be more successful.

4. Development and Coevolution of Delta Planning

In the following paragraphs, we describe the coevolving strands of Delta restoration planning as we defined them through our planning review research. Our interpretation of "what coevolves and how" was arrived at through iterative testing, focusing on content, structure, and process (Corbin & Strauss, 2014; Gerrits & Teisman, 2016). We applied the mixed research methods described above to the case studies until they consistently addressed the range of contexts, factors and concerns we uncovered. This was a pragmatic approach, recognizing that there can be multiple useful ways to parse the world, with this one customized to our particular concerns (Mitchell, 2009). From this process we arrived at six interrelated planning arenas: 1) Infrastructural Futures, 2) Scientific Mandates 3) Adaptive Management, 4) Economic Development, 5) Recreation and Public Access, and 6) Law Enforcement (Milligan & Kraus-Polk, 2017).[2]

4.1. Infrastructural Futures

Infrastructure is clearly the predominant matter of concern in Delta planning, as it is the very basis through which the Delta was transformed for settlement and extractive uses, and is the precarious basis on which such future uses depend. The reclamation of the Delta set an evolutionary trajectory that continues into the present. This technological path dependency includes the "reclaiming" of reclamation era levees for water conveyance for the state's massive water delivery projects, which to date remains the primary logistical function and dominant economic use of the Delta. The predominant, pivotal and contested planning question in the Delta concerns how much export of Delta waters should occur, both now and in the future (Lund et al., 2010). The extensive levee network that water deliveries and Delta

[2] A more extensive description of these categories is supplied in our reports appendices (Milligan & Kraus-Polk, 2016).

communities rely upon is subject to failures from earthquakes, rising seas, and funding challenges for maintenance and improvements. Accelerated sea level alone will make through-Delta freshwater conveyance increasingly less feasible. Any changes in levee infrastructure will directly effect what the future Delta will look like and how it will perform in ecological, economic and sociopolitical terms.

The Delta Stewardship Council (DSC)—the lead Delta planning agency established by the 2009 Delta Reform Act—recently completed the Delta Levee Investment Strategy (DLIS) which provided a framework to prioritize the state's levee investments through "combined risk analysis, economics, engineering, and decision-making techniques to identify funding priorities" (DSC, 2017). While the DLIS focuses on flood risk reduction and water supply reliability, there are concurrent mandates that investments also contribute to long-term improvement of river corridors with net benefit for fish and wildlife. The DLIS effort to reconcile the multiple functions of the Delta levees, will indelibly affect the human use of restored and naturalized areas, both quantitatively (how much restored area there is) and qualitatively (what these areas are, such as thickened levees of nebulous accessibility vs. flooded open access tracts).

For water exports, the state's current administration and Department of Water Resources are pushing heavily to move forward on the California WaterFix proposal which would convey diverted water under the Delta in subterranean tunnels for use in the San Joaquin Valley and multiple urban centers.[3] The sheer length and complexity of this planning proposal render it nearly impenetrable, and perhaps intentionally so. The previous 2013 (BDCP) iteration of this proposal consisted of a 17,000-page draft plan and a 22,000-page draft Environmental Impact Report.

Two general conclusions can be drawn about Delta infrastructure planning with respect to restoration. The first is that its future is highly indeterminate. Many plans to alter or sustain these logistical works are uncertain (both in execution, budget, and timeline) and likely to be changed and superseded by new propositions. Given the dominant agency of this planning arena, it renders planning in all others challenging and unpredictable. The second conclusion is that all Delta infrastructural plans for levees and water conveyance—current and proposed—will increase the acreage of restored and rewilded landscapes as required for mitigation of undesirable effects.[4]

4.2. Scientific Mandates

Scientific mandates are the primary impetus guiding ecological restoration efforts. Such mandates cover efforts to meet state and Federal regulatory requirements, mitigate for environmental modifications, and adapt to accelerated rates of biogeophysical change, including new species assemblages within novel ecologies (Moyle & Lund, 2015). Scientific mandates for ecological recovery are tightly coupled with the Delta's levee and water export infrastructure, and restoration efforts emerged in direct response to the detrimental effects of diverting and exporting water from the Delta. The loss of native fish populations observed in the 1980s catalyzed the formation of a conservation-oriented "fish-protector" stakeholder group and led to a partnership between state and Federal agencies called the CALFED Bay-Delta Program. CALFED created a fleeting peace by promoting the mantra that "everybody would get better together" (Shigley, 2012), yet ultimately was unable to deal with the underlying contradictions between environmental conservation and continued water-fueled growth (Kallis, Kiparsky, & Norgaard, 2009). Out of the failure of CALFED came the 2009 Delta Reform Act, which addressed these issues by defining the *coequal goals* of water supply reliability and protecting, restoring, and enhancing the Delta ecosystem. In theory, the coequal goals place infrastructural and ecological demands on equal footing. But given its institutional evolution, restoration is approached only from a technical and mitigatory perspective, rather than on its own terms or through a broader range of values. Ecological restoration is about meeting state and Federal regulatory requirements in reaction to infrastructural effects.

The concept of "restoration"—a return to some previous historical condition—is problematic in the Delta. Given its radical alteration, it is impossible to reset the Delta to some historic baseline, as it continues to evolve further from those former states at rates faster than many scientists and managers can keep pace. The growing acknowledgement of this ecological uncertainty is leading to new paradigms in Delta conservation, such as reconciliation ecology, defined as, "the science of inventing, establishing and maintaining new habitats to conserve species diversity in places where people live, work or play" (Moyle et al., 2012; Rosenzweig, 2003; Suddeth Grimm & Lund, 2016). We find these reconciliatory approaches promising for ecological recovery efforts, as they bring the social and cultural back into the ecological, and render scientific value judgments more overt and accessible.

4.3. Adaptive Management

Adaptive management is a learning technique that engages with landscape change through adaptive and corrective responses to emergent phenomena (Boelens & de Roo, 2016). When implemented, adaptive management can help circumvent paralysis in decision-making within contexts of uncertainty (Mitchell, 2009). The Delta Reform Act mandated adaptive management in the Delta, and its incorporation into the recently completed

[3] A previous iteration of this project, which entailed a peripheral canal, was rejected by state voters in 1982. Various proposals and propositions have intermittently been in play since that time, leading up to Waterfix.

[4] This assumes the resilience of Federal and State Endangered Species Acts and associated environmental regulation, which has been long under attack.

Delta Plan (DSC, 2013)—the integrative long-term management framework for the Delta. How adaptive management is put into practice in the Delta remains in question, particularly in the integration of efforts across the region and across different forms of science and knowledge making (Delta Independent Science Board [DISB], 2016; Lund & Moyle, 2013). In our review of "integrative" adaptive management protocols, we definitively observed that human presences and uses were not included, even though nearly all of the land managers and scientific researchers we surveyed or interviewed shared numerous informal stories of how they actively manage sanctioned and unsanctioned human uses (Milligan & Kraus-Polk, 2016, 2017). We interpreted this as another indication of the compartmentalization of science and restoration planning, since in spite of contact with pervasive social and cultural phenomena of varied effects, more inclusive adaptive protocols have not emerged in response. We speculate that this will likely change in the future, given the sheer magnitude and increasing human presence on these lands.

The three other planning arenas we identified—Delta Economic Development and Sustainability, Recreation and Public Access, and Law Enforcement—were observed to have far less presence and potency. They were weakly tied to restoration efforts, with the likely effect of diminishing the potential benefits and success of restoration efforts.

4.4. Economic Development and Sustainability

Delta economic development planning seeks to bring more visibility, allure and economic activity to the Delta, and with it, more financial sustainability to Delta communities. Major planning efforts include a National Heritage Area (NHA) proposal currently before Congress (Delta Protection Commission [DPC], 2017), a Delta Branding and Marketing Project, the *Vision 2030 Strategic Plan* (DPC, 2015), and periodically updated *Economic Sustainability Plans* (DPC, 2012). These plans tend towards assuming the continuation of agricultural production as it is in the Delta, yet this development pathway is threatened by several factors, including accelerated climate change, new water conveyance infrastructure (WaterFix), and national and international commodity volatility. Further, most of these plans focus on agricultural tourism and recreation with little if any attention to the Delta's novel ecologies and the many efforts to redesign, augment and manage them.

4.5. Recreation and Public Access

Delta planning protocols "recommend" rather than mandate that agencies provide recreation and public access opportunities in newly restored areas (DSC, 2013). Integrating recreation and public access into restoration and infrastructure projects has proven to be a challenge. Yet plans and efforts by state agencies to increase public access and recreation opportunities in the Delta exist (California Department of Parks and Recreation [CDPR], 2011; DPC, 2017). The *Recreation Proposal for the Sacramento-San Joaquin Delta and Suisun Marsh* lays out a range of reasons why planning for human use in restored and naturalized landscapes leads to a broad range of socio-ecological benefits. Whether such plans will be implemented is uncertain (CDPR, 2011).

4.6. Law Enforcement

Generally, we found law and resource enforcement issues critical to restoration virtually nonexistent in Delta planning literature. It was mainly through our interviews and conversations with law enforcement personnel that we gained a better understanding of their unique and changing needs.[5] As restored and naturalized lands expand so will demands for public safety and law and resource enforcement to address poaching, (il)legal marijuana production, vandalism, trespass, dumping, illegal encampment, etc. Resource enforcement is specifically concerned with upholding laws, such as those within the California Public Resource Code, that serve to protect, conserve and manage unique and limited natural resources held in public trust for current and future generations. Planning recommendations are particularly lacking in explicit support for resource enforcement.

Reading across these domains, it is clear that Delta restoration planning has developed in a particular way, as a mitigatory reaction to the mining and export of the state's water on a grand scale. As a well-intentioned effort to bring back what infrastructure has displaced, restoration planning has introduced its own abstractions upon the infrastructural abstractions it intends to counter, such as the setting of restored habitat acreage targets divorced from geographic specificity, mandatory environmental water flow quantities, etc. What infrastructure and restoration have both missed in these layered abstractions is an awareness of Delta as a unique, cultural and urbanized place. Social values and concerns within the greater Delta region (such as the economic, recreational, and law enforcement planning domains we described) have received little attention in these schemata, likely because they are overshadowed by the networked and subjugated infrastructural role the region plays. But specifically for restoration, these "Delta as Evolving Place" factors have a considerable role in whether or not these landscapes will be successfully stewarded and accepted by local communities. Based on our study's findings, in the following section we discuss

[5] The law and resource enforcement agencies we talked with included the Delta Bay Enhanced Enforcement Program (DBEEP) and the Marijuana Eradication Task force (MET), both special operations unit of the California Department of Fish and Wildlife's (CDFW) Law Enforcement Division (LED), US Fish and Wildlife Service (USFWS) law enforcement, the Drug Enforcement Administration, Sheriff's offices from all 5 Delta counties, the US Coast Guard (USCG), the High Intensity Drug Trafficking Area Program (HIDTA), and the California Highway Patrol (CHP).

three unique challenges of "Delta as Evolving Place" that conservation efforts are likely to encounter.

5. Conundrum and Challenges of "Delta as Evolving Place"

> The evolving is the tricky part, isn't it? [The Delta] has to change. It will change because of sea level rise if no other reason and because of continuing drought and possibly super floods from El Niños. Things are going to change. How it changes, whether it is a well thought out incremental program of change where people are convinced to participate, or whether it gets done to people through catastrophe, I don't know…a lot of people just want to see it stay the way it is, and who think the way it is the best way it should be or could be…So what is the nature of the evolution? (Jennifer Ruffolo [formerly with the Delta Protection Commission], research interview, September 2015, Milligan and Kraus-Polk 2016).

The California Delta is a unique and distinctive region, as recognized by the 1992 Delta Protection Act (CA Public Resources Code §29700–29780) the 2009 Delta Reform Act (CA Water Code §85000–85004) and the Delta Plan (DSC, 2013). As the Delta Protection Act states: "The Delta is a natural resource of statewide, national, and international significance, containing irreplaceable resources, and it is State policy to recognize, preserve, and protect those resources for current and future generations, in a way that protects and enhances the unique values of the Delta as an evolving place" (PRC sections 29701–2). This was further articulated by the Blue Ribbon Task Force and referenced in the Delta Plan:

> Protecting the Delta as an evolving place means accepting that change will not stop, but that the fundamental characteristics and values that contribute to the Delta's special qualities and that distinguish it from other places can be preserved and enhanced while accommodating these changes (Delta Vision Blue Ribbon Task Force, 2008). It does not mean that the Delta should be a fortress, a preserve, or a museum.

The ratification of these acts and the adoption of the Delta Plan acknowledge the importance of social and cultural attributes of the Delta in relation to pressing and controversial decisions that will affect the region, including water management and exports, land management and ecological recovery efforts. Yet how "Delta as Evolving Place" is developed, researched and articulated, per these mandates, remains elusive. As the DISB recently stated: "[l]ittle has been established about the unique values of the Sacramento-San Joaquin Delta as an evolving place and the social and environmental processes supporting those values. Research in this area is sorely needed if those values are to be protected and enhanced as decisions are made to meet the co-equal goals of reliable water supplies and restored ecosystems" (2017).

We found this conclusion particularly relevant to restored and naturalized Delta landscapes, where planning seems "freed" from such place concerns.[6] Human uses—be they scientific, managerial, recreational, or unsanctioned—can significantly affect restoration planning, implementation and metrics of success—beneficially and detrimentally. Distilling our study's findings across interviews, fieldwork, and literature/planning review, we outline three Delta place conditions that we see playing a major role in what the future of the region might be: 1) the highly dynamic nature of the Delta, 2) the Delta's territoriality, and 3) the pleasures and politics of experience. We found that these phenomena have persisted across time and affect all planning arenas, and thus should be considered in socially transformative ecological planning efforts.

5.1. Accelerated Change: The Delta in the Anthropocene

> The Delta ecosystem of today will not be the Delta ecosystem of tomorrow. The only constant is change, which we are not good at anticipating or embracing. (Moyle & Lund, 2015)

"Delta as Evolving Place" presents spatial and cultural challenges since the human conception of place depends on consistency over time, a quality that isn't characteristic of the region (Smith, 2013). The Delta's history of transformations and accelerated rates of change has led to a remarkable diversity of place definitions in a relatively short period of time (Center for California Studies, 2015). As part of the interviews we conducted for our study, we asked representatives from a variety of state and Delta agencies how they define "Delta as Evolving Place", or to talk about what it means to them for guiding governance of the Delta. This question was often met with a blank expression, a laugh, a shift to another topic, or a statement about general uncertainty. However, we were sometimes met with a focused effort to articulate an answer. We began this section with Jennifer Ruffolo's (Delta Protection Commission) response to the question, which seems to get at the difficulty and elusiveness of the concept and the thing itself.

Combining "place" with accelerated rates of environmental change that "evolving" entails is not just a legislative conundrum, but also a physical, spatial and political one. Human colonization and wholesale transformation of the Delta has been rapid in social, technological and geographic terms—only over a century in progress—and is being played out concurrently in large delta estuaries around the world (Renaud et al., 2013; Tessler et al., 2015; Vörösmarty et al., 2009). Climate change and sea

[6] This is despite repeated calls for better integration. The most recent being the November 2016 State of Bay Delta Science Report, which included in their forward thinking actions a recommendation to: "Weave 'Delta as an Evolving Place' into all science, planning and management programs" (DSC, 2016).

level rise in the Delta is a pressing concern, with conservative projections for 2100 ranging from between 0.2 m and 1.7 m of additional rise from the end of the 20th century (Dettinger et al., 2016). Regardless of exact rate and magnitude, sea level rise will increase salinity and increase stress on levees, threatening water supplies (Cloern et al., 2011; Dettinger et al., 2016). Tidal wetlands restored today may be drowned, or migrate into upland areas. As Jennifer Ruffolo remarked, the California Delta will continue to rapidly change, whether we want it to or not, due to actions we have already taken.

In working with "Delta as Evolving Place", it may be more useful to think specifically in terms of *emplacements* and *displacements* (for both humans and non-humans) over time, which speaks more specifically to evolutions in form and occupancy (Drenthen, 2009; Ogden, 2011), landscape migration (Milligan, 2015) and the "politics of nature" (Latour, 2004b; Ogden, 2011). In the Delta, the definition of place and its evolution are inherently political, economic and tied to territorial claims. Restoration efforts are one form of deliberate landscape change—an emplacing of a new place and simultaneous displacement of the former—and thus are embedded in this territoriality.

5.2. Delta as Territory and Perennial Frontier

> Water solutions almost always have both winners and losers. This is obvious in a case like the Delta, where it's simply not possible to find a fix that will make everyone better off. That's because every available option involves tradeoffs in which at least one party doesn't fare as well, whether it's farmers in the Delta, farmers in the San Joaquin Valley, urban residents south of the Delta, or the Delta's native fish and wildlife…As a society, we can aim for solutions that get the most benefits per dollar spent, but we also need to consider how to soften the blow if some groups are disproportionately bearing the costs. (Hanak, 2015)

> [W]hen environmental scientists are in charge of the recreation, public access is problematic. So it is easier not to do it. (Cheryl Essex [California State Parks], research interview, July 2015, Milligan and Kraus-Polk 2016).

In defining the Delta as a territory, we mean it in both the sense of a region with a different status than other parts of the state, as well as in the sense of territoriality—the behavior of trying to keep others away from an area one uses or controls. The Delta suffers from the latter because it is over-allocated, with neither the money, land or water to meet everyone's expectations. As Jane Wolff states, "[t]he range of people who want something from the Delta has grown…their goals for the landscape are different; they understand it in different ways; and they imagine its future differently. The fault lines[7] among the Delta's constituents are complicated, variable, and sometimes counterintuitive" (Wolff, 2003, p. 40). See Figure 7.

Figure 7. Entrance sign to Liberty Island, Summer 2015, revealing different conceptions and uses of the landscape. Image by Brett Milligan.

[7] For more on risks associated with seismic activity in Delta see (Mount & Twiss, 2005). This highly contentious paper catalyzed the formation of the Delta Blue Ribbon Task Force under Schwarzenegger and earned the lead author, Jeffrey Mount, the sobriquet "Dr. Doom".

This territoriality occurs in ecological restoration efforts. Within the scientific discourse, there is great uncertainty and debate regarding the definition and status of the current Delta ecosystem, the past to which it is compared and possible futures of what it might and should become. Many ecologists have become comfortable defining it as a novel ecosystem in which an unprecedented combination of species interact in its highly altered environments with actions that are often irreversible (Hobbs, Moyle, Fangue, & Connon, 2017; Moyle & Lund, 2015). Many non-scientists also embrace this novelty; participating in fishing tournaments for the non-native black bass (a major predator of endangered salmon), running bayou-themed eateries, or farming wine grapes beneath levees as ships sail "overhead". Some of the same people are adamant that the Delta cease its unruly changing, and that the state, which has played a fundamental role in its shaping, leave the Delta alone. Desired futures are based in part on select understandings of the past. Much contention stems from tenuous "baselines" used by diverse stakeholders to demarcate preferred and desirable states for the Delta, both wild and urbanized.

Accelerated landscape change combined with heightened territoriality paradoxically render the Delta as a perennial frontier—the dynamic limit of "settled" land. All empirical evidence shows that the Delta has been and will continue to be reoccupied in ephemeral ways, dating back to pre-European contact (Helzer, 2015). The Delta of today cannot be sustained, and our human settlement of it is part of a relatively young, adaptive experiment being carried out in urbanized deltas around the world (Renaud et al., 2013; van Staveren & van Tatenhove, 2016). As both territory and frontier, there are many prognostications, concerns and controversies regarding how the Delta will be settled, unsettled and rewilded in the near future.

5.3. Aesthetics, Pleasure and the Politics of Experience

> It is hard to tell people how they can experience wildlife. (Bart McDermott [Stone Lakes National Wildlife Refuge], research interview, October 2015, Milligan and Kraus-Polk 2016).

All types of Delta wilds (restored and naturalized landscapes) are essentially feral, having emerged from a state of domestication and former land uses. Rather than just simply being made, these transitions occur through various practices, whether of action or inaction. How a person experiences and interprets such rewilded landscapes is tied to their life experience and interests. Land managers and scientists working in Delta landscapes experience them differently than a Bay Area resident, who might visit the Delta every couple of years to "dawdle", seeking, "a place of escape, a hideout, a place to drop out of the modern world…" (Helzer, 2015, p. 40).

Compared to the sporadic recreationist, the land manager and the scientist's perceptions of restored or naturalized landscapes are developed through more habitual immersion within the landscape based on specific professional tasks and interests. As observed in our interviews and fieldwork, these habits are diversified, such as monitoring fish populations through sampling and collection, creating elevational surveys of a restored floodplain, and surveying the growth of plants on restoration test plots. They have an embodied and intimate relationship with these landscapes and what occurs within them, which for many, is why they chose this work (Eliason, 2006).[8] For comparison, consider how qualitatively different these "field" experiences are from that of a GIS mapping technician, or that of a planner's remote media access to these landscapes through technical reports and publications (Boelens & de Roo, 2016). These qualitative experiences and the knowledge they build are fundamentally different from that developed by living and working in the place itself. Different modes of existence (Latour, 2013) lead to different notions of place and value.

Anthropologist Tim Ingold refers to these "patterns of dwelling activity" as *taskscapes* (Ingold, 1993, p. 153), which can be a useful way to consider activities within restored and naturalized landscapes in the Delta. A taskscape encompasses the range of activities performed within or upon a landscape, and thus "[t]he activities that comprise the taskscape are unending, the landscape is never complete: neither 'built' nor 'unbuilt', it is perpetually under construction" (Ingold, 1993, p. 162). *Taskscapes* include everyday life: work and play. Over time, these everyday practices affect and are affected by the landscape medium itself, rendering them inseparable.

In planning and designing for restoration, user experiences matter. Human uses entail presences that enact and create landscapes through diverse practices, protocols, encounters, and desires. In terms of recreation, the Bureau of Reclamation expresses this diversity well: "The average visitor [or user] does not exist" (2011, p. 3). Their statement alludes to the complexities of planning for conventionalized types of outdoor recreation. Defined as what people do for fun and entertainment, recreation is inherently broad, transcending the simplified conventions often ascribed to it. In the Delta, recreation is only one sector among a much broader range of human uses that span the scientific, management practices, and a much broader spectrum of sanctioned and unsanctioned activities. All of these human activities, desires and practices play a role in the perpetual construction of Delta landscapes.

These challenges of "Delta as Evolving Place"—accelerated landscape change, territoriality, and diversity of experience and values—will need to be addressed in the planning, designing and managing for Delta Wilds. Suggestions and examples for how ecological recovery efforts might work with the challenges are addressed in the following section.

[8] This was consistently tested and demonstrated in our interviews.

6. Recommendations

Our *Human Use of Restored and Naturalized Landscapes* research project was focused on understanding how people currently use and occupy these places, and how they are approached and planned for within an infrastructural context. Given the general lack of social and place-based considerations we documented, the next step is to move towards ways of actively changing the status quo to generate more desirable and successful outcomes for people and ecosystems. This will require considerable work to shift from current practices to an approach that is more socio-ecological in orientation and more attuned to local contexts and place-based realities. Although we found that the way in which restoration efforts have emerged in the Delta are specific to its unique context, the minimal funding and priority given to community input, public access and cultural concerns generally in large-scale restoration efforts is a systemic national problem that has broad applicability (Ogden, 2008). In our study's report, we provide a variety of specific and targeted recommendations for improving socio-ecological restoration planning, design and management practices in the Delta, ranging from the local to national scale (Milligan & Kraus-Polk, 2016). Here we focus more generally on the value of pluralistic methods of interpretation and how urban environmental planning might effectively engage these challenges.

Our first general recommendation concerns how we access, experience and understand complex and conflictual planning environments. Based on our research experience, we advocate for the additional application of pluralistic and pragmatic methods for engaging with "wicked" planning problems. The need to move beyond single discipline or sectoral approaches to planning in these contexts, such as those of landscape planning approaches, is fairly well known. But effective methods for doing so are less developed and would benefit from the additional application and methodological testing (Bennett & Zurek, 2006). Based on our experimental research experience, a pragmatic and pluralistic approach provides an avenue to get beyond the single problem or solution identification paralysis described by Rittel and Webber (1973) since multi-faceted/perspective approaches do not assume a best entry point. Rather, they encourage an iterative, transdisciplinary learning process subject to refinement through interaction with a range of media, environments and stakeholder perspectives, as accessed through mixed, interrelated methods of encountering them.

Pluralistic methods provide access to what is coevolving with what, and in what ways, through inhabiting, interrogating and moving across these interacting arenas. In this way, "[p]lanners are not so much intervening as drawn into associations which are then the cause of change" (Rydin, 2014). In our experimental study, we found that what we learned across the six overlapping methods was greater than the sum of the components, and far greater than if we had deployed only one or two of the methods. Perhaps most critically, our approach combined distanced analytical methods (i.e. policy and governance review and GIS spatial analysis) with more personal and informal encounters (interviews) and embodied fieldwork (case studies). This allowed for us to see how top-down processes (such as infrastructural plans and scientific mandates) were interacting with bottom-up actions and context-specific realities (how people felt about these landscapes and what they were actually doing in them). This provided for a richer and messier understanding of these places that served as a counterpoint to pervasive tendencies toward overly reductive and universal explanations (Mitchell, 2009). This can help to avoid planning's own tendencies for material, social, and ecological abstractions that suppress specific landscape and contextual factors.

Our second recommendation, tied to the first and framed as a question, is how can we foster more *adaptive planning* within these indeterminate and challenging contexts? Our observations from the Delta (and likely those from elsewhere) suggest that urban environmental planning and its protocols often lag behind identified problems and emerging realities. The need for adaptive management in the Delta and conservation is widely recognized. Similarly, in planning practice, how can we adapt more quickly, responsively and contextually? We have two general suggestions for this: proactive opportunism and exploratory scenario planning.

As we have shown, social and cultural aspects of ecological restoration planning and practice in the Delta (and elsewhere) are typically side-lined, or left out entirely within the logic of infrastructural ambitions and scientization, which in turn leads to less sustainable and less publicly supported restoration. Fostering acceptance and place-based benefits in these efforts will require proactive action that utilizes opportunities as they emerge. This can occur across planning scales, from the project level to state and Federal planning. As an example, the North Delta Flood Control project is a state planning effort to convert a 1,600-acre Delta tract into flood management infrastructure (California Department of Water Resources, 2010). This will be achieved by breaching and modifying the tract's existing levees, which will create new open water areas, tidal marshes and riparian floodplain habitat for a variety of species, including humans. Again, in this instance only the infrastructural and ecological benefits of the project were being considered, even though it will have impacts on adjacent agricultural and urban communities and will be used by people, whether or not they are planned for or are invited into the planning process. This nascent project presented an opportunity to proactively envision a range of additional social and public benefits for the project and for the planning agencies involved, which in turn helped to build public constituency and support (Figure 8).

If the imagination of infrastructural logistics is typically limited to economic abstractions, then planning

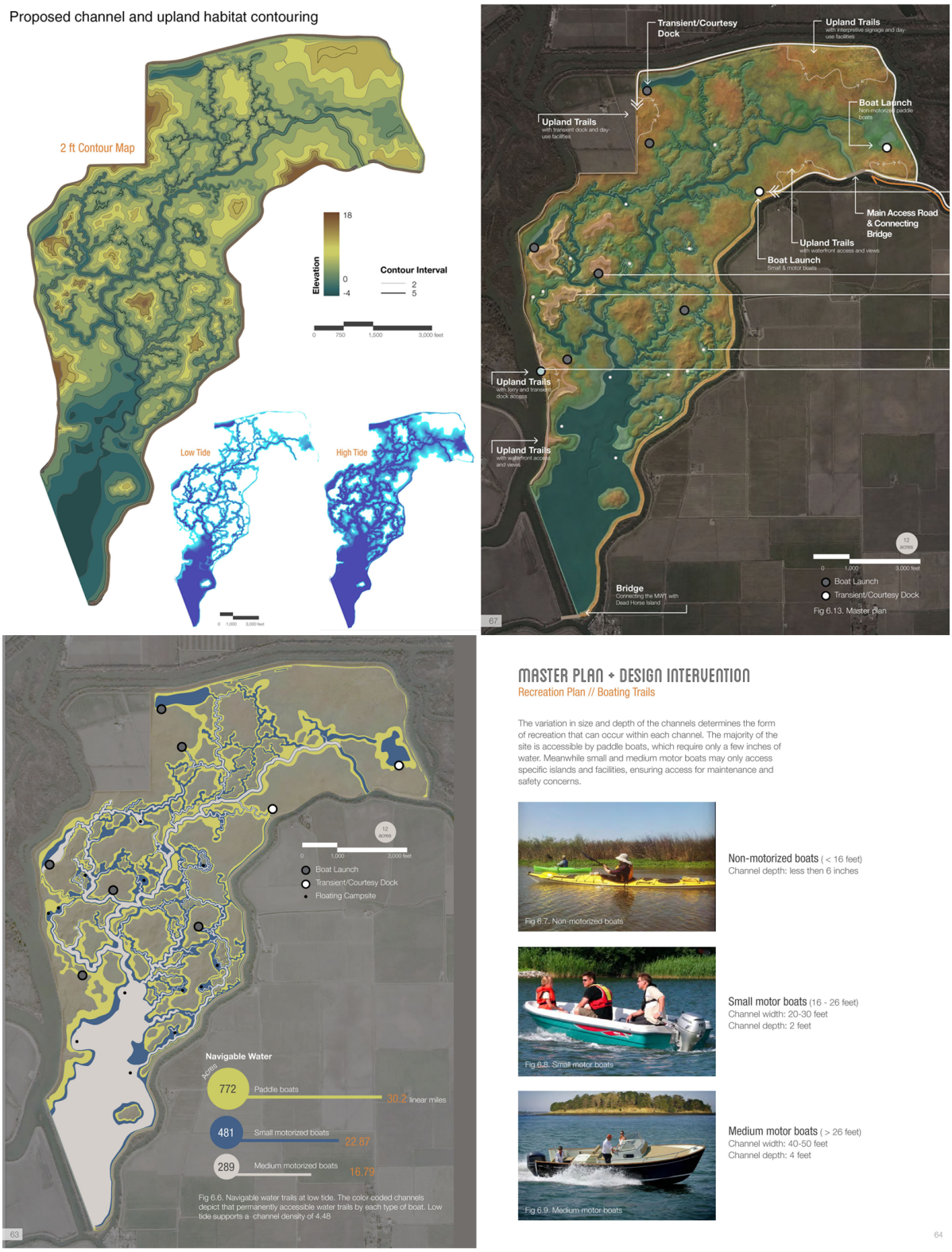

Figure 8. "Navigating the Delta: The McCormack-Williamson Tract" (2014); Excerpts from a Planning and Design Project by UC Davis landscape architecture student Katie Herman, including ecological restoration concept (top) and overlay of recreation planning (bottom). Katie's project was developed in an advanced planning and design studio that expanded upon existing planning frameworks for the North Delta Flood Control Project, building a vision for incorporating aquatic and terrestrial recreation within the new ecological and hydrological conditions of an intentionally inundated and re-sculpted landscape. Based on the growing recreational demand in the Delta, this plan proposes implementing a network of boating trails, campsites, and interactive wayfinding media for the new waterways. The project was coordinated with and advised by representatives from the California Department of Water Resources, The Delta Conservancy and the Nature Conservancy.

methods to expand these epistemologies are needed. High-level Delta planning reports have recently called out the need for scenario planning to allow for more integrative and long-term planning in the region (DSC, 2016; Luoma et al., 2015). Scenario planning is a disciplined and creative method for imagining potential future conditions. It can be considered a projective version of coevolutionary thinking, in which a chosen set of mutually affective trends and uncertainties are varied and played out across a set of tangible future scenarios (Peterson, Cumming, & Carpenter, 2003; Schoemaker, 1995; Shearer, 2005) (see Figures 9, 10 and 11). There are different varieties of scenario planning, and one of the most important distinctions is between exploratory and normative. Exploratory scenario planning is a method for imagining a plurality of futures that could potentially happen, rather than just those that "should happen", which is the basis of normative approaches. Exploratory planning can be particularly effective in opening up dialogue and collaboration where uncertainty and political conflict dominate, since they "compel participants to discuss and challenge their assumptions with others who hold

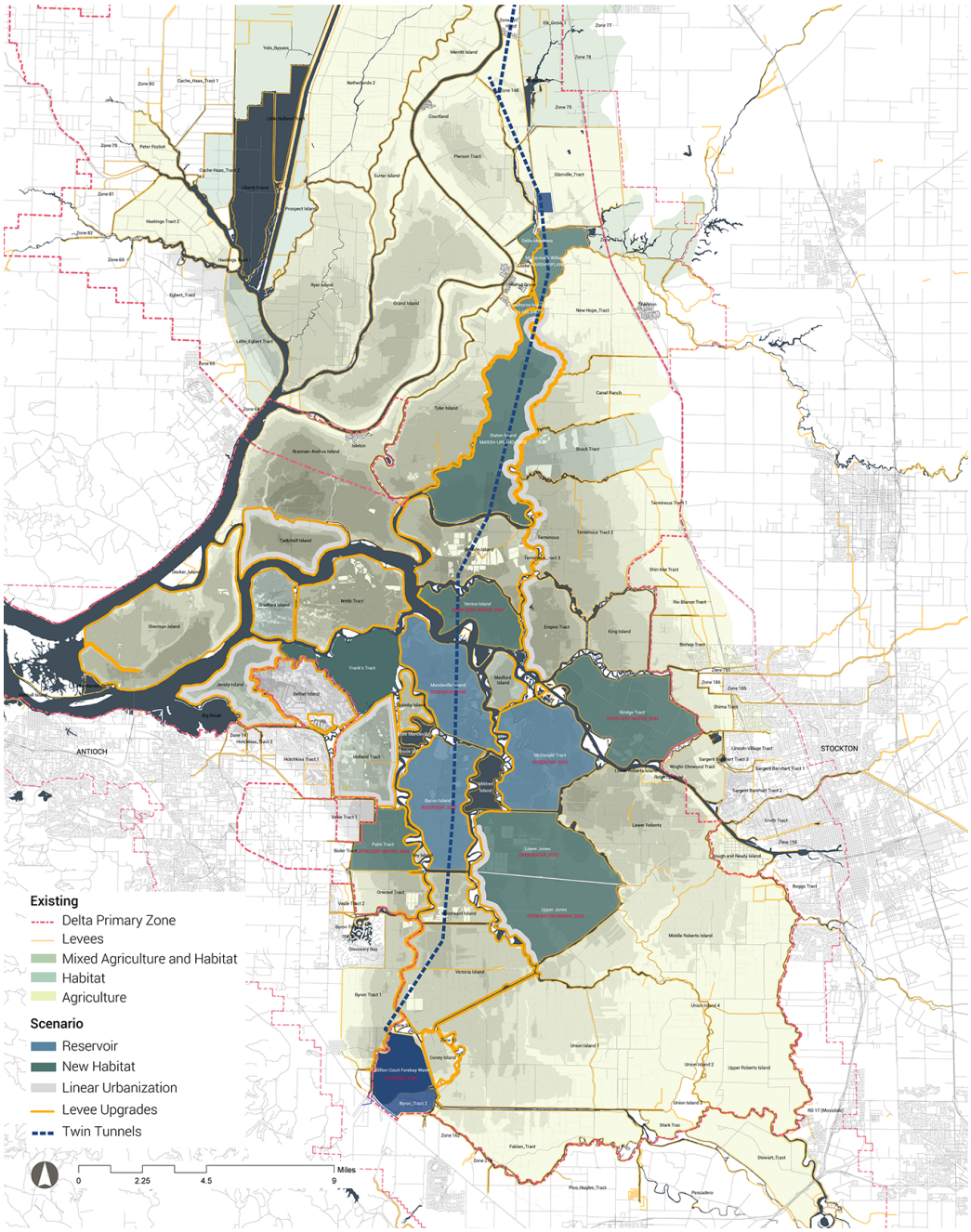

Figure 9. Delta-wide mapping of the *Water Machine* scenario (from Milligan & Holmes, 2016). The Water Machine scenario explores the potential social, ecological and political implications of the California WaterFix, a plan which proposes to build twin 40' diameter tunnels that would convey water from the Sacramento River over a span of thirty miles, 150' below the ground surface of the Delta to export to cities and southern agricultural interests (from Milligan & Holmes, 2016).

	Disasters	Infrastructural Investment	Water Exports	Technological Innovation	Regional Urbanization
	climate change drought temperature sea level rise species migration species extinctions seismicity subsidence salinity	policy climates (national, state, regional) legal action/inaction legislative action/inaction maintenance construction	export demands agricultural production state population change water allocations water input volume water input timing	desalinization levee improvements landscape robotics novel agriculture flood-adaptable housing market mechanisms (carbon, environmental)	population migration immigration speculation urban form/distribution high-speed rail
New Deal	Medium (Early)	Low (Early)	Low	High	Low
Water Machine	Medium (Late)	High	High	Medium	Medium
Augmented Earthworks	Low	High	High	Medium	High
Feral Bay	High	Low	Low	Low	Medium (Late)

Figure 10. Drivers (top) and four exploratory scenarios developed for the wicked ecologies project. The "water machine" scenario explores future possibilities in which significant investment is made in Delta infrastructure, with the primary goal of ensuring the stability of water exports. Climate change and earthquakes stress this water machine while land use fragments and diversifies, with some tracts surviving essentially intact while others are converted to novel uses ranging from open deep-water habitats to linear urbanization along super-levees (from Milligan & Holmes, 2016).

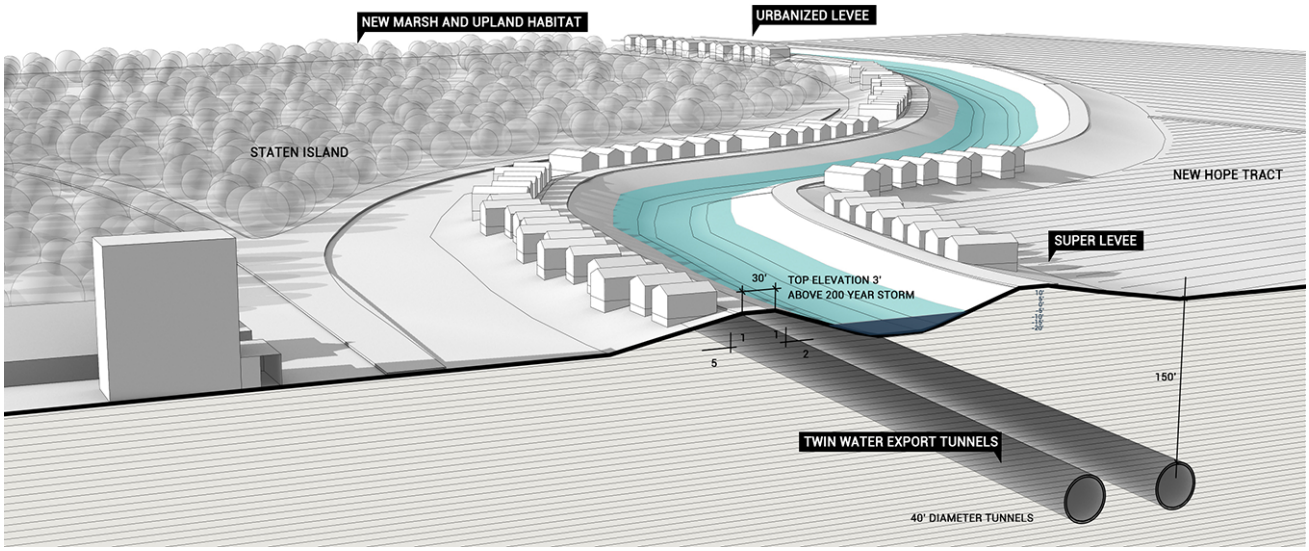

Figure 11. Spatially modeled section of the *Water Machine* scenario (WaterFix), showing urbanized super levees along the in-Delta water conveyance channels, restoration areas, and the subterranean tunnel infrastructure (from Milligan & Holmes, 2016).

different beliefs" and thus serves as a "tool for integrating and synthesizing across epistemologies" (Bennett & Zurek, 2006, pp. 276–277).

Envisioning how the Delta might evolve under very different conditions can permit planners and stakeholders "to inhabit multiple truths, nascent realities, contexts, and political perspectives" (Milligan & Holmes, 2016), thus making participants "aware of the added value of possible creative combinations of actions and/or of the existing limitations in capabilities" (Boelens & de Roo, 2016).[9] In turn, this transdisciplinary learning space can open up new realizations and possibilities in future planning efforts.

7. Conclusions

The California Delta is a mascot for the challenges of Anthropocene landscapes: radically remade through massive works of engineering; ecologically rich and vital, yet novel, and largely destroyed; vulnerable and changing

[9] The science that informs such planning is trending towards the post-normal, with an emphasis on deliberation, values, plurality of legitimate perspectives, uncertainty, and the erosion of the monopoly of experts within collective decision-making (Funtowicz, Alier, Munda, & Ravetz, 1999; Ravetz, 2005).

faster than we can understand it due to what we have set in motion; and just to make things more complex, add the US and global economies' reliance on its infrastructural capacity to export fresh water. As restoration mandates attempt to reconcile some of these challenges and competing needs, the overlapping planning arenas and place-based factors we have identified will continue to influence restored and naturalized Delta landscapes and the people who live, work and play in them. This human-environment coevolution will occur whether or not it is explicitly considered in restoration planning, design and management discussions. Yet the qualities these landscapes will assume very much depends on whether or not their development is intentionally stewarded and in what manner. Our research intervention is just one interpretation and envisioning of many possible developmental trajectories the Delta might assume.

Based on past mistakes and the emergence of new approaches in the Delta, we see signs of recognition that planners, engineers, designers and scientists interact in complex and indeterminate networks, rather than clear modernist hierarchies (Gerrits & Teisman, 2016). In turn, this recognition will require expanded epistemologies that can accommodate and plan for ecological *and* sociocultural values. We seek to advance a movement towards grounded, pluralistic and adaptive planning, focusing on rigorous experimentation and "incremental changes that are dictated by the possibilities that are specific to a certain time and location" (Gerrits & Teisman, 2016). The dynamic and territorial challenges of the Delta demand that planners are humble in their aspirations, yet do not shy away from "impractical changes" (Luoma et al., 2015; Norgaard, 2013).

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Conflict of Interests

The authors declare no conflict of interests.

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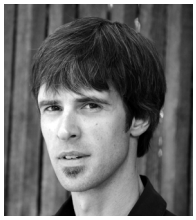

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Article

Maximizing Green Infrastructure in a Philadelphia Neighborhood

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Abstract
While the Philadelphia Water Department (PWD) is counting on Green Stormwater Infrastructure (GI) as a key component of its long-term plan for reducing combined sewer overflows, many community stakeholders are also hoping that investment in greening can help meet other ancillary goals, collectively referred to as sustainable redevelopment. This study investigates the challenges associated with implementation of GI in Point Breeze, a residential neighborhood of South Philadelphia. The project team performed a detailed study of physical, social, legal, and economic conditions in the pilot neighborhood over the course of several years, culminating in the development of an agent-based model simulation of GI implementation. The model evaluates a) whether PWD's GI goals can be met in a timely manner, b) what kinds of assumptions regarding participation would be needed under different theoretical GI policies, and c) the extent to which GI could promote sustainable redevelopment. The model outcomes underscore the importance of private land in helping PWD achieve its GI goals in Point Breeze. Achieving a meaningful density of GI in the neighborhoods most in need of sustainable redevelopment may require new and creative strategies for GI implementation tailored for the types of land present in those particular communities.

Keywords
agent-based modeling; green infrastructure; participatory modeling; stormwater; urban redevelopment

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1. Introduction

1.1. City Context

Philadelphia is a city of stark contrasts. On one hand, public safety, environmental quality, and property values in many of its residential neighborhoods are compromised by the presence of over 40,000 vacant properties, responsible for $3.6 billion in lost household wealth, $20 million in City maintenance costs, and at least $2 million in uncollected property taxes each year (Philadelphia Redevelopment Authority, 2010). Roughly one-third of the city's residents live in poverty (Romero, 2017). On the other hand, the City has emerged as a national leader in sustainable urban water management, as exemplified by the Philadelphia Water Department's (PWD's) *Green*

Cities Clean Waters (GCCW) program, which pledges a broad and long-term investment in green infrastructure (GI) practices.

While the central goal for PWD is to use GI to reduce combined sewer overflows (CSOs), urban stakeholders are also hoping to see this investment provide jobs and job-training, reduce heat island effect, beautify neighborhoods, and raise property values (Travaline, Montalto, & Hunold, 2015). Globally, GI is increasingly discussed as an urban adaptation strategy, and particularly as a means of reducing flood and health risks due to both climate change and increasing extent and rate of urbanization, and associated environmental risks (Zhou, 2014). GI is often viewed as a potential leveraging opportunity. Infrastructure investments mandated by the regulatory pressure to control CSOs are seen as an opportunity to also help revitalize residential communities, restore urban ecosystem function, adapt to changing climate conditions, and create green jobs, among other ancillary goals collectively referred to here as sustainable redevelopment.

However, as the GCCW program was structured at the time of this study, the likelihood that GI would be able to promote widespread sustainable redevelopment in many of the city's struggling residential neighborhoods appeared low. For one, cost factors limited the spatial extent of GI that will be constructed in the public right-of-way. The City's goal was to use GI to manage the 2.54 cm (one inch) of runoff from 47% of the directly connected impervious areas within the city's combined sewer service areas, leading to the use of GI to treat runoff from 3,870 hectares (9,564 acres), citywide[1]. However, given current and projected future average GI costs in the public right-of-way (>$250,000/GA [green acre] and $120,000/GA, respectively), PWD appeared unable to self-fund all of the required GAs that needed to be installed across the City using streetscape GI (Christopher Crockett & Marc Cammarata [PWD], personal communications, 2012).

Second, although a variety of carrots and sticks incentivized GI implementation on private property, these programs mostly targeted large and non-residential properties (Valderrama & Davis 2015). PWD's innovative *Parcel-Based Billing and Stormwater Credits* programs, for example, charges a stormwater fee to each non-residential parcel based its gross area and impervious area. Non-residential property owners have the option to reduce or eliminate this charge by installing GI. PWD's current Stormwater Code specifies that all earth disturbances in excess of 1,394 m^2 (15,000 ft^2) manage the first 2.54 cm of runoff, effectively incentivizing GI implementation for large redevelopment projects (PWD, 2014). This requirement, however, will not lead to incorporation of GI into the redevelopment situated on the more common, smaller lots that predominate in Philly's residential neighborhoods. The presence of privately owned vacant land is particularly important to prospects of GI (Montalto et al., 2012; Travaline et al., 2015), and this factor is ever evolving over time due to redevelopment. As sites are developed, GI opportunities may be lost.

1.2. Neighborhood Context

Starting in 2009, the project team began investigating the challenges associated with implementation of GI in Point Breeze (population 23,585), a 1.75 km^2 residential neighborhood of South Philadelphia (see Figure 1).

Given its proximity to Philadelphia's Center City, Point Breeze faces intense redevelopment pressure, and concerns about gentrification are common among the long-term residents. Most of the area was originally developed during the second half of the nineteenth century, and the neighborhood has historically been comprised of middle class and working class families. Like many other older sections of Philadelphia, Point Breeze experienced decline after World War II due to a waning manufacturing sector, overall population loss, and aging infrastructure. In 2000, roughly one-third of households were below the poverty line. More than 80% of the population is African-American.

Since 2000, community development experts have observed the onset of gentrification trends in Point Breeze, signaled by the scale, speed, and price point of new construction and the target audience of new businesses. Income levels and property values have grown most notably in the northern portion of the neighborhood, where demographic data reveals increases in white residents and residents with college degrees (Philadelphia Research Initiative, 2016).

Meanwhile, long-term residents of Point Breeze experience ongoing barriers to living wage employment such as limited educational attainment and criminal records. Accordingly, traditional workforce development training programs are of little help to many, and local stakeholders have expressed the need to develop a trained urban "green collar" workforce to meet the present and future employment demands of the steadily emerging environmental business sector (Conrad, 2009).

The extent to which residents experience ancillary benefits or improvements in neighborhood livability from the GCCW program is assumed to be directly proportional to the density of GI facilities that are installed. Achieving a meaningful density of GI in Philadelphia's struggling residential neighborhoods thus requires the development of new and creative strategies for fostering GI implementation on the types of land present in these particular communities, through alternative financing mechanisms and the forging of new forms of relationships between the City, the community and the private sector.

2. Project Goals and Methods

The general study goal was to investigate how GI programs in Philadelphia can be customized to take max-

[1] PWD defines the term "greened acre" (GA) as a region of 4,047 m^2 (1 acre) over which 2.54 cm (one inch) of runoff have been treated with GI.

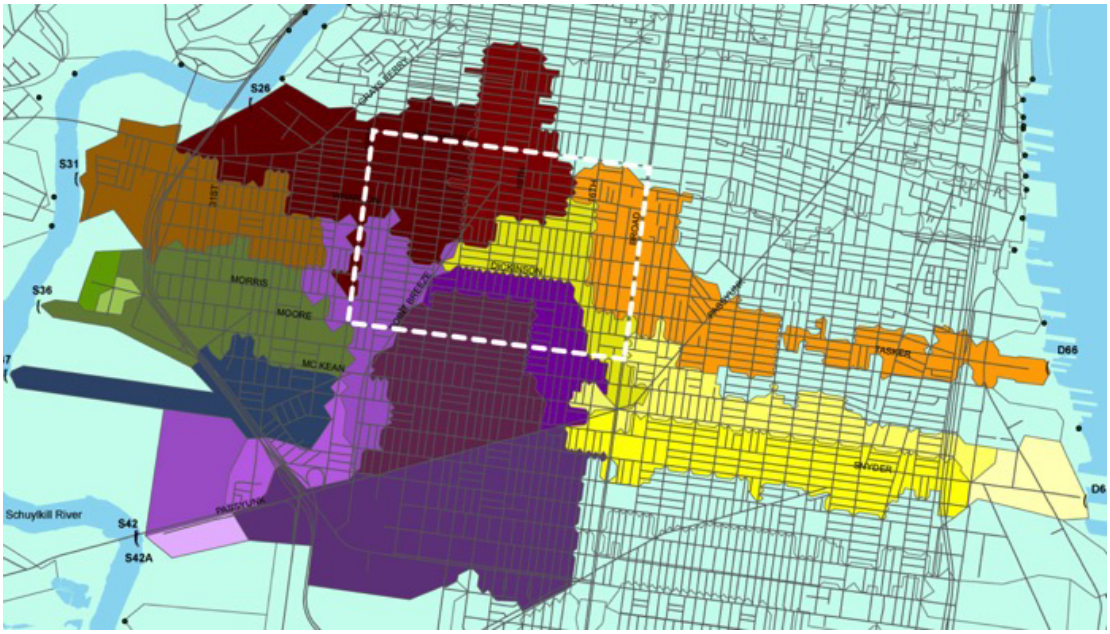

Figure 1. The Point Breeze neighborhood, with CSO drainage areas.

imum advantage of the opportunities presented by individual neighborhoods and their residents, thus promoting sustainable redevelopment. Focusing on Point Breeze, the team performed a detailed study of physical, social, legal, and economic conditions over the course of several years. This process included a physical site analysis, summarizing key features of development and planning in Point Breeze, an outreach effort to identify and summarize key features of GI technologies and programs that could be implemented, a legal study investigating issues associated with moving stormwater across property lines, and the creation of a database tracking GI cost, performance, and site applicability factors derived specifically for Point Breeze. The results of these various analyses are reported in detail in Travaline et al. (2015). In this study, we utilize these empirical results to develop an agent-based simulation of GI build out in Point Breeze. This simulation is used to evaluate the extent to which GI offers an opportunity for sustainable redevelopment.

2.1. Agent-Based Models for Green Infrastructure

A preliminary version of the Point Breeze agent-based model (ABM) was described in an earlier paper (Montalto et al., 2012), with an adapted and enhanced description of the model provided below. ABMs offer an accessible way for decision makers to assess the sustainability of complex infrastructure decisions by simulating their underlying physical and social factors (Jager & Mosler, 2007). An ABM allows physical and social/cultural environments to be modeled concurrently (Berger, Birner, McCarthy, Díaz, & Wittmer, 2007), and elucidates complex interactions between subsystems (Bah, Touré, Le Page, Ickowicz, & Diop, 2006). Autonomous agents are crafted within an ABM to adhere to a set of behavioral "rules". Agents may "learn" based on changes within the system, or their behavior may remain fixed. The agents interact with one another as well as their environment, patterns emerge, and the system itself evolves. In this way, ABMs are used to explore the roles that dynamic processes play in shaping the "emergence" of a particular outcome.

Although ABMs are useful as a predictive tool, their unique value is to explore relationships between heterogeneous agents and agent classes (Grimm et al. 2010). ABMs can be used to test whether a theory will produce its expected result, such as how a policy proposal might change behavior within a population. In this way, ABMs are a powerful tool for developing simulations that incorporate social science theories into representations of physical systems (Moss & Norling, 2006), and supporting decision-making by rapidly testing alternate solutions to a given problem (Voinov & Bousquet, 2010). Although many water-related ABM studies are described in the literature (Barthel, Rojanschi, Wolf, & Braun, 2005; Berger et al., 2007, Davis, 2000; Fagiolo, Moneta, & Windrum, 2007; Tillman, Larsen, Pahl-Wostl, & Gujer, 2005), efforts to apply this modeling approach to GI are fairly new.

As described in Montalto et al. (2012), the Point Breeze ABM has been used to explore the spatiotemporal emergence of rain gardens and green roofs in Point Breeze under scenarios involving economic self-interest, physical compatibility of GI with lot characteristics, and additional insights into the possible behavior of property owners. In this article, a revised and enhanced version of the model is used to compare different GI implementation strategies in terms of a) whether PWD's GA goals could be met in a timely manner in Point Breeze, b) what kinds of assumptions regarding participation and adoption would be necessary to achieve the GI implementation achieved as a result of different theoretical GI policies, and c) the extent to which GI could promote sustainable redevelopment in Point Breeze.

2.2. Model Overview

The ABM was programmed in *Netlogo*. In the model, implementation of GI by public agencies and private landowners in Point Breeze is simulated over a 30-year project timeframe. At each quarterly time step, public agencies and owners of single family residences decide whether to adopt GI options that are physically feasible on their properties and within their budget. On any given time step, GI adoption is physically constrained to those tax lots and public spaces with sufficient area to house the GI, and where synergistic activities such as roof replacement or street milling/reconstruction are currently occurring. The model steps through 30 years of simulation, updating the inventory of GI projects and the perception of PWD and private land owners at the end of each quarterly time step.

Because an overarching goal of the modeling effort was to evaluate the importance of interacting spatial, temporal, social/institutional, and economic dynamics, we elected to not simulate any of the hydrologic or hydraulic phenomena typically included in municipal GI modeling efforts. Instead, we assume that all instances of GI implemented in the simulation are sized to be able to store a volume of stormwater equivalent to 2.54 cm, the capture standard at the time of the research, multiplied by the area of their assumed catchment areas. However, using typical GI design standards as a guide, we have established limits on the size of individual GI systems, and constraints on their placement. For example, the total depth of excavation for stormwater bump-outs is limited to 1.5 m, to minimize labor-related compliance activities during construction. Setbacks of 1.5 m from building foundations are assumed for all private property GI. Depressions are limited to 0.3 m to avoid the creation of trip hazards.

The aggregate neighborhood percentages are presented in a time series chart. Although the ABM can theoretically be programmed to output a wide range of model metrics, for this study, we have elected to present two different types of outputs. First, we present the percent of each block greened at the end of the 30-year simulation period (i.e., the percent of directly-connected impervious area on each block over which the first 2.54 cm of runoff is controlled for each year of the 30-year simulation). The aggregate neighborhood percentages are presented in a time series chart. Then, we show the net greened acreage associated with each type of GI implemented in each simulation.

3. Model Development

Three different GI program scenarios were modeled. The model runs relate to three different types of GI implementation, per PWD's December 2011 Adaptive Management Plan. These include: a) PWD-initiated GI, b) GI linked to public infrastructure projects, and c) private GI. The differences between the three different model scenarios are determined by whether or not the features summarized in Table 1 are turned "on" or "off". In the model, all scenarios are cost equivalent and constrained by available funds.

3.1. Selection of Agents

The process used to select particular classes of agents to include in the model, and to assign individual attributes and behavioral rules to them involved a variety of widely recognized (Smajgl, Brown, Valbuena, & Huigen, 2011) empirical methods such as surveys, interviews, seeking expert knowledge, and participant observation. The results of these efforts are summarized in Travaline et al. (2015). This outreach effort suggested local perceptions if GI were many and varied, and future interaction between PWD and the community will likely change them further. In the ABM, such preferences can be dynamically adjusted. For example, the GI cost-sharing relationships

Table 1. Features alternatively toggled "on" of "off" in the model runs.

Feature	Description
Use of publicly owned, corner, vacant lots for infiltrating runoff generated within the census block.	This is an extension of PWD-initiated GI program that essentially would allow PWD to treat runoff originating on private property, but that relies on back alleys for conveyance.
Use of interior, and corner, vacant lots owned and managed by a private GI Banking and Credit Program for infiltrating runoff generated within the census block.	This is a scenario wherein a private third party is allowed to purchase and use privately owned vacant land for managing stormwater, also relying on back alleys for conveyance.
Implementation of a Raincheck program, whereby the cost of private GI (e.g. rain gardens and green roofs) is subsidized by 80% by PWD.	This is an additional incentive for GI on private property.
Implementation of a Community-Assisted Maintenance Program for engaging the local community in operation and maintenance (O&M) for nearby GI.	This program is indirectly associated with private GI adoption, since the assumption is made that by engaging the local community in the O&M of GI, they will develop a more favorable opinion of GI and be more likely to adopt themselves.

that evolve between PWD and other city agencies can be changed in time, as can private property owner GI adoption rates, in response to the shifts in public opinion that could occur as GI becomes a more common.

Following the framework and nomenclature introduced by Smajgl et al. (2011), agent-classes were identified principally from expert knowledge, the interviews, and participant observation. Agent attributes were devised based on surveys, census data and geospatial information collected by the project team.

Three principle agents are included in the model: the water utility (PWD), local community organizations, and property owners. The rules governing PWD's actions were derived from PWD's Implementation and Adaptive Management Plan with some modifications as described below. Property owner and community organization agents were assigned to the appropriate agent type using geospatial and downscaled census data. Disproportionate up-scaling using Monte Carlo approaches were used to initialize attributes of the entire population of these agents from the samples associated with the empirical work.

Initial conditions with respect to the age of a property owner's roof, property owner income, property values, tenure status (renter v. owner-occupied), and community organization membership for all tax lots were generated randomly at the outset of each simulation from the map data and community-derived data. It is assumed that there was no extant GI in the study neighborhood at the beginning of the simulation. However, we count undeveloped green space as among the GA present in the neighborhood, meaning that conversion of vacant lots to buildings is a loss of GA.

Owner occupancy and mean household income were assigned for each property based on random values drawn from the distribution of owner/renter occupancy status and income values reported for the respective census block group. Each property located within one of the geographic districts of interest to the community organizations was also assigned a probability of membership based on the number of members purported by the organization, divided by the number of properties in the area of interest. As an initial condition, each property was also assigned a residual useful roof life drawn from a uniform distribution with a minimum of 0 months and a maximum of 360 months. This residual roof life is reduced as time progresses in the model.

The initial conditions of the model were verified and calibrated by comparing histograms and descriptive statistics (minimum, maximum, mean and standard deviation) of specific parameters generated by the model (household income, roof age, proportion of properties rented per block) with actual GIS and spatially explicit census data.

3.2. Scheduling of Agent Decisions and Actions

Different agent decisions and actions take place at quarterly and yearly intervals. A summary of agent decisions and actions is presented in Table 2.

Table 2. Schedule of recurring events in the Point Breeze ABM.

Occurrence	Events in ABM
Annual	PWD learns about exogenously scheduled public infrastructure projects such as street projects, school projects, and park projects that can include a GI component.
	PWD updates its list of upcoming self-initiated GI projects.
	PWD establishes an annual budget for GI construction and O&M based on the number of GA implemented to date.
	PWD increases water and sewer rates at 6.5% per year.
	Annually, the GI Banking and Credit Program (BCP) sells its credits to PWD customers from outside of Point Breeze who elect to purchase GI credits in lieu of onsite stormwater management, at a profit.
Quarterly	If Raincheck program has been implemented, PWD acquires knowledge about funded requests for Raincheck program over the previous year.
	If publicly owned corner vacant properties are being used for stormwater management, PWD identifies all projects it can afford during this quarter.
	If Raincheck program has been implemented, PWD acquires knowledge about funded requests for Raincheck program over the previous year.
	PWD makes GI offers. Collaborating agents respond. GI is implemented. Construction costs are deducted from that year's annual budget.
	PWD updates its database of GI instances and recalculates the % green for each street block and for the neighborhood at large
	Loop back to 1 until the end of the year, then go back to the next annual calculation

Generally speaking, PWD evaluates its outstanding GA goals for the neighborhood (in the model PWD is continually attempting to manage the first 2.54 cm of runoff over 47% of the directly-connected impervious area in Point Breeze), and its remaining annual budget on an annual basis. On quarterly intervals, it generates lists of planned earth disturbances that could be leveraged for GI construction and determines whether the residual amount of its annual GI budget has been depleted. Based on what is left, PWD may make offers to public and private partners, who then decide whether or not to adopt additional GI. The general sequence of PWD decision-making is graphically depicted in Figure 2.

For projects conducted on public property such as sidewalks and parks, the contribution required of public agencies to construct and maintain GI is the difference between the actual cost (unit cost * size of GI) and the PWD leverage (PWD contribution * size of GI). If the PWD offer exceeds the construction costs, PWD is assumed to pay the entire construction cost and the public partner is assumed to pay nothing.

Cost per GA is assumed to decrease somewhat in time as a result of the economic learning curve. See Figure 3 for a graphic representation of this cost calculation.

3.3. GI Sizing Assumptions

A range of assumptions was made in order to size each anticipated GI type for inclusion in the model. Streetscape GI accommodates runoff from the street,

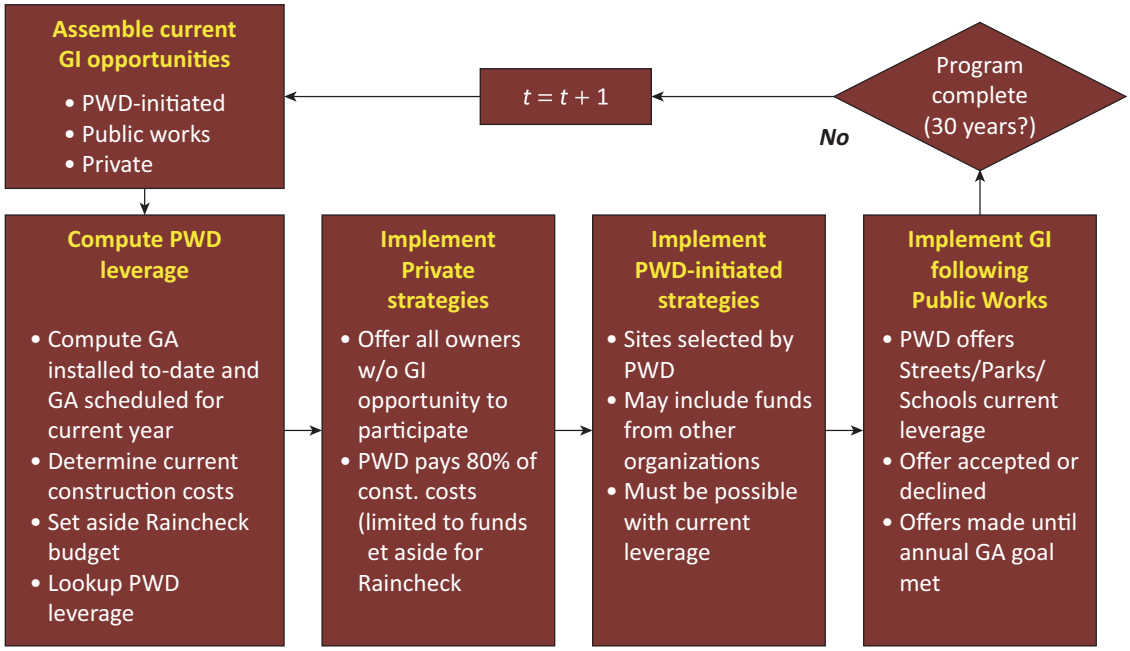

Figure 2. Flowchart depicting PWD's decision-making model.

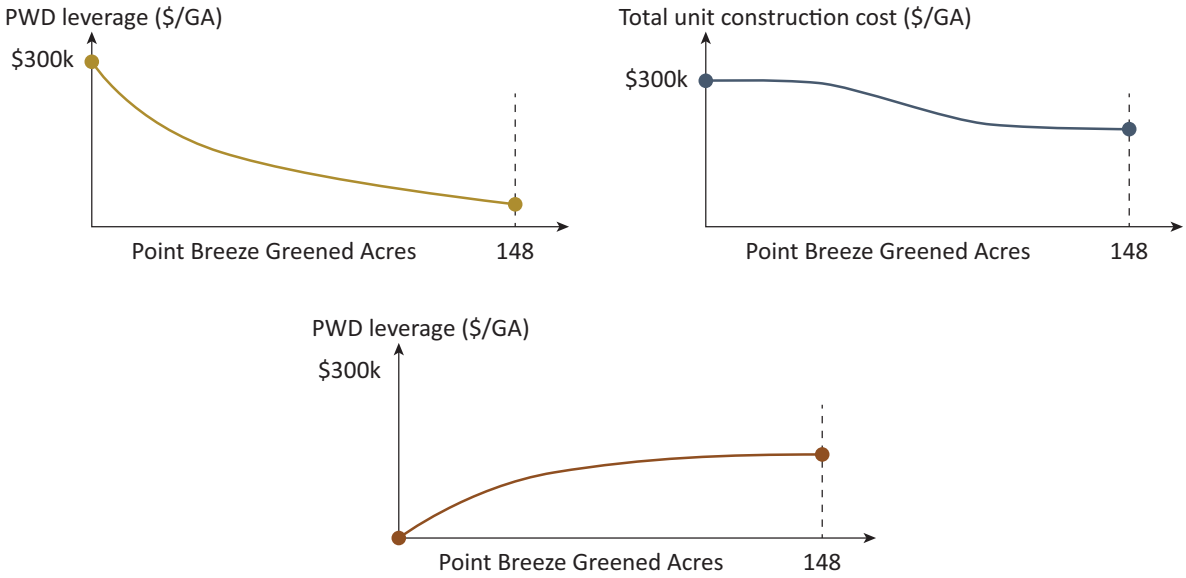

Figure 3. Calculation of PWD's leverage amount.

the sidewalks and any downspouts routed to the fronts of houses. Streetscape GI comprised of a combination of stormwater bump-outs, parking lanes with pervious pavement, and stormwater tree trenches.

The stormwater bump-out design is based on traffic and parking requirements, and its dimensions and stormwater storage capacity are fixed. One bump out is built per street segment, assuming flow is only in one direction for a given street segment. If the bump out does not have sufficient capacity to accommodate one half of the street's runoff, pervious paving is added to the parking lane to make up the difference. Pervious pavement is built in the parking lane only and can be built to the ends of the road segment, although from a cost perspective, the spatial extent of pervious paving should be kept to a minimum to reduce excavation and disposal costs.

Stormwater tree trenches are built to accommodate the runoff generated on the side of the street opposite the bump out. We assume that, given the relatively narrow streets in Point Breeze, bump-outs on both sides of the street are rarely feasible due to space limitations. Stormwater tree trenches are constructed with a minimum ∼4 m setback from street segment ends. This results in engineered tree pit lengths typically in increments of about 8 m. The trenches themselves are assumed to be about 1 m wide so as not to impede sidewalk traffic, and are not set back from the curb, since parking is assumed on the bump-out side of the street only.

A variety of GI options occur on private property in the model. These can be generally classified as rain gardens and green roofs. In some cases, the rain gardens are placed on vacant parcels and runoff from roofs within the census block is routed there through back alleys.

In the model, PWD offers private property owners a one-time $100 credit towards their water bill to install a rain garden. In contrast to the green roof program (described below) which kicks in when owners undertake regular roof maintenance, PWD would cover the entire life cycle cost of the rain gardens and offer the $100 credit because there is otherwise no motivation for individuals to make any such modifications to their backyards. The monetary incentive was inspired by the successful Portland, OR downspout disconnection program, which offered a similar one-time financial incentive to property owners who agreed to divert their downspouts from conventional drainage systems.

Rain gardens are assumed to be located on private developed lots and on vacant lots, given a variety of different GI policies considered in the model. We assume that the area of a rain garden is the tax lot area × ∼2.5 cm divided by ∼5 cm (corresponding to a ∼5 cm depression, or almost 1 m of engineered soil with 30% porosity), and minimum required setback of rain garden from buildings is ∼1.5 m.

Green roofs are considered viable GI options for properties whose roof area is at least 28m^2, under the assumption that the benefit to the homeowner and to PWD for building a green roof does not justify the cost when the green roof does not capture a significant fraction of the lot runoff. Because there are very few pitched roofs in the study neighborhood, all roofs meeting the size limit are considered viable for green roofs. This assumption does not consider the condition of the house and its ability to support a green roof and may result in some overestimation of the number of properties eligible for a green roof. Owners have the option of adopting green roofs only at such time that the roof is being replaced. Green roofs are implemented through a cost-sharing strategy, based on the incentive program described in Montalto et al. (2007). When the useful life of an existing roof is expired, willing property owners would pay the price of a new conventional roof, but would actually get a green roof, and a commitment from PWD to maintain it as a stormwater management facility for its entire useful life.

3.4. Factors Influencing GI Adoption on Behalf of Private Property Owners

In the model, adoption of GI by private property owners is determined by a variety of factors. Generally speaking, we assume that property owners are influenced by their own experiences with GI, as well as the experiences of members of their social network. We assume that they consider the functionality, aesthetics, and impact of the GI technologies that they encounter in their community.

3.4.1. GI Encounters

Private property owners develop preferences and perceptions about GI based on the GI they encounter directly and indirectly. Directly encountered GI includes GI on the landowner's property, GI on the landowner's block, GI on nearby parks or schools, GI on the landowner's associates' property on neighboring blocks, and GI on transportation corridors and commercial corridors the landowner uses. Indirectly encountered GI includes GI constructed and maintained by associates belonging to groups within their social network.

Landowners value directly- and indirectly-encountered GI differently. Directly encountered GI is assessed based on its functionality, its aesthetics and its impact. In the absence of other information, we assume that neighborhood residents value all directly encountered GI using the same criteria. That is, the importance an individual places on functionality, aesthetics and impact is the same for each directly encountered GI installation.

3.4.2. A History of GI Encounters and Their Impacts

The functionality, aesthetics and impact of each GI installation in Point Breeze are tracked during the ABM simulation of PWD's stormwater program. Each of the features is stored as an index with a value between 0 (no benefit) to 1 (fully providing benefit). An individual's "history"

with directly-encountered GI is calculated and tracked as:

$$\Gamma_{\text{hist}} = \frac{1}{N_{\text{direct}}} \sum_{j=1}^{N_{\text{direct}}} \frac{1}{3}(\gamma_{f,j} + \gamma_{a,j} + \gamma_{i,j})$$

where Γ_{hist} is the historical experience a landowner has with GI (number between 0 and 1), $\mathrm{N}_{\text{direct}}$ is the number of GI implementations the landowner has direct experience with, and γ_f, γ_a and γ_i are the GI functionality, aesthetics and impact indices, respectively. These factors are based on the research team's interaction with the community. Because GI perception is the cumulative experience of Point Breeze residents, the historical experience at a given time step is set equal to the two-year (eight-quarter) moving average Γ_{hist} for each tax lot owner, i.e.,

$$\Gamma_{\text{hist}}^{q} = \frac{1}{8} \sum_{k=0}^{7} \Gamma_{\text{hist}}^{q-k}$$

where q denotes the current quarter (present time).

The functionality of a given GI implementation is dependent upon its upkeep through O&M, as well as random acts of nature or other damage that reduce GI functionality. Although all private GI owners are likely to maintain their GI (since they chose to adopt it in the first place), it is not a certainty. By contrast, it is assumed that GI on public property, commercial establishments and lands maintained by a stormwater management BCP always receive required O&M and function properly. The likelihood that a private landowner maintains GI is dependent on the owner's experience with GI. Owners more positively disposed toward GI (as measured by the owner's instantaneous Γ_{hist} value) are more likely to maintain the GI over which they have control. In this way the GI functionality index for a given GI implementation is represented as:

$$\gamma_f = 0.5 + 0.5 \times \Gamma_{\text{hist}}^{q-1}$$

where $\Gamma_{\text{hist}}^{q-1}$ is the historical experience with GI for the GI owner on the previous quarter for GI on private property and is equal to 1 for GI on public lands or lands owned by the BCP.

GI aesthetics are derived from their design, and are obviously subjective. For this study, GI systems that are specifically designed for public spaces or specifically to enhance residents' experiences (e.g., GI that preserves open or green space) are assigned a positive aesthetic value whereas GI designed purely for functionality (e.g., porous pavement) is assumed to have limited aesthetic value. Values assigned to the different sorts of GI considered for Point Breeze (and several not currently in consideration) are provided in Table 3, and are assumed to be static during the simulation. The authors acknowledge that in actually aesthetic value will vary from person to person and potentially also change in time, and that the values in Table 3 represent a simplification. Future work will seek to better quantify the dynamic and heterogeneous aesthetic impact of GI in Point Breeze.

The impact a GI implementation has on its owner may be environmental, financial, or social. As with aesthetics, the GI impact is a feature of the GI type and assumed invariant over time in this simplified modeling effort. GI impact indices, based on the research team's interaction with this community and others, are listed in Table 4. For each GI type a brief description of the primary impacts anticipated are listed.

3.4.3. GI Adoption Algorithm

Owners of single-family residences differ in their likelihood of adopting GI based on the following attributes: residence status (are they resident owners or landlords?), residence status of their neighbors, household income, their experience with GI, exposure to GI in the vicinity of their residence, and the physical constraints of their property.

Each of these factors was included for predicting the likelihood of single-family residence GI adoption. The model predicts the probability that, on a single time step and with a known incentive from PWD (which may be $0 or more), the owner of a single-family residence elects to build a rain garden or green roof. The probability of adoptions is represented by:

$$P_{\text{GI adoption}} = f_s \times f_w \times f_e \times \Gamma_{\text{hist}} f_k$$

Table 3. Aesthetic indices assigned to Point Breeze GI types.

GI type	Aesthetic index
Transportation corridor GI (high visual impact)	1.00
Demonstration projects (e.g., basketball court)	1.00
School and Park GI	0.75
Green roofs	0.75
Vacant lot stormwater BCP GI	0.75
Curb bump-outs (penalized because some drivers may resent them)	0.50
Engineered tree pits with trees	0.50
Engineered tree pits without trees	0.25
Backyard rain gardens	0.25
Porous pavement	0.25

Table 4. GI Impact indices for GI in the Point Breeze ABM.

GI type	Impact index	Primary impacts
Transportation corridor GI (high visual impact)	0.50	Educational
Demonstration projects (e.g., basketball court)	1.00	Social, environmental
School and Park GI	1.00	Social, environmental
Green roofs	0.50	Environmental, health
Vacant lot stormwater BCP GI	1.00	Social, environmental, economic
Curb bump-outs	0.50	Environmental
Engineered tree pits with trees	0.50	Environmental, economic, health
Engineered tree pits without trees	0.25	Environmental
Backyard rain gardens	0.25	Environmental, economic
Porous pavement	0.25	Environmental

where f_s is a spatial feasibility factor (1 if the property can accommodate the rain garden or green roof, 0 otherwise), f_w is a willingness factor, set such that each owner has a 0.2 probability of adoption GI over the 30 year (120 quarter) simulation, f_e is an economic factor (described below), Γ_{hist} is the property owner's GI history (described above) and f_k is a knowledge factor (described below).

The economic factor assumes that adoption is more likely if the benefit received from implementation is significant in comparison with household income. The economic factor is implemented as a logistic function dependent on a factor, f_e, which is based on household income. At the outset of the simulation each property with land use of "single family" is randomly assigned an income based on the US Census average and standard deviation income for the census block in which the tax lot resides. The logistic function was scaled such that it varies between 0.5 and 0.9 over the range of incomes in Point Breeze:

$$f_e = \frac{1}{1 + e^{-(\gamma - 0.1)/0.152}}; \quad \gamma = \frac{I_{\text{PWD}}}{\text{Income}}$$

where I_{PWD} is the incentive offered by PWD (Model 3 only) and "Income" is the monthly household income.

The knowledge factor takes into account the owner's residency status, surroundings and associations and is calculated as:

$$f_k = \frac{1}{1 + e^{-(x_{\text{lot}} - 2.944)/0.849}};$$

$$x_{\text{lot}} = 1 - r_{\text{lot}} + 2m_{\text{owner}} + \left(\frac{n_{\text{GI}}}{n_p}\right)_{\text{block}} + \left(\frac{n_{ro}}{n_p}\right)_{\text{block}}$$

where r_{lot} is 0 if the property is a rental property and 1 if the lot is owner-occupied, m_{owner} is the number of group memberships of the lot owner, n_{GI}/n_p is the fraction of properties on the tax lot's street block with GI and n_{ro}/n_p is the fraction of properties on the tax lot's street block that are resident-owned. The knowledge function was scaled to provide a probability between 0.03 and 0.97 over the range of values expected for x_{lot} in the Point Breeze neighborhood.

4. Description of Model Runs

4.1. Model 1—Baseline Scenario

This scenario was developed to reflect PWD's most current strategy for GI implementation, as generally represented in the PWD's Implementation and Adaptive Management Plan. In this scenario, PWD funds only GI projects on streets and other public lands, like parks and schools, in coordination with other public agencies. GI on publicly owned vacant parcels and GI on private property are not funded, though private single-family residences may choose voluntarily to implement GI if they have sufficient space. PWD tracks the evolution of GI on private properties, and takes credit for it.

To spatially illustrate some of the GI considered in this study, and more fully flesh out the scenarios generated in the model runs, conceptual design drawings were developed visualize the GI that could be generated given the model assumptions and the scenario results. Conceptual designs corresponding to Model 1 (see Figures 4 and 5) target public surface run-off managed on public property with streetscape GI, the array of stormwater bump-outs, pervious paving, and tree trenches already introduced.

Stormwater bump-outs and pervious paving are located on the parking side of the street, with stormwater tree trenches in the sidewalk along the travel side. All of the street scale GI overflows into the combined sewer. In Model 1, GI could be used as a physical planning tool to establish 'gateways' to residential blocks, improve conditions for pedestrians by minimizing cross-walk distances, and limiting disruption to parking spaces and the interior of the block by targeting work to the first 21.3 m of the residential street.

Through the interior of the block, pervious pavement is used in the parking lane. Paving materials could be distinguished using a clearly defined separator or by using permeable pavement in a contrasting color. Additionally, on streets with "extra" capacity, the stormwater planting zone could be widened and extended into the generous traffic lane and/or a sidewalk.

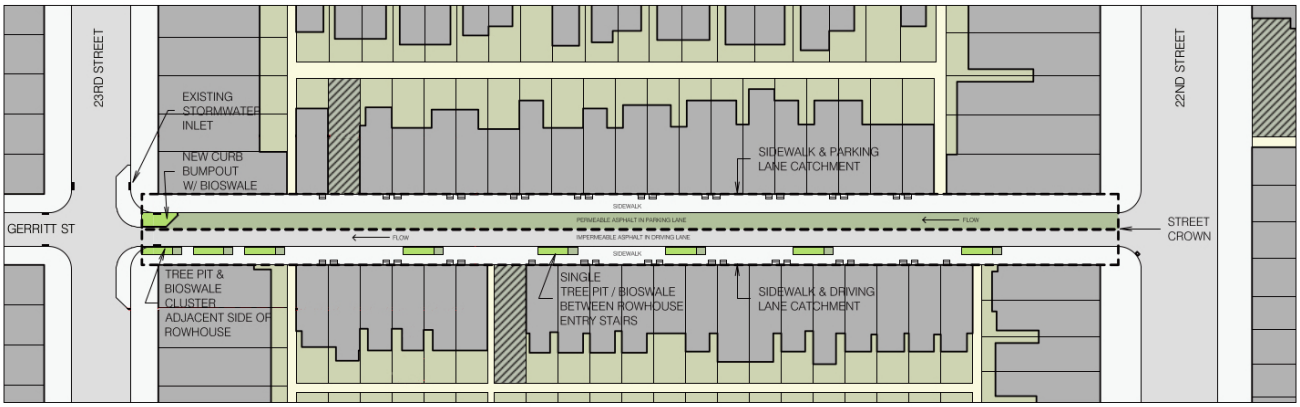

Figure 4. Model 1—Plan view of proposed streetscape GI.

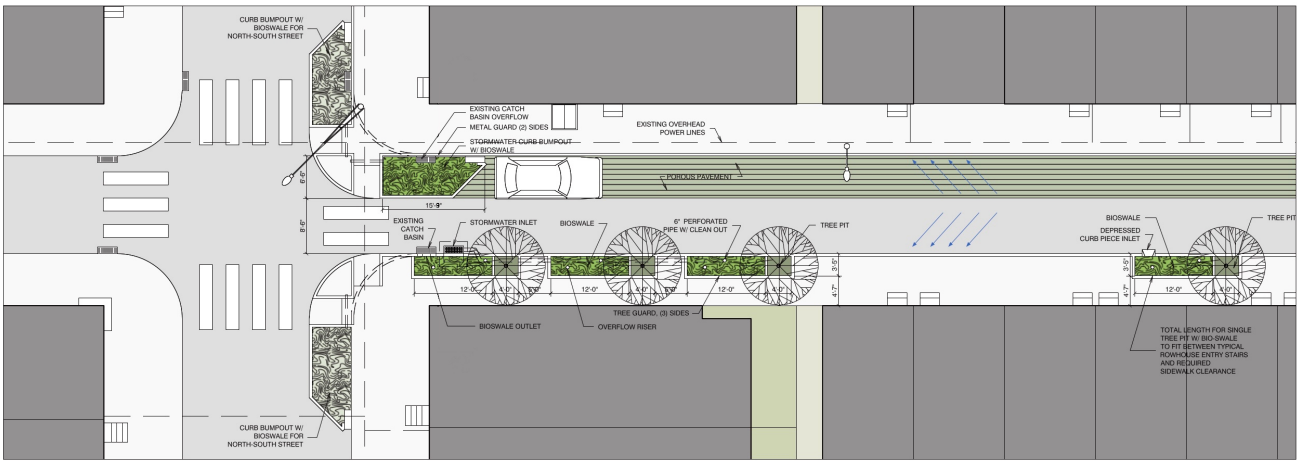

Figure 5. Model 1—Plan view of "gateway" arrangement of GI near the crosswalk and intersection.

4.2. Model 2—Public vacant land alternative

The physical analysis of land in Point Breeze revealed a number of publicly owned vacant parcels of land located at block corners (near stormwater inlets) on blocks with relatively high imperviousness fractions. In Model 2, we allow PWD to convert publicly-owned corner vacant parcels on blocks with at least 836 m^2 of potential private contributing area to stormwater management facilities which, depending on local site conditions, could be rain gardens, infiltration/storage trenches, or stormwater basins (referred to in aggregate as rain gardens). Model 2 also includes all of the public right of way GI strategies, school, and park programs included in Model 1. During a given year, PWD chooses to allocate budget to developing vacant parcels prior to considering GI on streets. As in Model 1, private single-family residences may also elect to build green roofs or rain gardens, but receive no financial incentive from PWD to do so.

The designs for Model 2 (see Figures 6 and 7), combine public and private surface run-off for infiltration/storage on public property. A common block type in the neighborhood has a large open parcel and multiple smaller, relatively equal-sized residential parcels. In this design, stormwater is conveyed from the residential rooftops and rear yards via the modified internal alley to a rain garden and on to an infiltration/storage 'trench' beneath the large parcel, in this case a new basketball court. The infiltration/storage trench also, accommodates stormwater from the public parcel itself. With the addition of the some or all of the GI suggested in Model 2, it is possible to accommodate public street and sidewalk run-off and to consider sizing the infiltration/storage trench for additional public stormwater (from adjacent streets and sidewalks) and from cross-street inner-alleys, as alley termination locations permit.

4.3. Model 3—Private Vacant Land Alternative PLUS

Because so much of the land area of Point Breeze is privately owned, Model 3 was developed in an attempt to characterize the potential of GI on private property. This was initially accomplished by adding to the GI strategies of Model 2 four new dynamics in Model 3: the *Raincheck* program, *Transportation Corridors* program, *Community-Assisted Maintenance* program, and *GI Banking and Credit* program (BCP).

In Model 3, the Raincheck program subsidizes up to 80% of the costs associated with green roofs and rain gar-

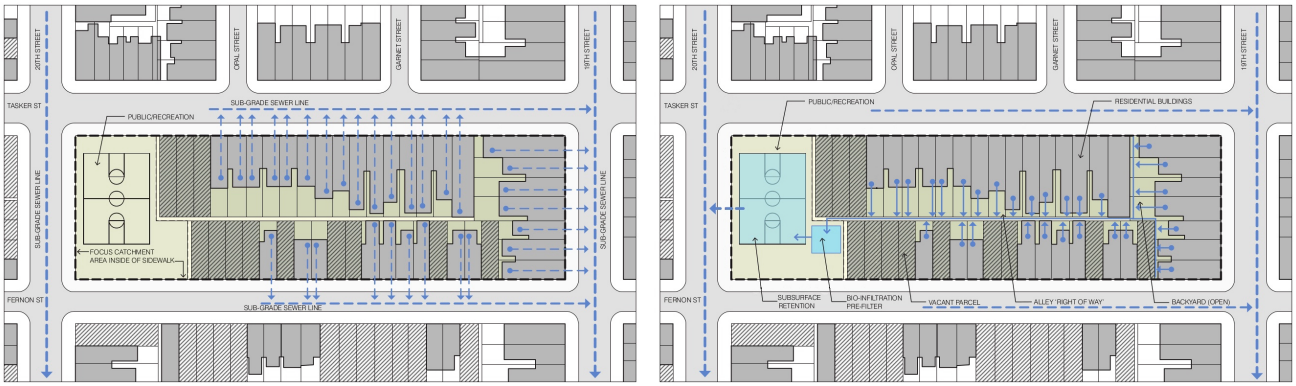

Figure 6. Model 2—Plan view of catchment area and existing drainage (left), and proposed GI (right).

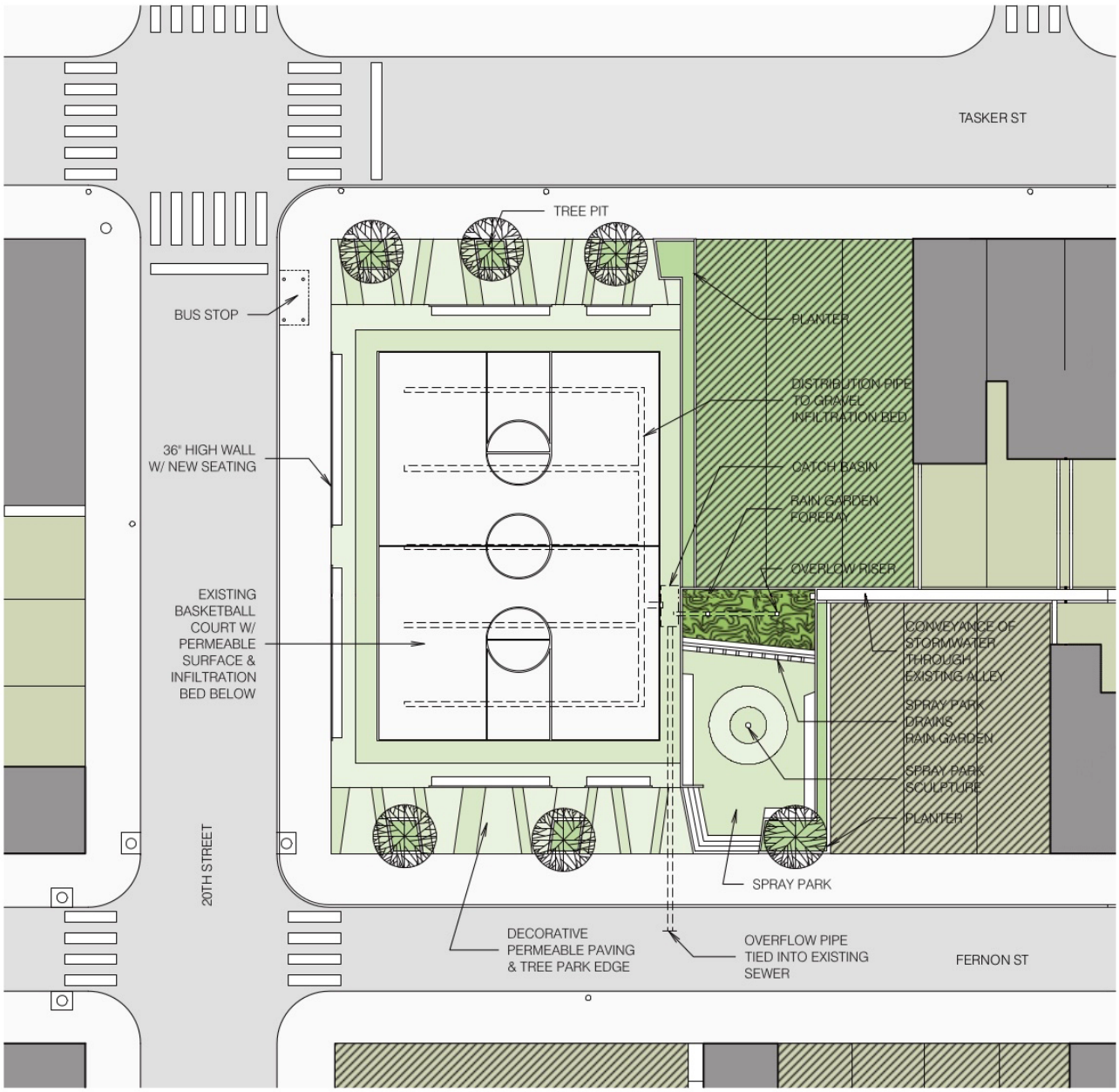

Figure 7. Model 2—Plan view of block-end parcel detail, including a central rain garden and permeable ball court.

dens on private land. Note that this policy differs slightly from PWD's actual Raincheck program, developed after this research was completed. These differences are discussed below. Under the Transportation Corridors program, PWD preferentially installs public right-of-way GI near transportation corridors (e.g., bus stops) over other street locations. This has a significant impact on Γ_{hist} since private property owners come into contact with these GI installations more frequently than they do other GI installations in less heavily trafficked sections of the neighborhood. The Community-Assisted Maintenance Program assumes that PWD engages community-based organizations to provide O&M for GI on public lands (excluding GI on streets). If performed through the Community-Assisted Maintenance Program, O&M costs are assumed to be a fraction (75%) of market rate. Finally, the BCP allows privately owned vacant lots to be reconfigured for stormwater management, and credits to be sold throughout the city, not unlike the stormwater credit program in Washington D.C. (Department of Energy & Environment [DOEE], 2013).

The design for Model 3 (see Figure 8) emphasizes the potential role of private vacant land, with a focus on utilizing single corner vacant parcels or on two adjacent parcels located near alley ends. Internal parcels may be designed in combinations of two or three, as building setbacks for GI typically take up useable area on single lots and a larger number of aggregated parcels may have higher value for construction purposes.

According to input from residents, the corner lots are seen as valued locations for small parks. Vacant corner parcel locations may also add significantly to the capacity of stormwater bump-outs and stormwater planters and by design, green intersections. Selected locations for higher-value corner lots may be aligned with transit corridors. One example of this concept is Point Breeze Avenue, a distinct diagonal and historically active commercial street, that could possibly benefit from spatially redefining the street into distinct and connected destination areas, focused on stormwater management 'parks' and taking advantage of the triangular parcels formed by remnant geometry.

A goal of this conceptual design is to envision a physical, social and economic network for stormwater management facilities that can be tied together at multiple scales in order to achieve PWD goals, and foster community revitalization and sustainable redevelopment.

After running Model 3 with all of these new dynamics and performing a sensitivity analysis, it was determined that incorporation of the Raincheck, Transportation Cor-

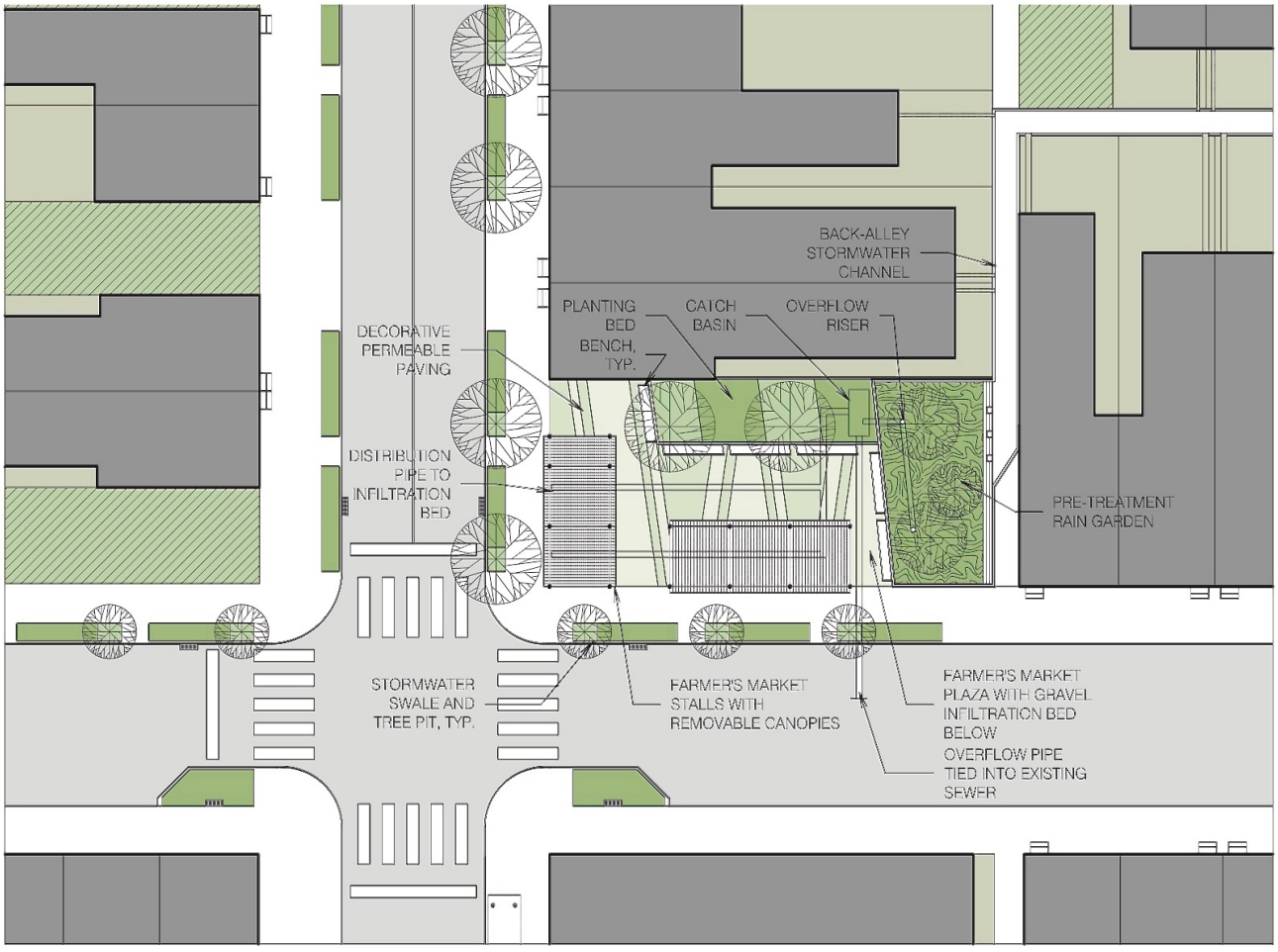

Figure 8. Model 3—Conceptual design for corner lot.

ridors, and Community-Assisted Maintenance programs minimally changed the results beyond those obtained from Model 2. The most influential change was the BCP, which is described in greater detail below.

4.3.1. The GI Banking and Credit Program (BCP)

Approximately three quarters of the vacant parcels of land in Philadelphia are privately owned (Philadelphia Redevelopment Authority, 2010). If some means of encouraging the management of stormwater of GI on private land could be developed, the goal of merging vacant land revitalization efforts with stormwater management could be significantly advanced. In Model 3, we allow a third-party GI banker to purchase privately owned vacant land in Point Breeze, reconfigure it to manage stormwater runoff originating on other private parcels within the same census block, and then sell the credits to developers and property owners from anywhere in Philadelphia, as compensation for the stormwater runoff implications from either new developments, or existing commercial and institutional developments subject to PWD's impervious billing policy.

This strategy incentivizes stormwater management on private properties, an important stormwater "sector" that is not currently addressed in PWD's Implementation and Adaptive Management Plan. A BCP is a means by which PWD and the City of Philadelphia can leverage vacant lands for meeting stormwater management goals (and realizing other benefits) without acquiring these lands. Moreover, it would create a market for private lands committed to stormwater management. Different uses of vacant land present trade-offs for PWD, neighborhood residents, and developers. The trade-offs faced by each of the groups is outlined below in Table 5.

A plot showing the expenses and income of a hypothetical BCP is presented in Figure 9. The bank begins with acquisition of vacant land at market prices and construction of stormwater management facilities. At present, vacant land is relatively inexpensive in parts of the Point Breeze neighborhood and it is assumed the PWD would be willing to contribute substantially to construction costs. PWD's willingness to contribute to a BCP is related to its need to utilize vacant land for stormwater management and its confidence in the success of a BCP as a sustainable partner for ongoing stormwater management in Point Breeze and beyond. Once the vacant land is developed for stormwater management, "credits" for stormwater management up to the capacity of the stormwater controls on the banked land are sold to commercial landowners, developers, and others with incentives or requirements for retaining/infiltrating stormwater. As depicted in Figure 4, the sale of stormwater credits must be sufficient to cover land acquisition, construction and O&M costs minus the contribution that PWD or another interested organization makes toward costs and to generate revenue. Consistent with PWD's adaptive strategy for implementing GI over the 30-year program, it is assumed that PWD will be most willing to contribute to construction costs on GI bank lands at the

Table 5. Value of vacant land to different interest groups.

Interest group	Benefits of vacant land use for GI	Liabilities of vacant land use for GI
PWD	Use of vacant land may be necessary to meet directly connected impervious areas targets	May not want to become landowner of vacant land as GI reduces number of rate- paying customers
Neighbors	GI on vacant land may provide environmental, aesthetic and social benefits to neighbors	Reduces opportunity for development the community desires such as affordable housing
Developers	Opportunity to meet stormwater requirements for new construction	Vacant land not available for development

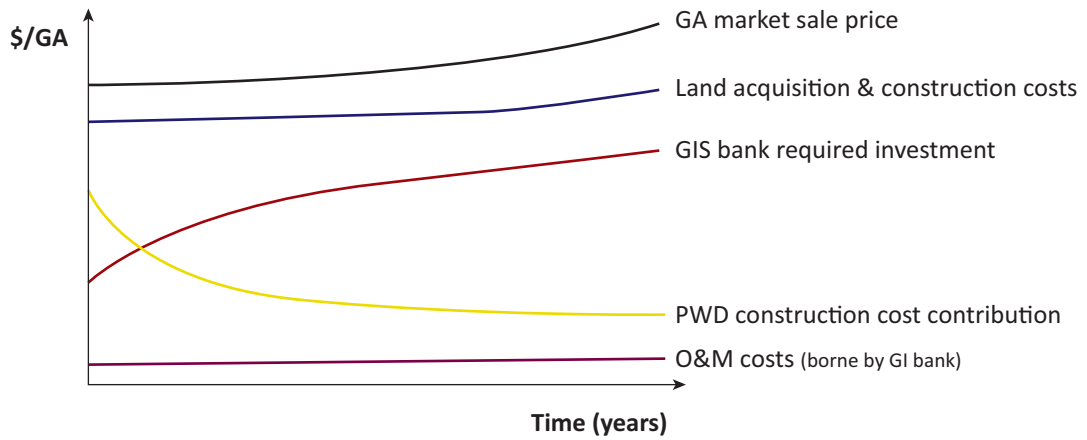

Figure 9. Economics of the BCP.

model outset and will less willing over time, as the GI bank is expected to become a sustainable entity.

It is worth noting the following assumptions are made in simulating a BCP in the Point Breeze ABM. In Model 3, the BCP is assumed to have enough capital to purchase and develop 5 vacant lots at the project outset, PWD is willing to contribute 100% of GI construction costs, and there are always individuals willing to buy stormwater credits at the market rate (the bank has an infinite market). It is also assumed that, at the project outset, the GI credit value is set equal to the land cost + construction cost + 30-year O&M cost (including rate escalation) + 10% profit margin for the GI bank, and the GI bank buys additional vacant land as soon as it has sufficient capital available.

4.4. Modeling Results

Figure 10 presents the time evolution of GA in Point Breeze as predicted by Models 1, 2, and 3. The grey areas in the charts represent the range of possible GA outcomes obtained in all 120 stochastic ensemble runs of the 30-year sequence. The median predicted GA values for each year are shown with a line.

Though models 1 and 2 arrive at a similar overall mean percent GA, there is more uncertainty in Model 2, and only Model 3 suggests the possibility that the 47% goal can be approached.

Figure 11 depicts the net new greened acres associated with each of the types of GI strategies that are implemented in the model. Streetscape GI will account for a large percentage of greened acres in all three models. However, in Model 3, the private vacant land strategy is likely to produce even more greened acres.

5. Discussion

Our modeling suggests that is unlikely that Philadelphia will meet their stormwater management goals unless PWD gets innovative regarding the management of stormwater originating on private land. As the GCCW program is currently structured (Model 1), it does not achieve the 47% goal at the neighborhood scale in Point Breeze. Model 2 represents only a marginal improvement in results over Model 1 simply because there are not many corner publicly owned vacant lots available in Point Breeze, relative to the total land area. A comparison of Model 1 and Model 2 also reveals greater vari-

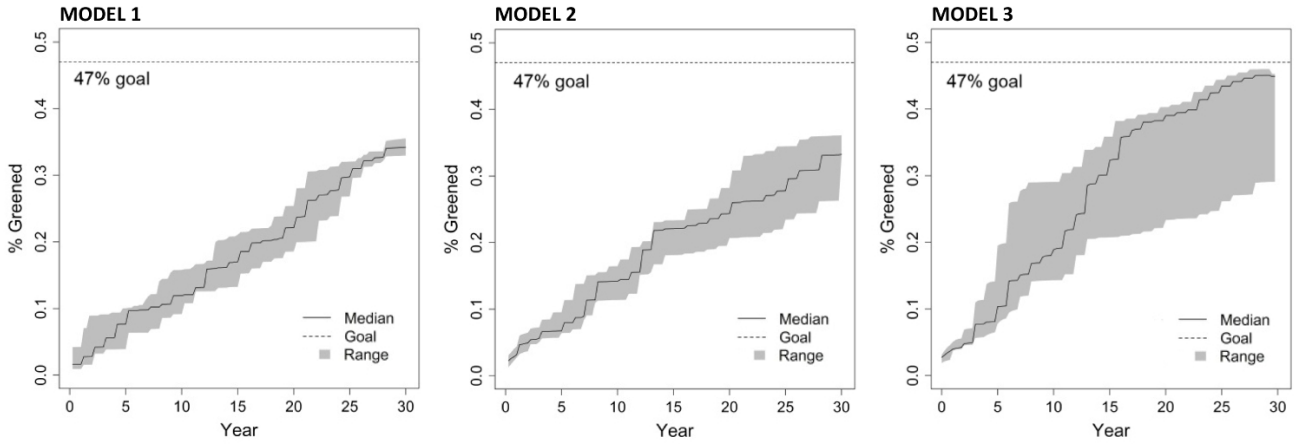

Figure 10. Results of model runs in terms of greened acres over time.

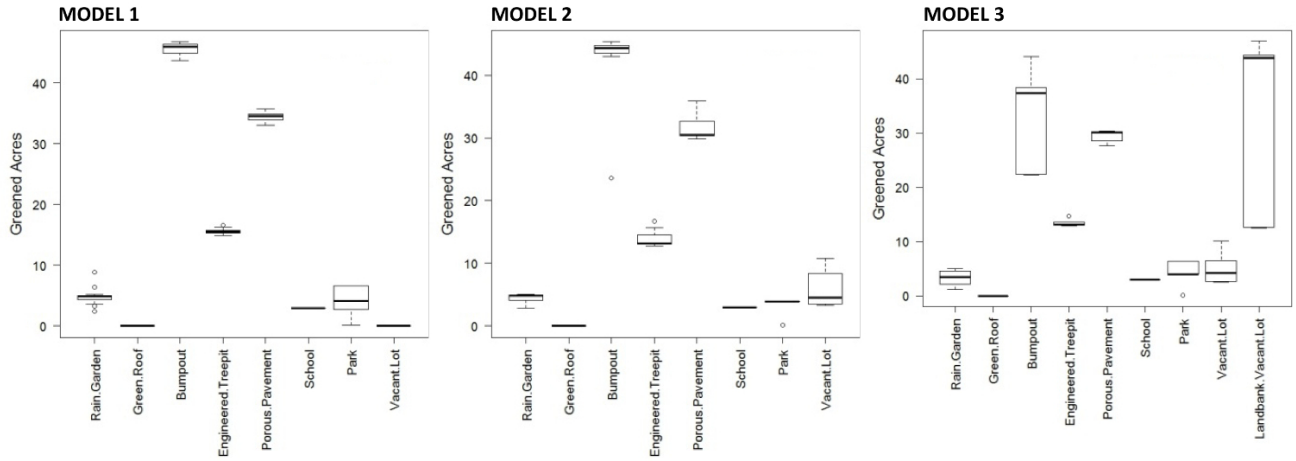

Figure 11. Results of model runs in terms of net greened acres after 30 years, by GI type.

ability in the results of Model 2 after 30 years. This finding is attributed to the path dependency associated with early GI decisions. If these decisions tend to favor more cost-effective GI (e.g., involve corner vacant lots), there is more money available in the long term for GI implementation and the number of GA generated is greater. If, on the other hand, early GI installations are less cost effective, less GA ultimately gets built. More options create more variability in the results.

Model 3 gets the closest to the 47% goal for Point Breeze, underscoring the importance of working with private landowners in helping PWD achieve its GI goals in this neighborhood. After 30 years, there is still great potential variability in the results (demonstrating the same path dependency described above), but the fact that the median net GA is near the upper end of range demonstrates that the GI bank played a key role in most of the model runs.

Streetscape GI strategies (bump-outs, tree trenches, and permeable pavement) will account for a large percentage of GA in all three models. Because these results are contingent upon assumptions made about how PWD works with partners, PWD's evolving collaboration with the Streets Department is thus considered to be of high value.

Clearly, the private vacant land strategy in Model 3 has the potential to produce the most net GA. In fact, trends since the completion of this work indicate an expanding interest in tailoring policy to incentivize GI installation on private land. Philadelphia has since launched several promising initiatives, including its *Raincheck* program, which directly offsets the cost of certain residential GI; the *Greened Acre Retrofit* Program, which provides funding to project aggregators who can build large-scale GI across multiple properties; and the *Stormwater Management Incentive Program*, which provides grants for GI on non-residential private lands.

Although private rain gardens occur (especially in Models 1 and 2), they do not make up a large percentage of the new GA that will appear in Point Breeze. Though these initiatives carry great value by helping to engage the community, it may be useful for PWD to seek opportunities to engender greater community support for streetscape GI, since these technologies will go much further towards achieving its stormwater management goals.

The ephemeral effect of neighborhood organizations is noticeable, but disappears by the end of the simulation. These issues are not reported here, but are the subject of a separate paper (Montalto et al., 2012).

6. Conclusions

This study investigated three ways that PWD could implement GI in Point Breeze, in an effort to achieve its goal of 47% GI coverage at the neighborhood scale. We note that, to our knowledge, the city's legal obligations do not specify any requirement regarding the spatial density of GI across the city, meaning that if GI were concentrated at higher densities in some neighborhoods, lower densities would likely be allowable in other areas, as long as the 47% goal is achieved citywide. This said, the modeling effort suggests that programs that incentivize GI on vacant private land represent a potentially significant regulatory compliance strategy for residential neighborhoods like Point Breeze. Specifically, the proposed GI banking mechanism would allow stormwater management on private land to be marketed city wide, significantly advancing GI penetration beyond the level feasible using only publicly-owned land, including in the right of way.

Comparable market-based regulatory strategies have been proposed or are in operation as a means of improving air quality (Napolitano et al., 2007), climate change (Ellerman & Buchner, 2007; Freeman & Kolstad, 2006), water quality (Hamstead & BenDor, 2010; Lal et al., 2009; Mariola, 2012), impervious surfaces (Welty et al., 2005), fisheries (Annala, 1996), and wetlands (NRC, 2001). In 2008, the U.S. Department of Agriculture established an Office of Environmental Markets for carbon sequestration, water quality, wetlands, biodiversity, and other ecosystem services.

This research suggests that a similarly structured approach for trading GI credits could help Philadelphia comply with water quality regulations, and the same conclusion appears to be emerging in other locales. For example, in 2013, Washington D.C.'s Department of Energy and the Environment created a Stormwater Retention Credit program to support compliance with new stormwater rules. Property owners may offset up to 50% of their onsite retention requirement by generating Stormwater Retention Credits either by installing GI on self-owned offsite properties, or by purchasing credits that are generated on properties that exceed their own regulatory requirements or voluntarily installing GI. This program is expected to achieve higher retention volumes throughout the district, and could result in a greater number of smaller GI investments going after the low-hanging fruit of "first flush" stormwater, containing the most concentrated pollutants. Moreover, the off-site provision in this regulation has the potential to prioritize GI investments in less affluent areas (DOEE, 2013).

DC's program is not unlike the program assumed in Model 3, but the final design of this kind of program for Philadelphia would obviously require further study of the values and motivations of the city's residents and property owners. Critical information for policy makers who are designing financial instruments for use of private property owners include the public's willingness to implement GI on private properties (Baptiste, Foley, & Smardon, 2015) as well as both the physical and financial barriers to program delivery (Ando & Freitas, 2011). The engagement reported on in Travaline et al. (2015) is a start, but additional work would elicit input from a larger sampling of the owners of vacant land across the city, accompanied by physical surveying of their location

and the level of effort that would be involved to divert nearby runoff to them.

A final conclusion of this work is the need to act soon to foster a diverse portfolio of GI implementation pathways. Because of the strict timetables associated with many stormwater regulations, water utilities like PWD need to achieve compliance within specific periods of time. A GI plan that replaces regular roofs with green roofs only at the end of their useful life, or that includes a Streets Department pledge to install porous pavement only as part of its ongoing urban repaving efforts will likely "miss the mark". If water utilities are to include GI as an integral part of their infrastructure strategies, they will need some assurance that threshold levels of implementation will be achieved within rigidly defined time frames. This may be approached by continuing to refine how to operationalize sustainability planning concepts to inform this newest investment in the quality and texture of our cities.

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Conflict of Interests

The authors declare no conflict of interests.

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Commentary

Plowshares or Swords? Fostering Common Ground Across Difference

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Abstract
With political polarization challenging forward progress on public policy and planning processes, it is critical to examine possibilities for finding common ground across difference between community participants. In my research on contentious planning processes in the United States, I found four areas of convergence between participants over transportation policy and process related to public process and substantive matters. These convergences warrant planners' attention because they united stakeholders coming from different vantage points.

Keywords
agonism; agonistic ethos; common ground; conflict resolution; sustainability planning

Issue
This commentary is part of the issue "Social Ecology of Sustainability", edited by Stephen Wheeler (University of California, Davis, USA), Christina Rosan (Temple University, USA) and Bjoern Hagen (Arizona State University, USA).

1. Introduction

Political polarization in the United States is hindering progress in public policy and meaningful engagement at all levels of government. How do legislative requirements—like those for regional sustainability planning in California—help or hinder meaningful public engagement? What are the biggest challenges and opportunities for improving engagement?

Public process design is critical when participants are ideologically divided and do not trust each other or the public agencies in charge. In these cases, it is important to seek common ground on contentious, ideologically charged issues connected to sustainability. For example, all participants in a process may not agree on whether climate change exists, but they might agree that electric and hybrid vehicles should pay their fair share of road costs. They may not be able to agree on whether high-density development is beneficial, but they could pursue joint fact-finding to assess its effects on property rights and values, gentrification and displacement, and public services like schools, police and fire departments.

During my research on contested sustainability planning and infrastructure processes, unexpected areas of convergence emerged in the San Francisco Bay Area, the Atlanta, Georgia region, and the City of Gainesville, Florida (Trapenberg Frick, 2013, 2016, forthcoming; Trapenberg Frick, Weinzimmer, & Waddell, 2015)[1]. These convergences arose despite staunch disagreement over which planning strategies would support prosperity in these areas. In the Bay Area, the Metropolitan Transportation Commission and the Association of Bay Area Governments held meetings aimed at developing the region's first Sustainable Communities Plan, known as *Plan Bay Area* and adopted in 2013. Tea Party and property rights activists came out in force to block these meetings and were not alone in their opposition. Plaintiffs from across the political spectrum filed four lawsuits against the plan: two had connections to Tea Party and property rights activists; one was brought by the building industry; and one was filed by environmental organizations. In the progressive stronghold of Marin County, citizens not affiliated with Tea Party or property rights groups opposed requirements associated with

[1] In addition to related citations by the author, this article builds on "Common Ground" in ACCESS magazine at https://www.accessmagazine.org/fall-2015/the-access-almanac-common-ground and "Can Planners Find Common Ground with Tea Party and Property Rights Activists on Means even if They Don't Agree on Ends?" in the California Planning and Development Report at http://www.cp-dr.com/node/3536

higher density development planning if cities wished to access regional funds.

In the Atlanta region, Tea Party and property rights activists led the opposition to a 2012 regional sales tax proposal. The measure would have dedicated half of the new tax revenue to public transit projects. A coalition of strange bedfellows emerged: Sierra Club and National Association for the Advancement of Colored People leaders joined the opposition, in part because they felt the proposed transit projects were not the ones the area needed. Although it is hard to say what effect the coalition had on the measure, the tax measure failed decisively with 63 percent of voters in opposition.

A loose coalition also emerged in Gainesville between Tea Party and property rights activists and some residents from East Gainesville, a lower-income African American neighborhood. They argued that the City's proposed Bus Rapid Transit line was too costly and unnecessary. The BRT line was initially proposed for funding in a county-based transportation sales tax before the voters in 2012. Due partly to this opposition, the county dropped the transit line from funding consideration in tandem with other transit projects.

2. Areas of Common Ground

I found four areas of convergence between participants over transportation policy and process in these areas. These convergences warrant planners' attention because they united stakeholders coming from different vantage points.

First, some conservative activists in Atlanta supported vehicle-miles-traveled (VMT) fee as a replacement for the gas tax if major administrative and privacy challenges were overcome. They argued that drivers of electric and hybrid vehicles are not paying their full share of transportation system costs. Progressives have often advocated for this fee transition as well with the hope that funding could be directed to transit, bicycle, and pedestrian projects.

Second, conservative activists in both the Bay Area and Atlanta questioned the wisdom of running costly rail lines in low-density areas. Their arguments aligned with those of environmentalists and other progressives who would rather have seen transit investment in central cities for equity and efficiency reasons, and with academic researchers who caution that mass transit needs a sufficient density of residents and jobs to generate significant transit ridership. In Gainesville likewise some conservative activists supported improved bus service for low-income residents for reasons related to equity and cost.

Third, conservative activists in the Bay Area and Atlanta regions questioned the authenticity of the planning process, suggesting that planners merely went through the motions to arrive at a predetermined outcome. Progressive activists in those regions and planning scholars have had similar concerns, debating for decades whether large-scale planning processes with public meetings and hearings are meaningful formats for public input.

Fourth, activists across the political spectrum opposed the 2012 sales tax proposal in Atlanta because they viewed it as a regressive across-the-board tax rather than a user fee. Planning scholars similarly caution against sales taxes to fund transportation infrastructure. They argue that in states where local sales taxes for transport run rampant, states should move towards a user fee approach. This could include gas taxes, tolls, congestion pricing, parking charges and transit fares. Federal gas tax revenue, a major funding source, has declined significantly as the U.S. Congress has not increased the tax since 1993. Local areas have looked to increasing sales taxes through voter approved ballot measures to shore up the difference. In contrast to the Atlanta case of opposition, some Bay Area environmental activists have reluctantly supported sales tax increases over the years if they included a broad-based package of transportation modes.

3. Opportunities

When the public is ideologically divided over planning issues, a way to move forward could be by seeking areas of common ground like the ones outlined above. As one Tea Party leader advised me, "When the left and right sits down and actually communicates with each other, many times both sides are amazed that there is agreement on issues. You just have to be able to respect the fact [that] both sides have a right to believe the way they do politically and not focus on it. If you disagree on 90% of the issues, you will be much more successful if you try to find a way to work together on the 10% you agree on."

Planners could draw from the theory of agonism to reframe their approach to civic engagement. I draw inspiration from political theorists Chantal Mouffe and William Connolly's key scholarship in this area. In agonistic contexts, participants come to consider their opponents as legitimate adversaries rather than as enemies unworthy of engagement. In such moments, people maintain their core values and identities (Mouffe, 2013). As a result, an agonistic ethos of respect may emerge between otherwise divergent citizens (Connolly, 1995). I find this ethos and framing opens up opportunities for activists to discuss potential common ground across difference even if in limited ways or agreeing to disagree. As they voluntarily participate in deliberations, they can seek to redirect or exit the discussions. Critically important to activists is retaining their primary identities to remain legitimate to their side of the aisle.

Mouffe's interest in agonism stems from her critiques of the theory of communicative rationality which she argues privileges consensus and speech practices devoid of emotions. This situation in turn stifles passionate debate and excludes dissenting views. Some planning scholars consider agonism as an antidote to communicative planning theory which they argue masks power dynamics and

reinforces existing societal inequities (for a summary of debates, see Bond, 2011 also see Innes & Booher, 2015). In divided cities, for example, planning scholars look to agonism in tandem with other strategies as a way forward for transitioning city actors to living with difference (Bollens, 2012, p. 239; Gaffikin & Morrisey, 2011). Other scholars argue that agonism and communicative practices can co-exist as planning processes evolve (Fougère & Bond, 2016; Inch, 2015; Legacy, 2016).

One way to set the stage for agonistic engagement and inform community negotiations would be for activists and planners to jointly conduct analyses that examine, for example, the range of potential property rights impacts (Jacobs & Paulsen, 2009) and full lifecycle costs of projects and plans. These analyses might underscore and/or uncover critical issues that warrant further attention and, thus, bolster continued activist involvement. Planning-related policy efforts and legislation could recommend such analyses be undertaken as part of larger processes that include public engagement. To aid deliberations and mutual understanding, these recommendations could include independent mediators trained in conflict negotiation and resolution as well as other techniques including in-depth interviews with key stakeholders and non-traditional activities such as site visits and walking tours outside of standard public meetings (e.g., Forester, 2009). Public agency planners and elected officials' participation is critical if they or proposed plans seem likely under attack be it from conservative or progressive and environmental activists. While an agonistic ethos might emerge between stakeholders, the gate keepers of plan making (public agency officials) could elect to dismiss or not incorporate mutual understandings stemming from such activities unless they engage in reframing their enemy Other into at least an adversary.

Pilot funding through public or other sources could be provided to implement agonistic processes and examine their strengths and weaknesses. Pilots and evaluation would be worth the cost if agonistic relations between divergent actors can be fostered and community engagement is improved—potentially paying dividends by also laying the groundwork for activist relations on other planning endeavors.

In sum, it is worthwhile to establish the long-term objective of transitioning from highly antagonistic, counterproductive encounters to interactions of agonistic debate. Such an objective—with its focus on convergence among opposing parties—may serve states, regions and localities well as they assess their public participation and planning requirements, particularly those related to contentious issues like sustainability and climate change.

Conflict of Interests

The author declares no conflict of interests.

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