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UNIVERSITY OF CALIFORNIA,  
IRVINE

Closing the Food Systems Loop:  
Leveraging Social Sciences to Improve Organic Waste Policy

DISSERTATION

submitted in partial satisfaction of the requirements  
for the degree of

DOCTOR OF PHILOSOPHY

in Planning, Policy, and Design

by

Sally Elizabeth Geislar

Dissertation Committee:  
Professor David L. Feldman, Chair  
Professor Victoria Basolo  
Professor Richard Matthew

2016



## DEDICATION

To

my father who brought me to the woods,  
taught me how to fish, and encouraged me to draw,

my mother who let me take my first dictionary to read on the bus,  
listened to all my dreams, and cultivated my love of arguing,

and to

my grandparents  
who built a better life so that we could too.

The soil is the great connector of lives, the source and destination of all.  
It is the healer and restorer and resurrector, by which disease passes into health, age into  
youth, death into life. Without proper care for it we can have no community, because  
without proper care for it we can have no life.

Wendell Berry  
The Unsettling of America: Culture and Agriculture

Growth for the sake of growth is the ideology of a cancer cell.

Edward Abbey  
The Journey Home

# TABLE OF CONTENTS

	Page
LIST OF TABLES	vii
ACKNOWLEDGMENTS	viii
CURRICULUM VITAE	x
ABSTRACT OF THE DISSERTATION	xi
CHAPTER 1: Introduction to Food Systems	1
Closing the Loop on Food Systems	4
Modernization of the Food System	6
The Industrialized Food System in an Urbanizing World	7
Economic Growth in the age of Globalization	9
The (Re)Birth of Organics Recycling	12
Challenges to Closing the Loop	14
Incentivized Landfilling	15
Urban Waste Material Flows: The Systems of Provision	19
Institutional Arrangements	22
Infrastructure Networks	22
Food Waste Folly: Environmental and Economic Impacts	23
The Economics of Food Waste	27
The Promise of Organic Processing	29
Subsequent Chapters	32
CHAPTER 2: The Urban Metabolism Framework	34
Metabolism: The Evolution of a Concept	35
Conceptual Tools from Urban Metabolism	39
Circulation and Circular Metabolism	42
Closed-Loop Water Systems	44
Innovations to Systems of Provision and Household Practices	44
Contextual Factors	45
Triple Bottom Line	45
Barriers	46
Analogous Food Systems Solutions	49
Innovations to Systems of Provision and Household Practices	50
Contextual Factors	51
Triple Bottom Line	51
Barriers	52
Food and Water Material Flows	54
Stage of Development and Demographic Transition	55
Conclusion	61

CHAPTER 3: Transformative Change Part I: The Systems of Provision	62
Sources of Transformative Change	63
Policy Responses to Problem-Framing	66
Policy Interventions Transform Systems of Provision	71
Policy Principles	72
Policy Instruments	72
Incentive and Promotional Programs	74
Emergent Food Waste Problem Frames	75
Federalism, Food Waste, and Urban Experiments	77
The Urban Laboratory	79
Distanced Disposal and Severed Feedback Loops	82
Negative Externalities and Severed Feedback	83
Conclusion	87
CHAPTER 4: Transformative Change Part II: Household Behavior	89
Systems of Provision and Household Behavior Change	90
Determinants of Food Waste and Sorting Behavior	95
Household Food Inputs	96
Household Food Metabolism	97
Household Food Outputs	99
Theory of Planned Behavior	103
Transforming Household Behaviors	106
Supply-Side Approaches, Material Contexts	107
Demand-Side Approaches, Individual Contexts	108
Demand-Side Approaches, Social Contexts	110
Social Influence Theory	111
Social Impact Theory	114
Summary of Theoretical Foundation	119
CHAPTER 5: Technical & Social Innovations: Methods & Results	123
The Case Study: Costa Mesa, CA	124
Hypotheses	126
Methods	127
Sample and Experimental Design	127
Trial Recruitment	127
Phase A: Natural Experiment	128
Phase B: Intervention Experiment	128
Questionnaire	129
Focus Groups	130
Results	131
Descriptive Statistics	131
Phase A: Natural Experiment	129
Phase B: Intervention Experiment	129
TPB: Hierarchical Regression Across Three Time Points	135

TPB: Time 1	136
TPB: Time 2	137
TPB: Time 3	139
CHAPTER 6: Technical & Social Innovations: Discussion	142
Analysis of Experimental Results	145
Social Influence Theories	147
Classifying Behavior-Change Tools: Right Tools for the Job	149
Analysis of Theory of Planned Behavior	150
Age versus Generation Effects	153
TPB: Extended Variables	156
Analysis through Urban Metabolism Framework	156
Nested Urban Metabolic Systems	157
New Socio-Ecological Relationships	158
Critique of Urban Metabolism Model	161
Limitations	167
Internal Validity	167
External Validity	168
Conclusions	172
CHAPTER 7: Policy Implications & Conclusion	173
Policy Implications	174
Transforming Household Behavior	175
Transforming Systems of Provision	178
Scale for Change	178
Problem-Framing	179
Reduced Distancing in New Socio-Ecological Relationships	180
Successful Organics Collection Programs	182
Infrastructure Matters	182
Education Campaigns	184
Ongoing Dialogue	186
Norm Communication	187
Future Research	188
Addressing Limitations	189
Improving Internal Validity	189
Improving External Validity	190
New Research Questions	191
Supportive Infrastructure and Intention	192
Household Dynamics: Age & Cohort, Responsibility & Power	192
Refining Normative Effects	194
Household Metabolism Model	195
Systems Thinking and Spillover Behaviors	196
Conclusion	201
Reducing Consumption	201
Engaging with Social Aspects of Waste Disposal	203
Urban Household Metabolism	206

REFERENCES	210
APPENDIX A: Constructs and Scale Items	224
APPENDIX B: Socio-Economic Characteristics	225



## LIST OF TABLES

		Page
Table 1	Contextualized Behavior Change Tools	117
Table 2	Experimental Timeline	129
Table 3	Time 1 Theory of Planned Behavior Results	137
Table 4	Time 2 Theory of Planned Behavior Results	138
Table 5	Time 3 Theory of Planned Behavior Results	140

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## PUBLICATIONS

- Geislar, S. (forthcoming) Closing the Loop on Urban Food Systems: A Comparative Case Study of Organic Waste Policy Implementation. In Y. Rollins & C. Kuyvenhoven, *Throw Away Societies: People, place, and waste*. Routledge Publishing.
- Geislar, S. (2013). From the Ground Up: Lessons on Incorporating Behavior Change Research in Sustainability Programs. *Empowering Sustainability International Journal*

## **ABSTRACT OF THE DISSERTATION**

Closing the Food Systems Loop:  
Leveraging Social Sciences to Improve Organic Waste Policy

By

Sally Elizabeth Geislar

Doctor of Philosophy in Planning, Policy, & Design

University of California, Irvine, 2016

Professor David L. Feldman, Chair

Urban food waste in the U.S. is almost exclusively bound for landfills, with significant environmental and the economic consequences. Contrary to this linear flow, cities across the developed world are implementing organics collection programs (OCP) that transform waste into a resource. These systems convert excess food into inputs (e.g. biofuel or soil amendment) for other processes (i.e. food and energy production, water reclamation) thereby approximating naturally occurring closed-loop nutrient systems.

However, efforts to address the flow of food waste into landfills have largely focused on technical solutions that alter the waste management systems of provision, largely ignoring the social aspects of food waste generation and source separation. Drawing on the Theory of Planned Behavior and concepts from social marketing research, results from longitudinal repeated-measures experiments indicate that providing supportive infrastructure is necessary for residents to act on their "intention" to divert food waste from landfills. The experiments are also the first to confirm that communicating the new community norms of separation in the context of a new OCP will increase separation

behavior. In sum, closing the loop on urban food systems demands transformations of the systems of provision as well as the social aspects of waste systems.

I trace the evolution of organic waste policy on two continents using problem-framing as a lens through which to understand how different characterizations of food waste as a problem (i.e. as one of *disposal efficiency*, *risk management* or *value recovery*) result in different policy responses with varying degrees of linearity in urban food material flows . This dissertation contends that successfully closing the loop on urban food systems will demand new problem-framing that employs systems-thinking at the highest levels of policy-making, transformations of both the systems of provision and social practices, and an understanding of the new relationships between social and natural systems (i.e. socio-ecological relationships).

## CHAPTER 1

# Introduction to Food Systems

---

Food systems in the developed world are largely linear systems where uneaten food becomes waste in landfills negatively impacting the environment and the economy. By contrast, there is no waste in a circular or closed-loop food system, as in an ecosystem for example. The waste products of one component (e.g. a decaying tree or deer carcass) becomes the building blocks for new life as inputs into another component (e.g. fungus or bacteria). Several scholars have attempted to translate this circular metabolism to that of a city (Burgess, 1925; Wolman, 1965; Kennedy, Cuddihy, & Engel-Yan, 2007; Swyngedouw, 2006), an effort that is not without its intellectual shortcomings. In a city, for example, this closed-loop food system would capture excess food for use as input in other processes such as biofuel or soil amendment for use in energy generation or agriculture.

Efforts to address the flow of food waste into landfills have largely focused on technical solutions to alter the waste management systems of provision, ignoring the crucial social aspects of food waste generation and source separation. This dissertation contends that transitioning from a linear to a closed-loop food system will demand transformations of both the systems of provision and the everyday behaviors of households. In this regard, this research makes several contributions to social psychology, especially the Theory of Planned Behavior and social marketing approaches to transforming behavior. The findings herein indicate that the TPB is a good fit for predicting food waste separation behavior, but that for the majority of the population supportive infrastructure is necessary for residents to act on their "intention" to perform food waste separation. Furthermore, this research is the first to test the effect of communicating normative behaviors of food waste separation in the context of an organics collection program (OCP). The results indicate that cities who employ norm communication alongside their



transformations of the systems of provision (i.e. curbside bins, collections services, and processing facilities) can expect significant gains in participation.

In its attempt to highlight food waste as an understudied aspect of food systems, this dissertation argues that a systems-thinking approach must be adopted. In part, systems thinking demands that scholars and practitioners alike consider how changes to one part of the food system will effect others. As cities adopt OCPs that attempt to disrupt and transform the flow of food waste from the home to landfills, we must endeavor to understand how these changes affect other stages of the food system such as production, retail, consumption, and distribution (i.e. both of food as a commodity and food waste). For instance, as households transform their food disposal practices, will this result in increased attempts to reuse food or will the use of more sustainable disposal options decrease the guilt associated with wasting resulting in an increase in waste generation overall. These questions are beyond the scope and available data for this dissertation, but will be discussed further in terms of future research.

These challenges have evolved in a context in which state-level policy has framed the problem of food waste as one of *disposing efficiently* and then of *reducing risk* to water and air quality. More recently, policy has framed the problem of food waste as one of recovering a valuable resource (e.g. for generating biofuels or compost) or of redistributing food security. Taken from an urban political ecology lens, these problem frames are seen as a continuation of the market-based relationship between human and natural systems that understands nature as a commodity through the labor of human effort (Swyngedouw, 2006). This market-based relationship may prove antithetical to the new ecological realities, but it continues to represent the motivations for mobilizing energy, materials, and labor. This dissertation contends that closing the loop on urban food systems will demand a systems-thinking approach in problem-

framing at the highest levels of policy making that understands the flow of nutrients through urban spaces as part of a socio-ecological relationship. Nutrients must be used and expelled at a pace that allows the ecosystems that support human life to recover and regenerate. Here we see that humans remain at the center of motivations for closing the loop; a sort of anthropocentric nutrient metabolism emerges.

### **Closing the Loop on Food Systems**

Linear food systems are characterized by the one-way flow of food from production to distribution and consumption. Food in these systems moves from one end of the food system to the other. In the U.S., this "other end" of the food system is usually marked by an end of life in the landfill. By way of contrast, a circular, or closed-loop food system is one in which uneaten food is used as input for another process in the food system, be it for producing compost or biofuel.

Cities around the world are under increasing political pressure to curb the flow of food waste into landfills. While many are implementing curbside programs for residential food waste, few have gone beyond information campaigns and financial incentives to encourage participation. What follows is an examination of the impacts of the linear food system we have inherited and evidence that supports the use of new tools to improve our best efforts to close the loop on urban food systems. More than a next step in landfill diversion efforts, closed-loop systems are necessary building blocks of resilient cities.

Food waste is created at each stage of the linear food system. In the U.S., a full 40% of food grown from human consumption goes uneaten, while 48 million people live in food insecure households (Gustavsson, Cederberg, Sonesson, Otterdijk, & Meybeck, 2011; USDA ERS, 2016). Moreover, residents pay for waste management corporations to bury or burn this

organic material rather than transforming it into compost or biogas that could be used to return nutrients to the soil or displace fossil fuels. Instead, our agricultural system pumps millions of gallons of synthetic nitrogen fertilizers onto our soils, spilling over into our waterways. And fleets of vehicles on the streets and in the fields rely on diesel and other fossil fuels, emitting greenhouse gasses (GHG) and toxins into the atmosphere. Yet, in large part, the uneaten food in this system does not go to fill up the bellies of the hungry, nor to nourish the next crop, but to swell our country's limited landfills. Worse yet is that once there, uneaten food contributes to a suite of environmental maladies from GHG emissions to toxic leachate.

Food waste is a problem, and it is an even bigger problem in a linear system. Transforming the linear food pathway into a closed-loop system will reduce the environmental and economic externalities that characterize the status quo. In the ideal closed-loop system, any outputs of one process in the system become inputs for another (Novotny, 2010). This interpretation of the solution (and so the problem) of food waste, represents the industrial ecological use of the urban metabolism framework to understand the flows of energy and materials through cities. It seems, however, to be in a vacuum outside social and historical contexts. That 'the urban' is simply a collection of processes where materials are transformed apolitically. This characterization omits the social context of inputs, metabolisms, and outputs of this system; the historical trajectory of relationships between urban to rural, or between the haves and the have -nots. This dissertation draws in part on urban political ecology to shed light on the social-political contexts and the socio-ecological relationships in which urban metabolisms operate (Swyngedouw, 2006; Heynen, Kaika, & Swyngedouw, 2006).

The US EPA and the EU Food Waste Hierarchies (Defra 2005, U.S. EPA 2016c) attempted to account for the social context of food waste in prioritizing the use of recovered food

waste materials. In that spirit, I argue that a closed-loop food system must prevent, sort, redistribute, and recycle food waste. Importantly, this system must "internalize the externalities", reducing the (psychological and spatial) distance between production-and-consumers (Princen, 2002), as well as between consumers-and-disposal (Clapp, 2002) such that the feedback effects of social and environmental degradation can be detected and addressed. In this dissertation, I focus primarily on the latter relationship. I argue that in order to transition to a closed loop urban food system, we must transform not only the supportive infrastructure and institutions for food waste management, but also the everyday behavior of households. I show that this is especially true for food waste flows and that it is possible through social and technical innovation.

In the following section, I will explore the development of the modern food system including the impacts of industrialization and rapid economic growth on how the average American eats. I then discuss the concurrent transformations of urban food waste systems of provision. The subsequent section discusses the environmental and economic impacts of the linear system . This is less to argue that the linear food system has negative externalities and more to contextualize the state of organics waste management and the current challenges for the reader. I close the chapter by outlining the dissertation chapters that follow.

### **The Modernization of the Food System**

Our food system has undergone dramatic changes in the past 100 years. Many of these changes threaten the sustainability of metabolic processes in urban areas. The "modernization of the food system" (Thyberg & Tonjes, 2016) has rendered it unrecognizable to a family a century ago. Many of the untenable symptoms of the linear food system have manifested through the processes of modernization. Industrialization, urbanization, and the globalization of food markets have transformed how the U.S. produces, distributes, consumes, and disposes of food waste.

**The Industrialized Food System in an Urbanizing World.** Industrialization, urbanization, economic growth, and globalization are key factors of the modern food system that shape the quantity, type, site, and causal variables of food waste (Thyberg & Tonjes, 2016). Of course, these forces shaped the entire food system from production through disposal. As a result of the intertwined forces of industrialization and urbanization we have seen the mechanization of modern life in tandem with the depopulation of farm fields and communities. Where once a community of labourers would rotate working on one field, then another, machines now roam the rows to plough, plant, and harvest. The rural communities soon became as vacant as the fields as people fled to factories in the cities in search of work. Abundant low-skilled jobs in urban areas welcomed the out-of-work rural laborer displaced by mechanized agriculture. Today, as cities continue to grow in sprawled form, housing developments and strip malls increasingly engulf the farmland and farm life of yesteryear, and the spread of technology drives more nails into the coffin of agricultural labor. In some cases, planting and harvesting is achieved without setting a single human foot on the field as GPS-guided machinery gradually replaces the few farmers that remain.

This trend represents a major transformation in human society. For the first time in human history, more than half the world's population—and more than 75% in the U.S.—lives in cities (U.N. Habitat, 2011). As cities grow, they threaten peripheral agricultural land, not only directly by buying farmland but by the subsequent increases in land value, and thus the costs of farming (NYFC, 2013). Farmers are often faced with the choice of paying more for land close to urban markets or paying for transportation costs of tilling the land that is farther afield. In this increasingly urbanized world, food travels farther and farther to reach urban markets.

Industrialization and urbanization also affected food waste generation and disposal practices. At first, rural migrants to the city maintained their waste disposal practices of dumping of food scraps outside one's doors and windows to be eaten by feral or domesticated animals (Strasser, 1999). For example, an estimated 10,000 hogs scavenging for scraps still roamed the streets of New York as late as 1842 (Strasser, 1999). Social historian Susan Strasser (1999) details the efforts of Sanitary Reformers who campaigned in the late 1800s for clean water, good sewers, and ultimately for swift garbage removal. Early attempts to establish municipal refuse collection programs, however, were met with resistance by citizens who had long given their scraps to "swill children" to be turned into fertilizer (Strasser, 1999; Clapp, 2002).

In many cities, the programs to collect household waste were underfunded and overwhelmed. By the turn of the century, household waste constituted one quarter to one third of all municipal waste (Strasser, 1999). Attempts to raise funds through property tax hikes were unpopular among landowners and merchants who already relied on private contractors to remove their waste. Cities were quick to realize that collected materials could yield a profit if it were converted into other products like soil or industrial-scale hog feed. This realization brought about the first, if short-lived, municipal "source separation" mandate in New York City in 1896 (Strasser, 1999). With the aid of civic groups, four-fifths of turn-of-the-century cities greater than 25,000 people "required some separation of organic garbage or ashes so that these wastes could be recycled or reused" (Strasser, 1999, p. 129). However, with the introduction of the "sanitary" landfill in the 1930s and the kitchen sink garbage disposal after WWII, many cities eased mandates on source separation (Strasser, 1999; Clapp, 2002). These technologies proliferated with the help of two additional forces that revolutionized the food system; economic growth and globalization.

**Economic Growth in the age of Globalization.** The spread of ideas, people, and goods at an ever more rapid pace has defined the modern era of globalization. As the barriers to international communication and travel ease, new ideas and trends can more easily reach far-off corners of the globe. Economic growth and globalization have transformed every part of the food system from the machinery on farmers fields to the inventory on the grocery shelf to the contents and destination of the waste bin.

Beyond the field, economic growth, and indeed industrialization, has transformed the household from a site of food production where the knowledge and skills for preparation and reuse are enacted, to a site of food consumption and disposal (Strasser, 1999). In fact, more than half of a household's food budget in the U.S. is spent on food prepared outside the home (USDA ERS, 2016). This trend is buttressed by a decrease in the price of food as a result of mechanization cutting labor costs and increasing efficiency. Combined with rising wages in the now-developed world, purchasing food is often a more economical decision for households than growing and preparing food.

Greater household income also translates to more fresh produce, more meat, and more variation in the home menu. Each of these contributes to more food waste compared to a diet characterized by repetitive, starchy foods (Thyberg & Tonjes, 2016). The modern household, however, has less time for home food preparation as increased gender equity in the labor-force has also led to more households with two wage-earners. In fact, factories, processing plants, and restaurants are now the most common site of food preparation in the developed world (Thyberg & Tonjes, 2016). The modern food system not only changes spending habits and household diets, but also global industrial arrangements.

Food systems in the developed world have transformed from local food production and disposal to regional and increasingly international food systems (Bloom, 2010). More and more cities are part of a global food market. Available food products are no longer a reflection of local tastes, seasons, and food production, but of global trends (Thyberg & Tonjes, 2016; Conca, 2001). Furthermore, though the industrialization of food systems made the global food market possible, it was the cost-cutting economies of scale and subsequent level of food surplus that drove producers in search of new markets (Roberston, 1990). What Conca (2001) classifies as *transnational commodity chains* have come to characterize the modern food system as well as more durable goods. A transnational commodity chain consists of globally dispersed "links" that represent stages of production, distribution, and retail (Conca, 2001). The grocery aisles are stocked with the products of these chains, especially in the winter months. From Chilean blueberries, to Mexican avocados, to tropical bananas, not even the produce section is free of these chains.

The global food market results in greater food miles travelled, less local produce consumption, and consumers who are further distanced from the processes and effects of production (Thyberg & Tonjes, 2016) and, as I will show, disposal. Consequently, decisions by consumers are increasingly *distanced* (Princen, 2002) from the “knowledge, information, and contextual understanding” of the regions of resource extraction and production processes (Conca, 2001, p. 63). One such consequence is an increase in food wasted as the labor embodied in the food is obscured (Strasser, 1999)

Nor is the effect of distancing solely confined to food production. Before the dense residential areas of cities or suburbia, before the inundation of synthetic packaging materials of the modern food system, much of household waste was organic (Strasser, 1999). Much of this



was processed at the point of generation in pig feed or compost piles. Households were directly engaged with the processing of material wastes. In contrast, contemporary municipal waste management typically collects household waste and delivers it far afield from waste generators thereby reinforcing the effect of distancing production (Princen, 2002) and contributing to a distancing of disposal (Clapp, 2002).

Today, most cities in the developed world have a waste management system that trucks waste to what are often large, regional processing facilities. Be these facilities landfills, incinerators, anaerobic digesters (AD), or composting, they relieve households of the hassle of managing the material wastes in the wake of their own consumption (Strasser, 1999; Rogers, 2005; Clapp, 2002). Furthermore, it can be challenging to know exactly how far trash travels from the household to its final resting place or recycling facility. A recent study from MIT sought to shed some light on this with a project called Trash Track. Tagging and tracking 3,000 individual pieces of garbage, researchers at the SENSEable City Lab found that while 95% of waste stayed within city limits, electronic waste and hazardous household waste, however, traveled 1,500 kilometers on average (Michell, 2012) Indeed, it is not uncommon for e-waste and hazardous waste to pass into other states, or even countries to be buried or burned (Rogers, 2005; Clapp, 2002).

In large part, the contemporary waste management system serves as the "end-of-the-pipe" for a linear, globalized food system. The centralized form of waste management demands only that households consider their waste enough to put it on the curb. Food and other wastes are then taken "away", distancing the material weight of daily life away from the householder. The form taken in the development of organics collection programs will do little to reduce this distance, however. Municipal efforts to develop organics collection programs (OCP) are almost

exclusively tapping into the existing infrastructure of waste flows. Separated organics will follow the same type of pathway as they do when commingled with other household trash. First, it passes into curbside bins collected by privately contracted waste haulers and delivered to large centralized processing facilities "away" from most households that supply the feedstock. By capturing a valuable resource, OCPs are nevertheless a critical first step toward closing the loop on urban food systems.

**The (Re-)Birth of Organics Recycling.** In the last thirty years, cities across the globe have revived systems of capturing and reusing food waste. While few in the developed world have turned to the hog farms of yesteryear's organic recycling<sup>1</sup>, cities with OCPs are generating valuable compost and biogas from residential, commercial, and industrial sources. In this age of organics recycling revival, the U.S. has had a late start. The Netherlands, for example, mandated separate collection of "biowaste" in the 1990s (ETC/SCP , 2013), as did Germany (UBA, 2016). Whereas the US lacked such political commitment until 2009 when San Francisco became the first city in the U.S. to mandate that households separate their organic waste for collection (SF Environment, 2013). Seattle (SPU, 2016), Portland (City of Portland, 2016), and Boulder (City of Boulder, 2016) have now followed suit and more recently, OCPs are popping up in cities that are not heralded as the bastions of environmentalism. This might be seen as an indication that organics recycling is moving from the fringe to the mainstream, though in some cases, the impetus is the result of impending statewide mandates that will ban organics in landfills as in Vermont (Vermont DEC, 2016) and Massachusetts<sup>2</sup> (Berdik, 2014), or that will set higher standards in landfill diversion rates as in California (CalRecycle, 2012).

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<sup>1</sup> As of 2005, more than 50% of South Korea's collected food waste was used as feed for poultry and livestock (Legislative Council, 2013)

<sup>2</sup> Massachusetts' ban on organics in landfills only applies to businesses that generate one ton or more of food waste per week (Berdik, 2014).

An international scope provides some examples of successful OCPs and those that have fallen short of the ideal. The Netherlands and South Korea, for instance, have both achieved among the highest landfill diversion rates in the developed world. But a look beneath the statistics reveals disparate means to these ends with disparate outcomes in status on the waste hierarchy. Both countries seem to have arrived at the pinnacle of organics waste management. In 1995, The Netherlands passed an organics landfill ban, as did Korea 10 years later. But compliance with this ban is achieved in drastically different ways. The former relies equally on incineration and composting (ETC/SCP , 2013) while the latter processes more than 80% of organic waste for compost and animal feed (Lee, 2013).

Driven by factors of rapid economic growth, subsequent increases in waste generation, and extreme spatial constraints for landfill expansion, Korea's waste management plans have aggressively targeted reduction and recycling since the 1990s (Legislative Council, 2013). Between 2000 and 2009, Korea simultaneously reduced the number of incineration plants by 93% and the number of landfill sites by 23% (from 10,055 to 772, and 383 to 296 respectively) (Legislative Council, 2013). To manage organic wastes that became prohibited in landfills during that time period, Korea developed a rigorous source-separation and organics processing system for composting and animal feed and more recently, anaerobic digestion.

During that same time, The Netherlands' already minimal landfilling rates remained stable thanks in large part to a ban of Municipal Solid Waste (MSW) from landfills in 2002 (MIM, 2007). The country had already developed a significant incineration and composting infrastructure to manage organic waste in response to their organics landfill ban in the mid-90's. Indeed, incineration rates for all MSW remained nearly unchanged during the first decade of the 21st century (ETC/SCP , 2013). At the national level, the Netherlands only sends an average of

3% of all waste to landfills. However, only about 51% of all MSW is recovered for recycling, reuse, and composting as seen in Figure 2 (CBS, 2013). Another 31% of diverted waste is incinerated, much of which includes incineration with energy recovery (CBS, 2013). The most recent figures indicate incineration (i.e. with and without energy recovery) accounts for the largest percent of organics processing in the country at nearly 70% (EEA, 2002).

Despite the high landfill diversion rates, these figures indicate a relatively low level of material recovery for composting and biogas in the Netherlands compared to South Korea. The implementation of organics waste policy in The Netherlands came to contradict the waste hierarchy set by both national and supra-national policies (ETC/SCP, 2013). In large part, it seems that changes in this trend will have to wait until contracts between municipalities and companies operating incineration facilities run out and are renegotiated (Van Heijst, 2013). Municipalities in the rest of the developed world should proceed with caution lest they fall to the same path-dependent fate by entangling policy implementation in capital-intensive projects.

**Challenges to Closing the Loop.** Developing organics collection and processing systems are critical steps to reducing the food waste destined for landfills and closing the loop on urban food systems, but infrastructure alone is not enough. For example, San Francisco was able to rely on new three bin system (food waste, commingled recycling, and landfill) and information campaigns to reach 80% landfill diversion. Yet, these waste management systems only work if people use them. Despite their relative success, a 2013 report from the San Francisco Department of the Environment (SF Environment, 2013b) found that half of the materials in the landfill bins are readily recyclable or compostable. A city like San Francisco may be able to rely on new bin infrastructure and information campaigns to divert the first 80% of the city's material wastes away from landfills. But it will take new approaches to make further gains.

Statewide mandates have made programs like San Francisco's far more attractive to municipalities in the last five to ten years. Strategic Directive 6.1 was adopted in 2007 and called for 50% organic waste diversion from landfills by 2020 (CalRecycle, 2012). This directive is set to aid the state in achieving other mandates to reduce GHG emissions to 1990 levels by 2020, and achieve 75% landfill diversion by the same year (AB 32 and AB 341, respectively) (CalRecycle, 2012). CalRecycle, the state Department of Resources, Recycling, and Recovery, insists that "the 75% [landfill diversion] goal cannot be reached unless a significant amount of organics now being landfilled is instead used in new composting/AD [anaerobic digester] facilities" (CalRecycle, 2012, p. 24). Indeed, CalRecycle estimates that over 30% of what is landfilled today is compostable organic waste (CalRecycle, 2012).

Even with full participation, organics recycling is only one component of a closed-loop food system. Furthermore, not all organics recycling are created equal. The EPA's food recovery hierarchy prioritizes reduction, feeding the hungry and animals, and industrial uses above composting and incineration and landfilling (U.S. EPA 2016c). The last pair are considered equivalent in the food recovery hierarchy. At the top of these hierarchies is waste prevention and re-use or re-distribution. Contrasted with organics recycling that seeks to manage waste, waste prevention seeks to preclude its management all together. This makes waste prevention a "top of the pipe" solution, though such metaphors are vestiges of a linear system. As with OCPs, preventing the generation of food waste will take concerted efforts to change the physical, legal, and social dimensions of our urban landscape.

**Incentivized Landfilling.** Household behavior change will be a linchpin in re-organizing the systems of provision to dis-incentivize landfilling organics. The incentive structures that have enabled landfilling organics to prevail are many and long-lived. Addressing

these incentive structures will demand transformations of the systems of provision (i.e. policy and infrastructure) and household practices. While the enactment of waste management is an inherently localized activity (Bulkeley & Askins, 2009), the influence of state-level problem-framing cannot be underestimated. Problem-framing defines the possible solutions around which policy principles, instruments, and incentives organize to achieve goals. The drive to close the loop on urban food systems must consider the path-dependency of existing unsustainable infrastructure. In these ways, change must come from "above" and "below".

Landfilling emerged as an efficient mode of disposal at a time when the problem of organics was framed in terms of "disposal efficiency" (Strasser, 1999; Bulkeley & Askins, 2009). It continues to be the cheapest method today (BioCycle, 2014a). Landfilling continues to be cheaper than alternatives, in part, because the infrastructure is already in place. The cost of constructing new composting or AD facilities falls onto municipalities and their private haulers in all but the handful of states with grant and loan programs (BioCycle, 2014a). In the U.S., some states have also implemented landfill taxes and organics bans. The EU instituted a series of landfill taxes and some member-states have outright banned entire classes of materials or even MSW altogether (e.g. The Netherlands, Germany) (ETC/SCP, 2013). Unfortunately, the landfill ban in Germany has promoted the exporting of wastes to be incinerated with energy recovery elsewhere.<sup>3</sup> It remains to be seen what effects the landfilled organics ban will have in places like Vermont and Massachusetts whose bans be fully implemented by 2020.

Landfilling residential wastes is also incentivized in that it demands the least amount of labor inputs. On a spectrum of waste stream labor-input, single-stream landfilling is on the lowest end. Whereas source-separated recycling and composting demands the highest labor.

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<sup>3</sup> Waste exportation is only legal between member-states so long as it is for recycling, though this includes incineration with energy recovery.

Single-stream landfilling of residential wastes sends all materials indiscriminately from one place (i.e. the home) to another (i.e. the landfill). This was the norm for much of the last half of the 20th Century (Strasser, 1999). Source-separation, on the other hand, requires labor input by residents to know how to separate the household material streams, and enact that knowledge every day. In cities where standardized bins are provided, it also requires additional labor in the form of bin manufacturing and home delivery. Some cities even alternate collection days or weeks resulting in the reorganization of household labor to deliver the correct bins to the curb on the correct days. In between these ends of the waste stream labor-input spectrum lies post-collection separation. This is a process by which the waste hauler collects commingled materials from residents and uses a facility to separate those materials, called a Materials Recovery Facility (MRF). Here the labor-input is enacted by the hauler via the MRF rather than the household.

These points on the "waste stream labor-input" spectrum result in different qualities of feedstock for organics recycling efforts and different environmental impacts of the waste stream overall. The wholesale landfilling of organics causes the most environmental damage (West Coast Forum RWG, 2013), but it also requires the least amount of labor input by any stakeholder. Alternatively, no additional house-hold labor is required for post-collection separation which results in higher levels of recycling than direct landfilling. These schemes recapture the material value and reduce the environmental degradation that results from landfilling. Here, the burden of realizing those benefits (through labor) is placed on the hauler and the MRF.

A systems-approach to understanding the flow of food waste in the city must recognize that adopting source-separation schemes shifts the burden to the householder. It is, nevertheless,

widely considered the best method for ensuring minimally contaminated feedstock for compost or biogas (BioCycle, 2014a; Saft & Elsinga, 2006). Source separation demands that householders incorporate into their everyday life the separation of material streams in order for the benefits of this scheme to be realized. At first glance, motivating the reorganization of labor by millions of households is a monumental feat compared to the labor required of establishing and managing a network of MRFs. However, establishing quality feedstock of organic material streams may be the best way to encourage the development of markets for compost and biofuel. Ultimately, this quality feedstock demands lower contamination, and this is only possible in schemes where food waste is never mixed with other material streams. This will demand attention to the social aspects of food waste streams. Ultimately, the challenge will be to encourage municipalities, haulers, and households to move farther along the spectrum of separation labor toward source-separation.

Similarly, a systems-approach demands recognition that changes to one aspect of household practices will effect others. It remains to be seen, for instance, whether separating food waste for "recycling" will have a similar impact as was found by a recent study (Catlin & Wang, 2013). Catlin & Wang found that when participants had access to recycling bins, they wasted significantly more paper than those who had no guilt-free disposal options. Will residents increase the quantity of food waste because they are relieved of the shame they would otherwise experience by sending food waste to the landfill? Or will the daily visualization of the sheer quantity of food waste as it fills its stand alone container leverage behavior change in other aspects of their everyday life that reduce overall waste generation? These are empirical questions that remain beyond the scope of this dissertation, but that should be explored in future research.



While these shifts in labor will result in a more valuable product to put back into the system (i.e. compost or biogas), there must be a market for these products. Currently, the lack of a strong recycled-organics market--whether in terms of compost or biogas--has been identified as a key weakness in reducing landfilling (BioCycle, 2014a). Compost and biogas are valuable products, but their nascent markets lack standards to ensure quality and appropriate use (BioCycle, 2014a). Farmer's may be concerned, for example, about their farm's organic certification if urban-sourced compost is contaminated with glass or metal, or pesticide residuals from discards. Similarly, efforts to incorporate biogas into pipeline systems have met with some resistance because a lack of quality assurance. Compost and AD operators, regulators, and other government agencies have been working together to establish acceptable standards (BioCycle, 2014a).

### **Urban Waste Material Flows: The Systems of Provision**

While the food system is increasingly global,<sup>4</sup> food waste systems face material realities that make it less likely that a global food waste market will emerge. Food waste is wet, making it heavy and expensive to transport great distances. Even if we erected immense systems to dehydrate it, food begins to putrefy and decompose on a more immediate timeline than other wastes. Even though this pathway from field to fork is global in some cases, the processes by which food instead becomes managed as a waste material are localized activities.

Bulkeley and Askins (2009) argue that waste management is co-created by household practices and systems of provision. I would extend this argument, such that the very processes that transform food into waste are co-created by householders and the waste infrastructure and

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<sup>4</sup> The average dinner includes ingredients grown in five different countries (NRDC, 2007). And food may travel on average 1,200 miles from where it is grown to where it is eaten, not to mention any miles it may travel if it is discarded instead (Weber & Matthews, 2008). Food miles traveled varies greatly depending on a number factors including type of food, site of consumption, and season (Weber & Matthews, 2008)

institutions. On the one hand, the everyday practices of households define which food materials will become waste through the enactment of routinized behavior in food purchasing, preparation, storage, reuse, and disposal (Evans, 2014). On the other hand, systems of provision shape what infrastructure is available for enacting different waste management processes. Whether or not a household has access to OCPs is a product of infrastructural and institutional arrangements (Bulkeley & Askins, 2009). Cultural preferences, social norms, habits, and identity, interact with spatio-temporal constraints and the systems of provision to shape whether and how food is transformed into waste in the home (Evans, 2014; Visschers, Wickli, & Siegrist, 2016; Gregson, Metcalfe, & Crewe, 2007).

These arrangements are at once enacted locally (i.e. in the home and by local waste haulers) and the product of international and national policies, or "multilevel governance" (Bulkeley & Betsill, 2005). This section will explore infrastructural and institutional arrangements in local organics waste management and the "interventions" through which they have been shaped by problem-framing at the national level (i.e. policy principles, instruments, and incentives). The chapter will close by highlighting the abundance of policies targeting systems of provision and the relative dearth of those addressing household behavior.

The waste of the food system is both manifested and managed locally. It is often not *processed* locally (Clapp, 2002; Princen, 2002; Rogers, 2005), but the infrastructural and social arrangements that collect and direct waste away from the site of generation are localized phenomena (Bulkeley & Gregson, 2009). That is to say that social practices and infrastructure work together to enact the management of waste at each stage of the food system where waste is created.

For instance, curbside collection is a common model for managing household organic waste in the U.S. It is most commonly accomplished through the combination of social practices of sorting and disposing (Gregson, Metcalfe, & Crewe, 2007; Evans, 2014) and infrastructure such as curbside carts and collection vehicles (Bulkeley & Gregson, 2009). Once collected and directed away from the site of waste generation, these materials are then amassed in a local transfer station where they are prepared for longer-distance transport (Rogers, 2005). These transfer stations may serve a region covering dozens of square miles, and are meant to be within reach of communities generating the waste. This proximity is important because as collection vehicles fill to capacity on their routes through mazes of neighborhoods, they deposit their bounty in the transfer station and return to fill up on the next phase of their route. In the case of OCPs, materials are typically amassed and transferred into long-range semi-trailers that transport materials dozens or hundreds of additional miles to processing facilities.

Processing facilities are typically designed to manage the waste of several million households. The newly constructed AD facility in Perris, CA, for example, processes 150 tons per day and up to 900 tons of organic materials with additional digesters when it is built to capacity (City of Perris, 2011). That is nearly 165,000 tons annually. Because of its size, the facility will need to attract the food waste of several cities to operate at capacity. At current processing capacity, the AD facility can manage the equivalent of nearly 500,000 residents,<sup>5</sup> or nearly all of the two largest neighboring cities combined. At full build out, the facility will process the waste of roughly 2.7 million residents, nearly 20% more than the county population. But this massive capacity is not happenstance. Regional materials management was a strategy built into the design of the facility.

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<sup>5</sup> Based on figures indicating the average American generates more than 20 pounds of food waste per month. (Buzby & Hyman, 2012)

**Institutional Arrangements.** Relationships between private industry, local waste authorities and state and national regulators shape existing waste management practices. Existing institutional arrangements may be transformed in an effort to close the loop on urban food systems. Processing facilities are often owned by the same companies that collect municipal waste and this type of “vertical integration” has been on the rise in the waste management industry since the 1990s (Rogers, 2005). With consolidation of the waste industry, many companies pursued vertical integration to drive down costs (Rogers, 2005; Strasser, 1999). For instance, haulers no longer pay tipping fees at landfills because they own them.

The AD facility in Perris, CA is owned by CR&R Environmental Services. Unlike other haulers, however, CR&R does not own any landfills. In personal communication with the CR&R Recycling Coordinator to the Costa Mesa Sanitary District, Lawrence Jones, he asserts that this was the primary reason why CR&R was the first in Southern California to offer organics recycling programs (Jones, 2016). Without a landfill to call their own, CR&R paid tipping fees for any municipal waste unfit for conventional recycling. CR&R also took advantage of other institutional arrangements in constructing their own AD facility, including the Greenhouse Gas Reduction Grant and Loan Program through CalRecycle (BioCycle, 2014b; Jones, 2016).

**Infrastructure Networks.** Infrastructure in the form of processing facilities are designed to use particular materials as input and produce particular output. Using the urban metabolism framework to understand organics recycling facilities, we can think of these processing facilities as nodes disrupting and linking linear systems. Enabled by a series of social (e.g. household behavior), institutional (e.g. public-private partnerships to deliver OCPs) and even other infrastructural arrangements (e.g. curbside bins, collection fleets), these facilities disrupt existing linear pathways of food waste from households to landfills.

On a large scale, they link processes that generate output (e.g. household food consumption) with processes that require input (e.g. soil amendments on agricultural lands, or fuel for fleets). The latter processes have previously relied on alternative sources of material inputs in the absence of organics recycling. Synthetic materials first developed from ammonium nitrate surpluses at the end of World War II are the dominant source for agricultural soil amendments. And, of course, petrol products are the dominant source of fuel worldwide. The status quo of these processes reflect linear metabolisms. Materials flow in as inputs (e.g. synthetic soil amendments or petrol products), are transformed or metabolized (e.g. into nutrients for plant growth or energy), and materials flow out as outputs (e.g. runoff or emissions). Organics recycling facilities provide infrastructure that begins to bend these linear systems into loops.

Organics recycling facilities transform materials sorted and collected by household separation practices, curbside bins, and collection fleets. Transformed materials are then used as inputs into systems that provide food for household consumption (i.e. compost for agriculture), or that provide collection services (i.e. biogas for fleets). The use of these materials in place of synthetic fertilizer and petrol fuels reduces or potentially eliminates the outputs as pollution. Thus, organics recycling facilities are nodes that disrupt linear food systems and link otherwise disconnected linear systems such as food, soil treatment, and fuel.

### **Food Waste Folly: Environmental and Economic Impacts**

Food is wasted at every stage of the linear food system. Food is left on the fields for its imperfections falling short of grocer standards. Food is spoiled and damaged in transport to the grocer or the processing plant. More food still is never sold but serves its purpose to give the appearance of abundance on the shelves of grocery stores. Even food that finds a home, hand

selected by the consumer, is so often forgotten or left to rot in the refrigerator drawer. In the developed world, the majority of food waste occurs in these last two stages, at the point of retail and household consumption (Gustavsson, Cederberg, Sonesson, Otterdijk, & Meybeck, 2011). While this dissertation focuses not on the generation of food waste per se, but on the development of new systems designed to reduce the environmental impact of food waste and importance of household behavior in the success of those systems. The remainder of this chapter will elucidate the environmental and economic consequences of food waste in the developed world that organic waste policy must address. *Environmental Impact*

It is a common misperception that food waste in landfills is inherently innocuous; that food is comprised of natural organic matter and will decompose in a landfill as it would "in nature". This process is far from benign. Because of the anaerobic (i.e. oxygen-free) conditions of the landfill and the sheer scale of these sites, organic matter decomposing in landfills has important environmental consequences. I will argue that in a closed-loop food system, these consequences could be ameliorated and in some cases altogether avoided.

The current linear food system generates unnecessary greenhouse gas (GHG) emissions, loses the nutrients and energy in food to landfills and wastes the resources used to generate the food in the first place. The EPA estimates that 97% of the more than 35 million tons of food waste generated in the U.S. finds a final resting place in landfills. Once there, it generates a quarter of the country's emission of methane, a potent greenhouse gas with twenty times the heat-trapping power as carbon when released into the atmosphere (U.S. E.P.A. 2013). Currently only a quarter of landfills have infrastructure meant to capture methane on site (U.S. EPA, 2011) and most of these are designed to flare the methane to merely reduce its impact on the atmosphere, rather than capture it for energy use.

Not only detrimental to the atmosphere, organics in landfills can result in polluted waterways by producing an acidic liquid as organics decompose. Worse, this liquid can become toxic as it leaches heavy metals from other materials in landfills (U.S. EPA, 2014). So-called 'modern landfills' are required by RCRA Subtitle D to have liners meant to slow the flow of leachate into soils and ultimately waterways and aquifers; however, as landfill liners deteriorate, this leachate seeps into soils and threatens local groundwater. Unfortunately, despite "modern" landfill technology, the US EPA considers this deterioration and the subsequent unleashing of leachate an inevitable stage in the life of a landfill (U.S. EPA, 1988).

Dumping food waste in landfills also fails to utilize the valuable nutrients and energy. Transforming food waste and other organic matter into nutrient-rich compost or soil amendments reclaims and redirects these nutrients toward the growth of new food. Applying compost to the soils has additional benefits, especially in water-scarce regions like California. Compost improves the water-holding capacity of soils by 30% (WSU, 2016; CalRecycle, 2016) and reduces surface evaporation, better preserving the water that is used (Gould, 2015; CalRecycle, 2016). This is one of the reasons that the California Department of Transportation (CalTrans) is a major consumer of compost. The agency has continuously increased the compost coverage of the more than 230,000 acres of roadsides they manage (Larimore & Balzer, 2007). The fivefold increase in compost use came even before the latest expansion in processing facilities across the state (CalRecycle, 2012; Larimore & Balzer, 2007). This transformed material saves the drought-stricken state millions of gallons of water.

With transformed food waste to fertilize our soils, our farmers and homeowners could reduce their use of synthetic fertilizers. Residue from these synthetic fertilizers flows from agricultural, residential, and industrial applications into waterways. This runoff has contributed

to the eutrophication of waterways in which an excess of phosphates promotes rapid growth and decay of algal plant life, leading to hypoxic water where nothing else grows (Kennedy, Cuddihy, & Engel-Yan, 2007; Novotny, 2010). The National Oceanic and Atmospheric Administration considers nutrient pollution a significant threat to wetlands and estuaries, noting that “most excess nutrients come from discharges of sewage treatment and septic tanks, stormwater runoff from overfertilized lawns, golf courses and agricultural fields.” (NOAA, 2008). Proper application of recycled urban nutrients from food and human waste “could replace 35-45% of fertilizer needs” (Forkes, 2007, p. 75).

Anaerobic digestion (AD) is another technological solution for transforming organic waste. AD works like a cow's stomach, green waste is used as an input and microorganisms in the tank transform organic materials into methane gas and carbon. In this process, all of the gas is captured, unlike landfill gas capture programs.<sup>6</sup> The captured gas from AD is then used as an energy source, powering everything from water treatment plants to garbage collection trucks. For instance, biogas from a new AD facility in Perris, California is being used to power waste collection fleets, replacing the diesel trucks that once traced the neighborhoods of Costa Mesa and other southern California cities.

This not only eliminates GHG emissions from diesel trucks and organics in landfills, it also has immediate air quality and health impacts on the communities that these diesel trucks frequented each week. Tiny particulate matter from diesel exhaust has been linked to poor human health outcomes; everything from increased asthmatic symptoms to complications during pregnancy to life-threatening cardiovascular diseases (U.S. EPA 2016a). The EPA estimates that particulate matter from diesel exhaust alone accounts for an additional 15,000 premature deaths

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<sup>6</sup> "Landfill gas capture can be flared, used to generate electricity, replace fossil fuels in industrial and manufacturing operations, or upgraded to pipeline-quality gas where the gas may be used directly or processed into an alternative vehicle fuel." (U.S. EPA 2016d)



each year (U.S. EPA 2016a). Transforming food waste, using it as an input for another process rather than treating it as merely an output of a linear food system, is a key step in closing the loop on food systems. Widespread use of these transformed organic materials has the potential to improve water quality, reduce our dependence on fossil fuels, and improve public health by reducing exposure to toxic chemicals and diesel exhaust.

So-called "end of the pipe" degradation is not the only concern in understanding the environmental impact of food waste. Each pound of food that is wasted embodies the resources that were put into producing, transporting, and storing that food as it passed through the food system. That means that the fuel used to power plows, the water used to grow, the fuel and energy used to transport and refrigerate that food in warehouses, groceries, and even our own homes, are all wasted. This is doubly true for food that undergoes value-adding food processing. Processed foods include many items in our kitchens from jams and pickles, to bags of pre-washed lettuce and frozen dinners, to take-out and even home-cooked meals.

Every step of the food system takes energy and water. The more processing that food undergoes, the more energy and water that is used in bringing it to our plates, and the more energy and water that is wasted when it is not consumed. When we see food waste we should also see the wasted energy, water, and land that served as input to producing, distributing, preparing and preserving that food. We should see the miles it traveled and the labor that brought it into being. Landfilling food waste then, only adds insult to injury. While transforming food waste into new inputs in a closed urban food systems will not undo the losses suffered from the unnecessary inputs, it will improve the net effect of food waste. Unfortunately, the longer the commodity chains (Conca, 2001), the stronger the distancing effect (Princen, 2002; Clapp,

2002), both in terms of production and disposal systems, severing the feedback loops that communicate the loss and damage wrought with each strawberry left to rot.

**The Economics of Food Waste.** Economic considerations tend to focus on the "end of the pipe". Yet the economic impacts of food waste are perhaps most salient in the financial toll it takes on farmers. Approximately 7% of food that is grown is left to rot in the fields (Bloom, 2010), for reasons ranging from crop failure, to labor shortages, to retail standards of appearance that only accept perfect parsnips and beautiful broccoli. For the Georgia Fruit and Vegetable Growers Association in 2011, labor shortages alone cost the state \$140 million (NRDC, 2012).

Of course, food is lost at each stage of the food system. And these financial blows can hit different players in the food system depending on the point of food loss. Before food ever sits on a grocers' shelf, packers, food processors, and distributors each lose millions of pounds of food each year (NRDC, 2012). Of the produce that does make it to the store, an average of 10% of it will leave in a waste bin <sup>7</sup>(USDA ERS, 2009). This is in part due to overstocked displays. "Industry executives and managers view appropriate waste as a sign that a store is meeting quality control and full-shelf standards" (NRDC, 2012, p. 10). Indeed, food waste has been incorporated as part of the cost of doing business.

Some of this cost can be defrayed, but again, economic incentives shape the contours of food waste. For example, while grocers and restaurants can take advantage of existing tax codes that reduce business' taxable income by the amount of unsold food sent to landfills, tax deductions for donations are not so simple. While corporate grocers and restaurants can receive tax deductions for donating unsold food to qualified non-profit food recovery centers (USDA, 2016), small business owners depend on temporary bills that must be renewed each year. This uncertainty makes it difficult to put long term plans in place. Furthermore, the added cost in time

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<sup>7</sup> This figure ranges from 0.6% to 63% depending of product (USDA ERS, 2009)

and labor for packaging and coordinating the logistics of donation often outweighs the economic benefits (FDC, 2015).

If grocers have made food waste part of the cost of doing business, households seem to have made it part of the cost of homemaking. The average household spends between \$5,200-\$8,800 on food each year, and a quarter of that is never eaten (Bloom, 2010, p. 187). Fresh produce is the most commonly wasted food items in American homes, followed by dairy and meat (Bloom, 2010, p. 187).

The key features that emerge as drivers of household food waste center on the physical and social arrangements of daily life. Physical factors include zoning that separates grocers from residents, transportation to and fro, even the physical layout of grocery stores and the portions available in packaged food effect the amount and type of food purchased, the frequency of shopping trips, and the types of food production systems that are supported. Social factors that shape food waste in the home include changes in the labor market that find fewer households with a full-time homemaker (Strasser, 1999), expectations of how food is "supposed" to look (NRDC, 2012), social desires to maintain order in the home and to be a good provider (Visschers, Wickli, & Siegrist, 2016), and even habitual behaviors or routines (Evans, 2014). All this comes at a significant loss to families trying to balance the monthly budget.

**The Promise of Organic Processing.** Transforming food waste to be reused rather than forgotten in landfills also produces economic benefits. Waste haulers and recyclers have begun to collect separated food waste in cities across the U.S. and the developed world, not because of their verdant hearts, but because there is economic incentive to do so. Recology, the exclusively contracted waste-hauler in San Francisco, is generating a valuable product from the spoils of the city by selling its compost for landscaping, farmers, and vineyards in the region (Recology,

2016). Caltrans, a major consumer of compost, not only reduces the water used on roadside vegetation in drought-stricken areas, it also saves money it would have spent to purchase and transport the additional water precluded by compost use.

In some cases, the economic incentive to capture food waste takes the form of avoiding disincentives. The state of Vermont, for example, recently passed a statewide ban on household food waste in landfills that will go into effect in 2020 (Vermont DEC, 2016). Similarly, there are two California mandates driving cities and haulers to act on food waste. Preventing food waste from entering landfills by using compost and AD transformation will boost the state's reductions in GHG emissions which must be below 1990 levels by 2020 under California's AB 32 (CA EPA, 2014). More directly, AB 341 requires statewide 75% landfill diversion by 2020 (CalRecycle, 2012). With food waste comprising the single largest material stream entering landfills or more than 20% (U.S. E.P.A., 2014), OCPs are a clear tactic to avoiding future financial penalties under the mandate.

In many regions of the U.S., the most significant barrier to widespread food waste diversion is insufficient processing capacity (BioCycle, 2014a). CalRecycle estimates that in order to meet the 75% diversion mandate the state will need to "double [its] organics infrastructure" (BioCycle, 2014b). The state is overcoming this gap with the help of an expansive statewide grant and loan program for the construction of new processing facilities. Most of these new facilities are AD rather than compost, a trend driven largely by the relative challenges of obtaining permits for compost compared to AD. There are still further subtleties that could tilt California to AD. One significant consideration is that composting contributes more emissions while AD replaces fossil fuels. (CA ARB, 2015).

California currently recycles 10 million tons of organic wastes with just over half processed in the 140 composting facilities (BioCycle, 2014b). This green infrastructure not only aids cities in closing the loop on urban food systems, it provides an additional boon to job growth. CalRecycle estimates 100,000 new jobs related to organics programs (BioCycle, 2016). Other states have seen job growth that supports these estimates.

"Based on ILSR's research for Maryland, for every one million tons of organic materials composted (and not disposed) at a mix of small, medium and large facilities — with the resulting compost used in-state — almost 1,400 new full-time equivalent jobs could potentially be supported, paying wages ranging from \$23 million to \$57 million. In contrast, when disposed in Maryland's landfills and incinerators, this tonnage only supports 120 to 220 jobs." (BioCycle, 2014a)

The new bins and trucks and processing facilities of an OCP often come at a cost. For most cities in the U.S., contracts with waste haulers result in some increase in service fees to the resident. On average, residents are paying between \$20-25.00 per month for collection services that include food waste. Residents served by the Costa Mesa Sanitary District in Orange County California, for example will pay an increased \$1.95 each year on average (CMSD, 2015).<sup>8</sup> Seattle charges about \$5 per month for their mandatory organics cart collection and was the first city in the country to fine residents for food waste in the regular trash cart--albeit \$1.00 (SPU, 2016). Portland charges about \$25.00 per month for a bundled compost, recycling and trash cart pickup service.

Other cities have innovated collection schemes that maintain the number of trucks on the road and thereby reduce the cost of OCPs. After a successful and informative pilot program, the City of Portland, Oregon implemented weekly collection of organics and biweekly collection of landfill waste (City of Portland, 2016). Instead of three trucks on the roads each week, the city

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<sup>8</sup> CMSD was the first client to agree to feed the waste hauler's new AD facility and entered into an evergreen contract to secure a low rate (CMSD, 2015). In fact, the Sanitary District was ultimately guaranteed that their residents would pay the lowest rate of the dozens of cities anticipated to contract with the hauler for OCPs (CMSD, 2015).

has only two trucks for recycling and organics each week and a third for landfill every other week. Ultimately this scheme is also intended to function as an incentive to use the organics carts (City of Portland, 2016). As anyone who has left their kitchen garbage sit too long knows, you do not want your food waste sitting in the bin for two weeks.

### **Subsequent Chapters**

The remainder of the dissertation outlines the urban metabolism framework, and argues for the need to transform both the systems of provision and household practices in order to transition to closed loop urban food metabolisms. In chapter 2, I ground the concept of closed-loop systems in the urban metabolism literature. I discuss the evolution of thought on urban metabolism and its usefulness as a framework for transitioning to closed-loop urban food systems. I then discuss existing examples of closed-loop systems from the domain of water, and the solutions and barriers to closing the loop on food systems. Finally, I discuss critical considerations of development and demography in defining appropriate efforts to transition to closed loop food systems.

In Chapter 3, I discuss different sources of change (e.g. private sector, local action, top-down governance) and the influence of policy framing on shaping the policy responses by local and state actors. This chapter argues that systems thinking in the highest levels of policy-making will drive the transition to closed-loop systems. I first discuss arguments in the literature for the virtues and vices of transformations initiated by local-level and regional decision-making and the private sector. Many scholars point to the need for state-level command-and-control policy to transform urban systems. I then examine how policy framing has defined the problem of organic waste, and so, the perceived available solutions, thus guiding local action in the pursuit of particular goals. Subsequently, I argue that policy interventions (principles, instruments, and

incentives) derived to meet these goals have then shaped food waste management systems in the U.S. and the U.K., with special attention to federalism in U.S. policy innovation. The chapter closes with a discussion of the effects of the scale of waste management on feedback effects from system impacts.

In the following chapter, I argue that understanding the determinants of waste generation, and sorting behavior household behavior change is critical to the success of source separated organics programs and. I first examine previous research on the predictors of household food waste generation and sorting behaviors. Then, I outline the evolution of the Theory of Planned Behavior and its applicability to the domain of food waste. Finally, I discuss conventional policy approaches to change household behaviors (e.g. information campaigns, punitive measures) and research from social psychology testing new social innovations to change behavior. Gaps in the research are addressed throughout.

Chapter 5 presents the Methods and Results of the two-part community-based experiments. I open the chapter by discussing the case study: the Costa Mesa Sanitary District. I then define the hypotheses, outline the research design, and present results from the two-part experiment. Chapter 6, analyzes the findings and articulates the contribution to different bodies of literature including social psychology and urban political ecology. A discussion of the study limitations then close the chapter. The final chapter identifies the policy implications of this research, tips to cities for successful OCPs based on the research, suggested lines for future research, and closing thoughts on the larger argument of the dissertation.

## CHAPTER 2

# The Urban Metabolism Framework

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## **Metabolism: The Evolution of a Concept**

The roots of metabolism as a concept run deep; tracing lines through early life sciences, engineering, and social sciences. Swyngedouw (2006) links the development of 'metabolism' and 'circulation' as concepts to advancements in scientific understandings of chemistry and the body. For instance, Swyngedouw (2006, p. 28) evokes Antoine Lavoisier's 18th Century discoveries of chemical reactions as "(metabolic) transfigurations or rearrangements of components that in the process produced qualitatively new assemblages, but in which nothing was lost or disappeared" (2006, pp. 28-29). Later, William Harvey's (1628) ideas of "double circulation of blood in the vascular system of the human body" ultimately became accepted by the medical community and formed the basic premise of 'circulation as an infinite circular process' (Swyngedouw, 2006). These discoveries elided the conceptual tools for circular metabolic processes that define modern ecology.

"The 'circulation' and the 'metabolism' of matter became fused together as the two central metaphors through which to capture processes of socio-natural change, and of modernity itself" (Swyngedouw, 2006, p. 29).

From these early conceptualizations, urban metabolism has emerged and survived a series of applications in human ecology, industrial ecology, and urban political ecology. Each iteration has limitations and has been shaped by society's contemporaneous relationship with nature (Wachsmuth, 2012). Indeed, "the conceptions of urban metabolism have changed as urban metabolism has changed" (Wachsmuth, 2012, p. 520). In support of this argument, Wachsmuth draws on Fischer-Kowalski's (1998) comprehensive history of urban metabolism in the social sciences and Keil and Graham's (1998) periodization of market-driven society-nature relationships.

Human ecology is the first "ecology" in Wachsmuth's treatment of the evolution of urban metabolism. This approach is reflected in the Chicago School at the height of the early industrial period. In both the urban metabolism concept and in popular thought at the time, "the natural environment itself is simply a backdrop to a purely social process of urbanization" (Wachsmuth, 2012, p. 519).

"A purely social urban metabolism, endlessly growing but nevertheless self-contained, only became a plausible idea once cities were sufficiently large as a result of rural-urban migration, sufficiently autonomous as social realms, and sufficiently significant in the general course of social life" (Wachsmuth, 2012, p. 512).

Industrial ecology then developed urban metabolism research in a context of Fordist thought in which "nature is the source of the urban metabolism's fuel and the destination for its wastes" (Wachsmuth, 2012, p. 519). Finally, in the post-Fordist context of urban political ecology, Wachsmuth (2012, p. 513) argues, "nature can no longer be tenably understood as outside the city, but is fundamentally incorporated into its further development." Here, the concept of urban metabolism is "process-oriented" and recognizes the interaction of local, regional, and global "socio-natural systems" in (re)producing the city (Wachsmuth, 2012, p. 519).

The concept of urban metabolism in industrial ecology has been used to describe the flows of resources into, through, and out of a city (Kennedy, Cuddihy, & Engel-Yan, 2007; Wolman, 1965; Novotny, 2010). Abel Wolman, a civil engineer, first revived the concept responding to significant environmental degradation from the rapid urbanization of the mid-twentieth century (Wolman, 1965; Kennedy, Cuddihy, & Engel-Yan, 2007). Novotny (2010, p. 1) summarizes Wolman's urban metabolism as a process by which "resources (water, food, energy, materials, and chemicals) are delivered to an urban area, metabolized and changed to outputs". These outputs are characterized as wastewater, runoff, and solid waste and can flow in

linear or circular metabolic processes (Novotny, 2010). Yet Wolman's language here implies a linear process in that outputs are not characterized as inputs into another process. Later, Kennedy et al (2007, p. 44) defined urban metabolism as the "sum of technical and socio-economic processes that occur within cities, resulting in growth, production of energy, and elimination of waste".

Urban metabolism is a useful framework for understanding and defining a sustainable city (Kennedy, Cuddihy, & Engel-Yan, 2007; Novotny, 2010). Through this lens, a sustainable city is one in which the flows of inputs and outputs of an urban region do not surpass the capacity of the hinterlands to support it (Kennedy, Cuddihy, & Engel-Yan, 2007; Wolman, 1965; Novotny, 2010). This balance is key to determining the sustainability of a city (Novotny, 2010). A circular or closed-loop urban metabolism can reduce demand for inputs and burdens of waste absorption by increasing reuse of resources and preventing waste generation.

The sustainability of a city has also been understood as an ecological footprint. This is the amount of land and water needed to support all urban processes for a particular city (Novotny, 2010; Rees, 1997). Novotny explains that the size and density of a population and the per capita resource consumption determine the ecological footprint of a city, with generally smaller footprints as density increases (2010, p. 7). The degree of linearity or circularity of urban material flows impacts the ecological footprint. For instance, a city with greater reuse of resources and prevention of wastes will require less land and water for production of new materials, and therefore have a smaller ecological footprint.

The industrial urban metabolism literature provides useful conceptual models for framing the flow of materials into, through, and out of cities, and the relative ecological footprint those cities have as a result. Linear and circular systems are distinguished by the nature of inputs, the

metabolic processes, and the levels of outputs as waste and pollution.<sup>9</sup> In a model outlined by Novotny (2010), the linear system relies more on "depletable" resources whereas the circular system utilizes "renewable" inputs. The metabolic processes within the city are not well defined in the linear model but as a throughput of inputs directly to outputs. The circular model emulates ecosystems in the following way.

"The output of one organism is the input to other species, organic matter provides energy and elements of growth, and in the final outcome the matter is broken (decomposed) to its original mineral forms and organic residues" (Novotny, 2010, p. 3)

The metabolic processes in a circular urban system recycle organic and inorganic wastes for reuse within the system, thus reducing waste and pollution generated. Waste prevention efforts at the inputs and metabolism stages (e.g. production, distribution, and consumption) also obviate both recycling and waste disposal and further reduce the ecological footprint of cities. Contrarily, the outputs of the linear model dump liquid wastes, emissions, and solid wastes in the hinterlands of the city.

The study of flows in urban metabolism research tends to focus on water, energy, materials, and nutrients (Ferrao & Fernandez, 2013; Pincetl, Bunje, & Holmes, 2012; Kennedy, Cuddihy, & Engel-Yan, 2007; Hermanowicz & Asano, 1999). In this context, nutrients may be food entering the city, the nutrients in wastewater leaving the city, synthetic nutrients applied to agricultural lands that support a city, and even the chemical byproducts of other urban processes such as nitrogen emissions from transportation (Kennedy, Cuddihy, & Engel-Yan, 2007; Novotny, 2010). The flows may be affected by the age of the city and its infrastructure, the particular climate and population density, the stage of development, and cultural factors (Kennedy, Cuddihy, & Engel-Yan, 2007).

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<sup>9</sup> Indeed, given that recycled wastes become inputs for new processes, these systems also differ in the level of inputs demanded from the 'hinterlands'.

**Conceptual Tools from Urban Metabolism.** Growth and accumulation are two additional processes identified as critical to urban metabolism within the industrial ecological paradigm;. Kennedy et al (2007, p. 56) emphasize that "growth implies a change in storage". Storage, or accumulation, is a process by which flows of inputs are stored in urban areas or their hinterlands (Kennedy, Cuddihy, & Engel-Yan, 2007; Ferrao & Fernandez, 2013). Accumulation may manifest in any of the urban flows. For example, it may be "water in urban aquifers, heat stored in urban canopy layers, toxic materials in the building stock, and nutrients within urban waste dumps" (Kennedy, Cuddihy, & Engel-Yan, 2007, p. 44). This metabolic process is typically characterized by environmental degradation. Processes of accumulation may also be characterized by depletion, as in the case of urban aquifers (Kennedy, Cuddihy, & Engel-Yan, 2007).

For the purposes of this dissertation, the flow, growth, and accumulation of nutrients is of particular interest. In terms of nutrients, urban metabolism research in industrial ecology tends to focus on nitrogen and phosphorous (Kennedy, Cuddihy, & Engel-Yan, 2007). The majority of nitrogen flows emanate from transportation (Kennedy, Cuddihy, & Engel-Yan, 2007). Flows of phosphorous, on the other hand, are primarily accounted for in food production, import, and consumption (Bjorklund et al 1999 & Baker et al. 2001 as cited in Kennedy, Cuddihy, & Engel-Yan, 2007). Nutrients may be stored or accumulated in ground water, soil, or disposed of in landfills. Nutrients can also be accumulated through nutrient cycling or recycling, as when food waste is transformed into compost or biogas.<sup>10</sup> Yet, more than half the nutrients in the cities never leave the system (Kennedy, Cuddihy, & Engel-Yan, 2007). Most of these nutrients are instead transformed into outputs and accumulated in landfills, agricultural soils, and groundwater (Kennedy, Cuddihy, & Engel-Yan, 2007).

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<sup>10</sup> Globally, however, few cities do so.

It is not only the magnitude of flows and accumulation that is of interest for defining a sustainable city in the urban metabolism framework, but the nature of changes in accumulation. For instance, scholars of urban metabolism identified nutrient recycling as a necessary part of sustainable urban nutrient management. Girardet's study focused on balancing the "fertility exchange" between urban and rural peripheries (as cited in Kennedy et al. 2007). However, this relationship may be too narrow in scope for the global food markets supporting cities today. Kennedy et al. argue (2007) that contemporary urban areas often draw inputs from beyond the immediate periphery. The model, then, must be expanded to consider the larger region--even global in scope--upon which the city draws inputs and disposes of outputs (Kennedy, Cuddihy, & Engel-Yan, 2007).

Cities in the developed world, and increasingly in the developing world, receive their agricultural products from a continental or global market. Global food markets create a tension between distance of food traveled, food waste and compost generated, and proximal compost demand. For instance, the resources necessary for delivering compost to be applied where the food was sourced from (in order to achieve balanced fertility exchange) are prohibitive in a global food market. Even if compost were directed locally to subsequent radii of agricultural land surrounding a city, the distance that compost was transported would increase with the city's population and density. That is to say, when the inputs of food are globally sourced, the food waste generated by a city will grow faster than the demand for compost in the immediate hinterlands. That means that as food waste recycling in a global food market city approximates complete, the distance that compost would need to be transported to be used on agricultural land would increase beyond cost-effectiveness.

This tension in nutrient flows where food inputs greatly supersede local demand for compost may be alleviated by alternative processing. Utilizing AD facilities in addition to compost facilities may be necessary to achieve sustainable nutrient management in the face of global food markets. Transforming food waste into fuel for the region where the food waste is generated (rather than where the food is sourced from) may reduce the miles traveled by, and so the cost of, food waste in a nutrient recycling scheme. The right balance of compost and AD facilities is dependent on the relative demands of fuel and more soil amendments (e.g. compost, chemical fertilizer). This balance is likely also dependent on the sum of other metabolic processes in a given region.

The first iterations of urban metabolism in social theory are rooted in Marx and Engels' accounts of the transformation of natural capital through labor (Swyngedouw, 2006). For Marx, labor is "...the activity through which the metabolism between man and nature is mediated (Marx 1861-1863)" (Swyngedouw, 2006, p. 26). For the purposes of this dissertation, the concept of "labor" will be expanded to include the everyday behaviors and sets of routines that households engage in, especially as they pertain to the transformation of household food inputs into outputs (i.e. human waste, or materials placed in trash or composting conduits).

The early intellectual effort of Marx and Engels illuminated the social and political processes of (re)producing the urban and the power relations inherent in those processes. Ultimately, Swyngedouw argues that the theoretical position Marxist social analysis falls short of a socio-ecological theory in its "over-emphasis on the social relations under capitalism that...tended to abstract away from or ignore the material and socio-physical metabolic relationships" (Swyngedouw, 2006, p. 27).

**Circulation and Circular Metabolism.** Circular flows of food waste emerge in this context of global capitalism only insofar as these new (i.e. redirected) flows can be monetized, understood, and socially-mobilized through the framework of a capitalist economy.

"Metabolic circulation...now firmly rooted in generalized commodity production, exchange, and consumption, is increasingly subject to the socially constituted dynamics of a capitalist market economy in which the alpha and omega of the metabolic circulation of socio-ecological assemblages is the desire to circulate money as capital" (Swyngedouw, 2006, p. 31)

So long as private haulers orient their goals toward perpetual growth of profit, they will be incentivized to collect and redirect the flow of food waste to reduce circulation-preventing 'blockage' (Swyngedouw, 2006) that occurs from otherwise valuable materials accumulating in landfills. In the context of capitalist-economies, however, "'circulation' has become less and less identified with closed circular movement, and more with change, growth, and accumulation." (Swyngedouw, 2006, p. 30). The danger here, is that circulation without the goal of circular metabolism may revert to linear processes of merely circulating (i.e. movement of) organic materials as capital. As externalities are externalized (Dauvergne, 2010) to reduce costs and maximize profit, the waste and pollution of linear systems that spurred Abel Wolman's (1965) early research on urban metabolic processes return.

Sennett writes on the historical emergence of 'motion' as the "first principle of the free society" (Swyngedouw, 2006). He points to the Baroque emphasis on circulation for the sake of ceremonies of movement toward an object, and the Enlightenment planner's understanding of motion as an end in itself. What is needed now, in contrast, is to turn toward motion (i.e. or circulation) as a means to an end. Not an end so superfluous as ceremony nor as mundane as getting laborers to work on time. Instead, using the same medical imagery of circulation adopted by Enlightenment planners (Swyngedouw, 2006), we can think of the ends toward which motion



moves as the healthy functioning of the urban body, its nourishment. Here circulation would be oriented toward the continued metabolism of organic materials (and the nutrients and energy embodied therein) in the re-production of urban spaces that nourish the human bodies and the fertile soil that urban spaces depend on.

Material flows must be free from 'blockage' as Sennett (1994) and Corbin (1994) have argued (Swyngedouw, 2006). Above, blockage was discussed in terms of severing the circulation of organic materials by their internment in landfills. Blockage can also occur on account of impurities in material flows. Contamination of glass or plastic in food waste streams, for instance, results in materials flowing to landfills instead of organics processing facilities. Thus, the continued circulation of organic materials is severed.

Insofar as contamination prevents material from being transformed into new system-inputs (i.e. soil from compost or fuel from AD), it constitutes blockage. Source separation of household organics can be seen as a socio-ecological process intended to reduce contamination and the resultant blockage, promoting circulation. This process depends on new relationships and new labor arrangements between households and the organic materials therein. Successful circular urban food metabolisms depend on householders accurately "placing" food (Evans, 2014) and subsequently (re-)producing the socially-mobilized flows (Swyngedouw, 2006) of food waste into appropriate conduits (Evans, 2014) enabled through supportive systems of provision (Bulkeley & Askins, 2009). Thus, household behavior is the linchpin in reconfiguring the social organization of circular food waste flows in the city.

Urban metabolism provides a lens through which we can understand the sustainability of a city as the impacts of nutrient flows and accumulation over time. As a general trend, cities have been increasing resource use (inputs) and increasing waste (outputs) (Kennedy, Cuddihy, &

Engel-Yan, 2007). Transforming the linear urban food system into a closed-loop system may mitigate this trend. To abate the flow of nutrients into accumulated waste, the closed-loop system must prevent food waste, redistribute uneaten food to the hungry, and capture wasted food to be transformed into inputs for another process (e.g. compost or biogas). The status quo, however, is characterized by a linear food system and has important environmental, economic, and social consequences. The following section will examine key drivers that brought about the modern linear food system.

### **Closed-Loop Water Systems**

Efforts to close the loop on other resources have shown some success. Water, for example, has received significant attention in this regard (Hermanowicz & Asano, 1999; Nelson, 2008; Zoltay, Vogel, Kirshen, & Westphal, 2010; Daigger, 2009). Closed-loop water systems have also been referred to as "adaptive regenerative design" (Barraclough & Lucey, 2009), "integrated resource management" (Corps et al 2008; O-Riordan et al 2008), or "advanced integrated urban water and waste management systems" (Daigger, 2009). Each of these approaches attempts to close the loop on resource flows through principles of systems-thinking, conservation, highest and best use, and linking outputs of one process to inputs of another. By ensuring adequate supply and equitable access to clean and safe water, closing the loop on water resources increases the resilience of a city.

**Innovations to Systems of Provision and Household Practices.** To aid in this effort, Daigger (2009) outlines a water management toolkit of technical and social innovations including rainwater harvesting, conservation, and reclamation to avoid water supply shortages. He also identifies technologies and management strategies capable of capturing heat energy and nutrients in wastewater such as anaerobic digestion and land application. Source separation

infrastructures maintain different flows for different wastewater sources (i.e. kitchen, black and yellow). This enables their highest and best reuse. Furthermore, these tools can be used in various combinations and levels of decentralization or centralization depending on the local constraints and opportunities.

**Contextual Factors.** Daigger (2009) argues that the stage of development and the demographic transition shapes the challenges and appropriate solutions from the toolkit to draw upon. These contextual factors will be discussed in greater detail in the following section. Ultimately urban water systems should be designed to deliver equitable access to adequate supply of clean and safe water (Daigger, 2009). Growing populations can strain existing infrastructure and water supplies, and may likewise pose threats to public health if wastewater systems become overburdened. The level of development and economic solvency of an urban area determine the capacity to respond to these challenges with different solutions. The key take away for this discussion is that the toolkit is meant to empower urban areas to close the loop on urban water systems by addressing the challenges of adequate and equitable urban resource flows--a reflection of the economic and population characteristics.

**Triple Bottom Line.** Together, these tools can achieve the "triple bottom line" of sustainable water systems (Daigger, 2009). That is, a system that considers environmental, economic, and social impacts. From an environmental perspective, water management systems should maintain a sustainable local water supply where recharge exceeds net withdrawal, be energy neutral and capture nutrients (Daigger, 2009). Furthermore, water utilities should be financially stable enough to maintain their infrastructure, and socially responsible enough to provide access to the changing demands of the population growth.

**Barriers.** The barriers to advancing a closed-loop water system are many; informational, economic, institutional, and existing infrastructure among them. As examples of closed-loop experiments proliferate, future research must endeavor to quantify the benefits of specific approaches in different contexts. Daigger (2009) admits a lack of proper economic evaluation of some of the alternatives in the toolkit. Large scale nutrient recovery, for example, is not as widespread as water reclamation and conservation efforts. This limits the ability to provide realistic estimates for the economic benefits of these systems for a given locality.

A further economic constraint not discussed by Daigger, lies in the diversity of standards of living within the same country. Conca (2001) argues that national measures of development obscure within-country and even within-region disparities. Indeed, the challenges and capacity to respond will differ greatly between cities like Flint, Michigan and Santa Monica, California, for example. In the same state, furthermore, some cities may be able to institute new building codes requiring low-impact development for permeable pavements and bioswales. Whereas neighboring cities may be economically depressed and desperate to attract new development, rendering these same measures unviable. Even within the same city, resources may be disproportionately devoted to some areas over others.

Social or political barriers also differ greatly within the same region or country. In the drought-stricken region of Southern California, for instance, water districts in Orange County have successfully operated large scale water reclamation projects for nearly 40 years (OCWD 2016, U.S. EPA 2016h). Yet when Los Angeles Department of Water and Power prepared to announce the completion of an indirect use water reclamation project in 2000, the idea was squashed in the public imagination with three words; "Toilet to Tap" (Fleischer, 2014). The project, which was approved just five years prior, would have captured billions of gallons of

water to be recycled for drinking water each year (Fleischer, 2014). The sudden campaign against the project leveraged psychological responses of disgust and contamination to turn public opinion off of recycled drinking water (Rozin, Haddad, Nemeroff, & Slovic, 2015).<sup>11</sup>

Additional challenges lie within the institutional arrangements within which urban water systems are managed. Daigger (2009) argues that the profession of water managers is plagued by a state of "stove-piping" in which there is no single entity responsible for water management. Instead, different utilities are responsible for "storm water, water supply, and water management" (Daigger, 2009, p. 821). Similar challenges face other urban resource flows. The professional entities overseeing the food system span agriculture, distribution logistics, retail, charity organizations, waste hauling, and organics processing facilities. Furthermore, each of these professions may fall under different scales of government regulation and oversight. This fragmentation serves to obscure the systems-thinking perspectives that support sustainable solutions (Daigger, 2009). But Daigger is optimistic. He characterized these institutional barriers as "within the control of the profession" to change (Daigger, 2009, p. 821).

Daigger's approach engages in systems-thinking by taking into account not only each stage of urban water systems, but also how the flows of this system can be linked to other critical resource flows (i.e. nutrient cycling). It espouses highest and best use by promoting separated water flows so we can finally stop flushing drinking water down the toilet. Finally Daigger's toolkit addresses not only "end of the pipe" solutions, but "top of the pipe" as well. It emphasizes the need to capture what would have been waste in order to transform it into another input, and the need to reduce waste in the first place.

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<sup>11</sup> These efforts were thought to be fueled by a contested mayoral election that saw the overnight shutdown of the newly minted facility by City Attorney Hahn, who also ran for mayor that year (Connell, 2008).

A practical example of the implementation of this toolkit is found in the Dockside Green development, formerly a 15-acre brownfield site in the heart of Victoria City on Vancouver Island, BC.

"The principles of this design were to use as little potable water on site as possible, treat, reclaim and reuse water wherever possible both inside and outside of the buildings, minimize the impervious surfaces on site to eliminate stormwater runoff, and use all water in a beneficial way to restore ecological function on the site." (Barracough & Lucey, 2009, p. 31)

These guiding design principles have resulted in minimal water use (below 66% of baseline LEED standards), lower water and energy bills for residents, and a net positive energy generation (Barracough & Lucey, 2009). City-wide and regional manifestations of these same design principles are exemplified elsewhere.

The city of Peterborough, UK is the first to adopt a city-wide 'circular economy' approach. The city is leveraging concepts of "systems thinking, urban metabolism, and biomimicry...[in] the development of a collective roadmap and action plan owned and tailored by the various groups and stakeholders" (Peterborough DNA, 2016). Integration and grassroots are key to the city's strategy. Toward these ends, the city has helped develop a network for businesses to share under-utilized goods, hosted several Hackathons to develop smart city systems, invested in resident development of sustainability skills and attracted recent graduates (Peterborough DNA, 2016). By placing people at the center of the plan, Peterborough has taken a step beyond the industrial ecological approach to urban metabolism. Yet it falls short of the urban political ecological approach by distinguishing society and nature on the city's website.<sup>12</sup>

In Stockholm, Sweden, we see examples of a regional approach to designing for circular metabolisms where a cooperative of 25 regional municipalities manage water supply security

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<sup>12</sup> The website discusses the flow of "...[people,] materials, and energy *between* nature and society and within society" (Peterborough DNA, 2016).

(Beatley, 2000). This collaboration established regional coordination of supply, strict water protection areas, source-separated systems for wastewater treatment, and water and heat energy reclamation systems. Coordinating within bio-regional boundaries rather than political ones enables a whole-systems approach to problem solving (Ferrao & Fernandez, 2013). It also incorporates more stakeholders who would likely be impacted by watershed decisions which has the potential to reduce negative externalities to these populations.

### **Analogous Food Systems Solutions**

Closed-loop water systems provide a lens through which to imagine analogous systems for food. Indeed, in many ways, these and other urban systems intersect. Food, water, energy, and materials streams are interconnected and dynamic. Food depends on water for growth and water systems can be damaged by food waste in landfills. Energy is used in producing and transporting food and food waste can be used to generate renewable energy. This renewable energy from food waste can be used to power water recycling plants to more efficiently use accessible water. Packaging materials are used to transport and preserve food and these materials require energy and water to produce, recycle, or dispose of.

As is the case for water, closed-loop food systems must use principles of systems-thinking, linking outputs of one process to inputs of another, conservation, and highest and best use. Closed-loop food systems should be arranged to provide adequate supply and equitable access to safe nutritious food, making cities more resilient. Here, I will discuss approaches to closing the loop on food systems with Daigger's water systems case as an example.

As we saw with water systems (Daigger, 2009), changes must occur in the systems of provision (i.e. institutional and infrastructural arrangements) (Bulkeley & Askins, 2009) as well as everyday practices of households (Bulkeley & Askins, 2009; Evans, 2014; Gregson, Metcalfe,

& Crewe, 2007). These changes will demand technical and social innovations targeting food waste prevention, redistribution, and recycling at each stage of the food system. Innovations such as crop-monitoring drones for farmers, "inglorious produce" sections at grocery stores, social-network-based food donation, and organics recycling programs are already taking hold in some areas.

**Innovations to Systems of Provision and Household Practices.** Social innovations have begun to transform the grocery store produce sections where "inglorious" fruits and vegetables are now sold at a discount. This requires new institutional arrangements in which grocers now accept less-than-perfect produce from farmers, saving the crops from being left to spoil. New infrastructure in the stores keeps this produce separate from the rest to enable discount pricing. Finally, various media campaigns have helped to normalize this market in an effort to alter shoppers preferences to make room in the cart for the malformed, but delicious produce.

Looking to the "end of the pipe", technical innovations such as curbside collection programs and large-scale organics processing facilities convert food waste into inputs for another system (i.e. biofuels, compost). By providing a collection service, these systems reduce the burden on residents who would otherwise need backyard composting to keep food waste out of landfills. Social innovations at this stage are targeting education, participation rates, and accuracy among households in source-separated organics. As in the case of water, different levels of decentralization will help to close the loop, from backyard composting, to community composting, and regional organics processing facilities.

**Contextual Factors.** The social and technical innovations discussed above must take into account contextual ecological, demographic, political, and economic factors (Daigger, 2009).



These factors can affect the type and quantity of material in the waste stream (e.g. regional and seasonal variation in foliage production). Demographic factors such as rates of change in population and standard of living affect the quantity and type of local demand for food and food waste generated. Furthermore, political and economic factors shape the viability of public or private investment in infrastructure such as new organics processing facilities, or food redistribution channels. Community-to-School gardens in some regions, for example, may be an appropriate means of reducing financial and physical barriers to fresh produce and returning nutrients to the soil through composting. In other contexts, however, toxic residuals in soil and (scarcity of) water or the lack of social or financial capital to initiate or maintain such a project may prove prohibitive.

**Triple-Bottom Line.** In parallel with Daigger's (2009) analysis, food systems must meet the triple bottom line of environmental, social, and economic costs. In terms of environmental impacts, Daigger points to the recharge-to-withdrawal ratio to secure groundwater supplies. In the case of food, this would be a ratio of nutrients returned to the soil (i.e. through compost and other land application of organic wastes) to nutrients drawn from the soil through food production (Forkes, 2007). Here, nutrient capture is central to the success of nutrient recycling through land application.

Energy neutrality is another component of reducing environmental impacts of food systems, as in water systems (Daigger, 2009). New technologies such as anaerobic digestion generate fuel from food waste in the form of methane gas. Utilizing AD instead of incineration to generate energy from food waste avoids the negative externalities for environmental and human health that incineration generates (i.e. dioxins, particulate matter, and landfilled ash). Generating energy from food waste can reduce the net energy demands of the food system. As in water

systems, however, renewable energy generation must be coupled with conservation to approach energy neutrality.

Financial stability of food systems and equitable access to food are especially challenged by professional "stove piping" also present in water systems management (Daigger, 2009).

Unlike water systems though, the only stages of the food system operated by utilities are in municipal sewage and in some cases, waste collection. While financial stability and equitable access to services that maintain sewer and food waste systems is critical for the triple-bottom line of the circular food system there is no single entity responsible for food systems management. Food provision remains a complex arrangement of farmers, processing facilities, distribution centers, and retailers of diverse practices and scales supplying products to local, regional, and global markets. As with water systems, this complexity impedes a systems-thinking approach to closing the loop on urban food systems.

**Barriers.** Like efforts to close the loop on water systems, economic, institutional, and existing infrastructural arrangements pose significant obstacles. With limited examples at different scales of implementation (e.g. single housing unit, community, regional, or national) a dearth of data on the viability of these systems plagues efforts to attract investment. Disparities in standards of living within the same country, state, and even city define different food system challenges and local capacities to address them. The most pressing problem in some regions may be the unlabeled presence of genetically modified foods in stores or the struggle for more local food-sourcing. While other neighborhoods in the same city struggle with basic physical and financial access to fresh produce. Disparities in economic conditions within and between regions also make it difficult to determine how proven systems in one context could translate to different

settings. One city may be able to provide curbside OCPs, backyard composting bins, and training sessions to their residents while another struggles to provide adequate trash collection at all.

Institutional arrangements within and existing infrastructure of food systems are especially complex in the provisioning stages. Institutional complexities were discussed in the previous section. Existing infrastructure can limit alternative food provisioning strategies. Consider a city that is largely built out. The degree of accessible green space can limit opportunities to expand food production within city limits. "End of the pipe" institutional arrangements and existing infrastructure also pose challenges. Cities are often bound by their contracts with private waste haulers to provide sufficient "feedstock" of wastes to capital-intensive infrastructure such as landfills and incinerators (Van Heijst, 2013). This tends to lock-in path-dependent decision-making where previous investments and decisions limit the field of possible future decisions.

Political and social factors may also serve as barriers to closing the food system loop. Siting for new regional organics processing facilities may be prohibited by existing air quality standards and the pre-existing emissions load. For instance, siting compost facilities in Orange or Los Angeles County, California proved especially difficult because adding emissions from large-scale composting to the existing emissions load could put the region over limits set by the state Air Resources Board (CA ARB, 2015). The newest facility was sited in the Inland Empire which maintains lower baseline emissions. Social factors limiting efforts to close the loop may involve cultural norms, habitual behavior, or performance of identity through food production, consumption, redistribution, and disposal. These factors will be discussed in greater detail in Chapter 4.

**Food and Water Material Flows.** Distance is another important factor in considering food systems, and one that differs from water in important ways. Transporting food, food waste, or water across great distances can be very costly. For one thing, these are heavy materials. Food waste is wet, making it very heavy, though less so than water alone. This weight requires additional fuel and puts greater burden on roads or rail systems. But water has some advantages for long distance transport that food and food waste lack. The Romans figured out how to transport water great distances without the use of fossil fuels. Instead their aqueduct infrastructure took advantage of gravitational force and many modern day aqueducts rely on similar design principles. However, it is difficult to imagine such an elegant solution for the flow of food and food waste in urban systems. But while a fruit aqueduct may not be in our future, pneumatic tubes have proven successful for transporting wastes without waste trucks in Songdo, South Korea. The city was built on land reclaimed from the Yellow Sea and these tubes were incorporated into the city-wide design, a logistical luxury not available in most cities .

Water has another key beneficial characteristic that food lacks; time is on its side. While water can be collected and stored nearly indefinitely, fresh food has a very short shelf-life. Managing the flow of food in an urban system is a battle against the clock. To redistribute uneaten produce to the needy, food must be collected and transported, and needy populations need to be aware of and gain access to that food all before it starts to spoil. Refrigeration technology can buy time, but at a hefty energy cost. These energy costs in refrigerated storage and transport along with the race against time pose additional challenges to closing the loop on urban food systems that are not part of the accounting in water systems.

On the surface, it seems that food has a key advantage on water systems. We can grow more food, but we cannot make more water. Yet to grow more food, we need more water--or at

least to use existing water more wisely. And aside from costly desalination processes, water systems are dependent on what falls from the sky and what can be retrieved from the ground. Shortages in water systems trickle down to impact food production. A duration of shortages in rain fall and snow pack can be devastating for entire regions, and their trading partners. The latest California drought is an apt example. While new technologies and efficiency measures can improve the unit of food per unit of water ratio, food systems cannot be considered without considering the flow and storage of water. These systems are inextricably linked.

### **Stage of Development and the Demographic Transition**

Household-level behavior change is a necessary component of successful policies designed to shift urban areas in the developed world to a closed-loop urban metabolism. Many of the challenges that face efforts to close the loop on critical resources will require changes in the relevant systems of provision as well as changes in the everyday behavior of households (Bulkeley & Askins, 2009; Dietz, Gardner, Gilligan, Stern, & Vandenberg, 2009). This is especially true of the developed world (Thyberg & Tonjes, 2016; Daigger, 2009).

The stage of development and the progress in the demographic transition of a country are critical factors in determining what solutions are needed to close the loop on urban resource flows (Daigger, 2009). The demographic transition is a process by which a country shifts from high birth and death rates to low birth and death rates (PRB 2010). Meso-states of the transition result in rapid population growth as the decrease in birth rates lags after the drop in death rates. Furthermore, the demographic transition and development are intertwined processes.

Early discourse on global issues of sustainability focused on problems resulting from over-consumption, affluence, and economic growth; problems faced by and resulting from the economic conditions in the Global North. This was exemplified during the 1972 UN Conference

on the Human Environment (Conca, 2001). At the same time, political narratives of the problem of waste focused on curbing the mounting per capita waste generation (U.S. EPA, 2002). This discourse evolved to incorporate consideration for the “pollution of poverty” and the “sustainability of growth” in the Global South with the 1992 Brundtland Commission report (Conca, 2001, p. 54). Later, previous arguments against the false dichotomy of developed and developing countries came to the fore in discussions of environmental degradation (Conca, 2001; Dauvergne & Farias, 2012; Layzer J. A., 2010).

For example, the terms "middle power" or "emerging powers" have been useful in classifying world economic and military powers in the post-war era (Dauvergne & Farias, 2012). Among emerging powers, the BRIC nations (Brazil, Russia, India, and China) share distinctive characteristics.

"[E]xtensive area; large populations; status as regional 'pivots'; aspiration to a global role; growing economies; high GDP but relatively low GDP per capita; large domestic inequalities and high absolute poverty levels." (Dauvergne & Farias, 2012, p. 905).

Some argue that countries in this meso-stage tend to share similarly high levels of environmental degradation and low levels of political attention thereto (Dauvergne & Farias, 2012; Castán Broto & Bulkeley, 2012; Daigger, 2009; Layzer J. A., 2010; Thyberg & Tonjes, 2016).

By contrast, Conca (2001) cites Alan Durning (1992) in identifying a “Sustaining Middle”. This middle strata is defined by more sustainable patterns of consumption and livelihood. Populations in the middle consume lower amounts of grain-fed meat, more person-powered transportation, and more durable materials as opposed to throw-aways than countries at the top (Conca, 2001). The lifestyles of the "sustaining middle" are characterized by "rewarding social relations, meaningful work and enjoyable leisure activities, and are low in material throughput, energy use, and environmental degradation" (Conca, 2001, p. 68). The difference

here seems to be the unit of analysis whereas the Sustaining Middle seems to focus on the environmental impact of consumption patterns, the 'Emerging Powers' distinction seems to focus on production patterns and political efficacy.

Both Conca (2001) and Dauvergne & Farias (2012) argue that these strata may co-exist within a single nation or state and that negative externalities may disproportionately burden populations in the same city or on other parts of the globe. From the native tribes of North America (Dauvergne & Farias, 2012) to rural towns in Mexico and the U.S. (Conca, 2001),

"[t]he costs of consumption are drifting into the world's most vulnerable ecosystems and poorest societies as powerful states and corporations externalize the environmental and social costs from the majority of consumers" (Dauvergne, 2010, p. 3).

Indeed, economic and ecological differences within and between countries make it increasingly insufficient to consider the environmental impact of a single region or nation as though they exist in a vacuum. The flow of energy, water, and materials through urban systems often draws on inputs from global sources and may expel outputs as far afield (Princen, 2002; Clapp, 2002; Conca, 2001). The "shadows" (Dauvergne, 2008) of global commodity chains (Conca, 2001), consumption (Dauvergne, 2008), and waste (Clapp, 2002) reach beyond national boundaries and regulatory reach (Vogel, 1997). In fact, Dauvergne (2010) argues that of international trade has served to obscure the source and impact of production, consumption, and disposal, making accountability difficult to enforce. Poorly regulated e-waste recycling, for example, floods the developing world with the burdens of planned-obsolescence and hyper-consumption of new technologies in the developed world.

On the other hand, Vogel (1997) contends that international trade between developed and developing countries has resulted in a "California effect", actually increasing the environmental regulations on production to meet the standards of the richer nations. Vogel (1997) explains that

importers from poorer regions improve their practices to meet the standards of the markets in richer regions with more stringent environmental regulations as a condition of importing. Once these companies have invested in meeting these higher standards, they are more likely to push for more stringent regulations in their home region (Vogel, 1997). Bressers and Rosenbaum (2000) argue that a "learning curve" plagues environmental policy as the world continuously enters new territory of knowledge and action on environmental change and degradation.

"A 'learning curve' purchased with time is not only essential to prudent environmental policy-making, but the learning curve also involves the sharing and testing of policy strategies between governments within and between nations."  
(Bressers & Rosenbaum, 2000)

So, as the developed world experiments and implements new strategies to mitigate and adapt to the challenges of climate change, Bressers and Rosenbaum argue that these innovations must be shared with the developing world. Layzer (2010) echoes this imperative in highlighting the uniquely challenging situation of the developing world. South Korea's Korean Development Institute, for example, leads the international Knowledge Sharing Program to communicate lessons learned in the country's development experience with countries working through the that process (KDI, 2012). In this way, developed countries and their cities can make the learning curve a little less steep in the places that need it most.

The forces of population growth and rapid urbanization in the developing world demand change in the face of collapse. Cities in "middle-" and "lower- income" countries (U.N., 2014) will be the sites of the most significant growth in population in the coming decades. In fact, more than 90% of the world's population growth over the next 40 years is expected to occur in Asia and Africa (U.N., 2014). "Sustainable development challenges will be increasingly concentrated in cities, particularly in the lower-middle-income countries where the pace of urbanization is fastest" (U.N., 2014, p. 1). Rapid growth of urban populations in these countries will put



significant strain on infrastructure and flows of food, water, energy, and material waste (U.N., 2014). We see here some drivers of the steep learning curve to adapt, underscoring the need to share successful innovations from the Global North.

Of course, new environmental policy innovations cannot simply be taken from one context and dropped in another. Attention to the ecological, demographic, and development context is critical. For example, in his analysis of factors influencing appropriate water system solutions discussed above, Daigger (2009) identified four classifications based on changes in population and standard of living. First, developed countries may either have (1) constant or declining population as in Western Europe and Japan, or a (2) growing population such as in the U.S. and Australia. The third stage captures developing countries with (3) increasing populations and standards of living such as several Asian and Latin American countries. And finally, underdeveloped countries, like many in Africa, are experiencing (4) population growth, but with very little change in the standard of living.

Understanding how development and demography shape the challenges facing a particular region will improve efforts to address those challenges. Daigger (2009) developed a toolkit to identify the best fit solutions for water systems based on the demographic and development context. For instance, in developed countries with constant or declining population size (Scenario 1), reducing water and energy consumption and increasing nutrient recovery are the biggest challenges (Daigger, 2009). On the opposite end of the development spectrum, (Scenario 4) significant portions of the growing population "lack access to safe water and appropriate sanitation" with few signs of improvement (Daigger, 2009, p. 812). Rather than reducing consumption levels, the greatest challenges facing countries in this category are infrastructure and access. The lack of access in (Scenario 3) developing countries, on the other

hand, is being met with concerted efforts to develop centralized management systems, this is especially the case in affluent areas (Daigger, 2009). In (Scenario 2) the U.S. and other developed countries with growing populations, inadequate supply has led to the adoption of water reclamation projects and conservation campaigns.

With demographic realities in view, Daigger (2009) outlines solutions that best address the contextual challenges. Conservation and nutrient recovery efforts are most appropriate for the first demographic scenario, whereas the second and third scenarios may also benefit from expanded water reclamation and source-separation projects. Finally, the third and fourth scenario demand expanded infrastructure and access to clean water and sanitation. Overall, this toolkit suggests a trend in which consumption levels rise to an unsustainable level as development increases, while underdeveloped countries struggle to construct sufficient infrastructure to meet the needs of a growing population. By expanding knowledge and technology sharing, perhaps countries in the midst of developing can avoid some of the pitfalls of unsustainable development. Nevertheless, contextual considerations should guide attempts to close the loop on urban resources.

The implications of Daigger's analysis support the argument that changes to both the systems of provision and household practices will be necessary for closing the loop, an argument I will revisit in the following chapter. Addressing the challenges in developed countries with both growing and stabilizing or declining populations will require reduction in consumption as well as improved infrastructure. These demographic and development contexts also shape the challenges in other urban resources such as energy, food, and waste materials. Importantly, the progress in development and the demographic transition characterize not only the nature of the

challenges to begin with, but the capacity to respond to these challenges (e.g. comparative capacity of (Scenario 3) and (Scenario 4) to respond to insufficient and unsanitary water access).

## **Conclusion**

Urban metabolism gives us the language, the concepts with which to understand how a closed-loop system happens; it communicates what is the loop, what it means to be closed. "Closed-loop" is merely a description of a system (in contrast to a linear system), an outcome, in which material outputs are reduced, and those remaining material outputs are instead transformed into inputs for another part of the system. Without an urban metabolism framework, we lack the conceptual tools to articulate this future. "Material flows", "inputs and outputs", "accumulation", "transformations of materials", these are all concepts borrowed from urban metabolism to frame our understandings of the machinations of closed-loop systems. This framework allows us to identify and understand the nature of the material flows, the factors that constrain and support inputs and outputs, and the who, where, and how of material transformation. With the urban metabolism framework, we can understand the socio-ecological relationships of human and natural systems and identify the political, social, and economic transformations necessary to shift toward the closed loop future.

## CHAPTER 3

# Transformative Change Part I

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## The Systems of Provision

## Sources of Transformative Change

This dissertation contends that in order to close the loop on urban food systems, the systems of provision and household practices must change. There are several forces that may drive this transformation of linear systems, whether that be to reduce the impacts of linear systems or to design solutions to close them altogether. Scholars point to both private (Dauvergne & Lister, 2012; Vogel, 2010) and public initiatives. Public efforts may originate from bottom-up "civic environmentalism" (Kraft & Mazmanian, 1999; Knopman, Susman, & Landy, 1999), regional ecosystem-scale efforts (Layzer J. A., 2008), or traditional top-down, command and control (Layzer, 2002) approaches.

In terms of local level decision-making, significant enthusiasm has been put into print over voluntary, deliberative stakeholder collaboration, or what many term "civic environmentalism" (CE) (Layzer J. A., 2002; Knopman, Susman, & Landy, 1999). CE is characterized by three components:

"community-level decision making within a framework of federal and/or state regulatory standards; collaborative problem-solving that engages all stakeholders ...; and custom-designed solutions that are implemented voluntarily, such as public-private partnerships..." (Layzer J. A., 2002, p. 194).

Yet while some scholars argue that CE has resulted in significant gains in human and social capital (Beierle & Cayford, 2002), others argue that there is little evidence that these approaches result in greater environmental protection than top-down approaches (Layzer J. A., 2002; Layzer J. A., 2008). Furthermore, where these approaches have shown gains, understanding of the causal relationship remains obscured (Layzer J. A., 2008). For instance, Layzer (2008) points to Beierle and Cayford's (2002) analysis that "funding and the passage of time" may have as much to do with collaborative success as the collaborative decision-making approach per se. Indeed, critics contend that without state-level regulation, local authorities are unlikely to take

meaningful action to protect the environment (Layzer, 2002). This is in part because local decisions are often made in a context of significant fiscal constraints. Thus the outcomes of CE will tend to favor economic development over environmental protection (Layzer, 2002).

Regional coordination of decision-making in environmental protection may be able to overcome these constraints. Ecosystem-based management (EBM) is characterized by decision-making at the "landscape" level and overcomes several challenges faced by local and even national authorities (Layzer J. A., 2008). Regional efforts like EBM can draw from a greater pool of financial and technical expertise than local efforts, while maintaining greater ability to tailor solutions to local contexts than national initiatives (Layzer J. A., 2008). However, EBM approaches tend to be populated by "interest-group representatives" and loses out on some of the social capital benefits of CE (Layzer J. A., 2008).

If local and regional governments fail to enact meaningful environmental protections, can the private sector be trusted to transform their practices to reduce their impact? In many ways, global firms, or multinational corporations (MNCs), are increasingly leading the charge to "green" their operations (Cashore, 2002; Dauvergne & Lister, 2012; Vogel, 2010). More than corporate sustainability (Vogel, 2010), this "global civil regulation" is an increasingly legitimate form of governance (Dauvergne & Lister, 2012).

"Global civil regulations [are] voluntary, private, non-state industry and cross-industry codes that specify the responsibilities of global firms for addressing labor practices, environmental performance, and human rights policies..." (Vogel, 2010, p. 68)

In some cases, firms or coalitions of firms take action in order to abate the perceived need for more stringent regulatory standards (Vogel, 2010). A classic example of this is in the voluntary coordination of global civil regulations in which firms agreed to establish greater chemical plant safety standards after the Bhopal disaster in 1984 (Vogel, 2010). In other cases, MNCs' interest

in their "green image" has driven them to adopt monitoring and certification programs. "Supply chain tracing, product life-cycle assessments, and supplier audits... reduce exposure to questionable practices by poor-performing producers" (Dauvergne & Lister, 2012, p. 40). MNCs' increased attention to supply chain sustainability has only served to increase their influence on the operations of other firms and even governments.

MNCs increasingly influence government action on environmental regulations. In fact, governments have adopted monitoring and certification programs from the private sector (e.g. Life-Cycle Assessments, Forest Certification; LEED green building standards) (Dauvergne & Lister, 2012; Cashore, 2002). Some have even entered agreements in which MNCs effectively co-regulate portions of the supply chain. For instance, "the government of Yunnan province [China] has signed an agreement with Starbucks to improve farmer practices and yields" (Dauvergne & Lister, 2012, p. 42).

Because MNCs operate across national borders, it can prove impossible to hold these firms to any one nation's regulations (Conca, 2001). Ken Conca (2001) points to the increased fragmentation of lines of production across national boundaries as indicative of decreasing capacity for the regulatory state to effectively mitigate the environmental impact of human activity. Faced with weakened enforcement of environmental policies and regulation, can the public rely on industry to self-regulate in the interest of human health, and ecological sustainability?

The reach of influence of MNCs seems only to be spreading as expanding global markets serve populations with rapid growth rates and rapaciously rising expectations for the middle-class consumption levels of the developed world (Dauvergne, 2008). Even as regulations are passed, for example, to prohibit the use of toxic substances such as DDT, BPAs, PBSEs in one

location, markets are quickly expanded to populations who lack the political and economic capital to protect themselves in similar fashion (Dauvergne, 2008). Progress that is gained by deflecting harms onto populations and ecosystems elsewhere is what Dauvergne refers to as “delusional environmental progress” (2008, p. 14). An economy with increasingly complex and often international commodity chains, moreover, places a seemingly impossible burden on regulatory agencies to enforce regional laws, as well as on consumers to make ecologically and socially responsible purchases (Conca, 2001; Dauvergne, 2008).

Yet, by "endorsing and adopting" what large MNCs are already doing to reduce their environmental impact, governments are hoping to leverage cross-border and cross-industry influence over business practices (Dauvergne & Lister, 2012). The effectiveness and dependence on global civil regulatory approaches varies by development context and stage of the supply chain. In developed countries, this private voluntary approach is less effective than enforcement of command and control regulations, but in developing countries, they may "constitute the only effective form of business regulation" (Vogel, 2010, p. 80). This has important implications for efforts in developing countries in adapting to the effects of climate change. Furthermore, these agreements tend to focus on particular sectors in the supply chain and products bound for a Western market, leaving other consumer goods behind (Vogel, 2010).

Overall, these approaches to transforming the environmental impact of the linear system operate within existing state-level regulatory standards. Without significant changes to expectations of economic growth and the economic evaluation of natural systems, many scholars doubt the net positive effect of the aforementioned approaches (Layzer J. A., 2010; Vogel, 2010; Dauvergne & Lister, 2012). Firms maintain an operational framework of endless economic growth. Even where companies go beyond "green washing" to effectively reduce the per-item



environmental impact, this green image is being leveraged in order to grow the business and increase sales (Dauvergne & Lister, 2012). Furthermore, the political-economic system must be transformed to account for the "triple-bottom line" (Daigger, 2009) where the economic, natural, and social costs of the product life-cycle weigh on the value of the product (Layzer J. A., 2010).

### **Policy Responses to Problem Framing**

The local systems of provision in organics waste management are organized around the achievement of targets and strategies set by state, national, and international policies. How the problem is framed at these higher levels of governance defines the focus of targets and the strategies designed to achieve them. Problem framing defines (and so, limits) the solutions that are perceived as appropriate and possible, as well as the systems of provision that are arranged toward those solutions. For example, the problem of organic materials has recently shifted away from one of "disposal efficiency", to a problem framed as "risk" to be managed, "value" to be reclaimed, and "justice" to be redistributed. As the narratives shifted, so too did the national and state-level 'interventions' designed to influence local waste management activities (Bulkeley & Betsill, 2005). For the purposes of this dissertation, state-level 'interventions' will refer to the policy principles, instruments, and incentives used by the state (supra-national, national, or state) to elicit some change in material flows. This section will explore how state-level problem-framing shapes these interventions.

International and national agencies (e.g. EU, UN, US EPA) play an important role in framing the problem of organic waste. How an agency frames the problem constrains the perceived appropriate solutions, and therefore the goals toward which they strive and actors they entrain. Different goals and actors will then guide the arrangement of systems of provision (Bulkeley & Askins, 2009; Hultman, 2012). To put it another way, these agencies establish a

"governmental rationality...[that] identifies the goals of government and entrains other actors into working toward these goals" (Bulkeley, Watson, & Hudson, 2007, p. 2737). Governmental rationality is an outcome of problem framing, both of which differ across space and time (U.S. EPA, 2002; Bulkeley & Askins, 2009; Bulkeley, Watson, & Hudson, 2007; DETR, 2000; Defra, 2007).

For instance, much of the history of waste management in developed countries since the early 1900s has been characterized by a frame of "disposal efficiency" (Bulkeley 2007). Here the problem with organics is, like other materials, one of how best to remove them from people's homes to a disposal site as cheaply and efficiently as possible. The goals under this frame would center on achieving the lowest input of resources (e.g. money, fuel, time) for every ton of food waste disposed of. National-level policy principles, instruments, and incentives were largely absent in the pre-war period save a handful of extreme examples.<sup>13</sup> It was this absence of oversight that enabled severe environmental and human health problems that ultimately led to Congressional action in the 1960s-1970s (e.g. SWDA, RCRA, CAA, and CWA).

In the EU the 1999 Landfill Directive identified landfilled organic waste as a significant contributor to environmental degradation through the generation of methane and toxic leachate (DETR, 2000; European Commission, 1999). The directive marked a shift in the problem-framing of waste. Rather than an issue of developing the most cost-effective disposal method (i.e. "disposal efficiency"), the directive framed the issue of waste in terms of "risk" (Bulkeley & Askins, 2009; Bulkeley, Watson, & Hudson, 2007). Specifically, the directive highlighted the need to avoid environmental degradation that occurs from decomposition of organics in the anaerobic conditions of landfills (European Commission, 1999).

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<sup>13</sup> The first mandated source separation for residential waste that included organics was established by Col. Waring in New York City circa 1892 (Strasser, 1999) Eliminated and not reinstated until recycling in the 1980s and organics recycling at the end of the aughts (SF Environment, 2013).

In the U.S., waste became characterized as a problem of risk management rather than disposal efficiency in the 1960s. Though not targeting organics in particular, Congress passed the Solid Waste Disposal Act (SWDA) in 1965 and the Resource Conservation and Recovery Act (RCRA) in 1976 as an amendment (U.S. EPA, 2002). These acts were established in response to increasing evidence of the environmental damage caused by hazardous waste, open dumping, and the swelling of per capita waste generation (U.S. EPA, 2002). The SWDA followed on the heels of Rachel Carson's *Silent Spring* (1962) and growing concerns over water contamination from industrial and chemical manufacturing sites (U.S. EPA, 2002). The focus of "source reduction" and "recycling" in RCRA was centered on the swelling of disposables in the post-war era (Rogers, 2005; Strasser, 1999).<sup>14</sup> Between 1950-1960, per capital waste generation increased 60% (U.S. EPA, 2002). These factors shaped RCRA's focus on controlling hazardous waste, establishing standards for landfills, and reducing and recycling wastes. While language compelling composting made its way into official documents like the EPA's *Agenda for Action* and Integrated Waste Management approaches (U.S. EPA, 2002), the swell of disposables and the threat of hazardous waste demanded the lion's share of attention.

While both the US and the EU adopted a new narrative of waste legislation in terms of "risk management", each responded to different problem contexts --hazardous waste and per capita waste increases in the former, and anthropogenic climate change in the latter. These disparate problem frames, led to disparate solutions. The EU established organics diversion targets for member-states to address the risk of environmental degradation caused by biodegradable municipal wastes in landfills. Local authorities in the EU subsequently established

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<sup>14</sup> The bottling industry underwent a dramatic transformation in manufacturing and distribution systems with significant effects on the American waste stream. Across the country, systems of returning refillable bottles to industry for reuse fell by the wayside. Consolidation of producers and centralization of bottling and distribution centers changed the equation in favor of disposables (Rogers, 2005).

organics collection programs (Bulkeley & Askins, 2009; DETR, 2000) decades in advance of cities in the US (SF Environment, 2013).

The U.S. EPA has identified organics in landfills as a significant source of methane emissions (second only to livestock) and toxic leachate in waterways (U.S. EPA, 2002). In this way, organics are framed as a "risk" that must be managed. In particular, organics are identified as a risk in that they contribute to air pollution (e.g. methane) and threaten human health (e.g. groundwater contamination). This framing may be attributable, in part to the source of the EPA's authority to enforce emissions and water quality standards. After all, the agency was created to enforce the Clean Air Act of 1970. It was in this act, specifically CAA Section 111(d), that Emissions Guidelines limited methane levels from stationary sources such as landfills were established. Recently, the EPA has proposed reductions to these methane thresholds, but it has yet to adopt national organics diversion standards (U.S. EPA, 2015).

Indeed, national standards to address issues of methane emissions from landfills in the U.S. have largely focused on improved landfill technologies and standards, rather than diverting the flow of materials from landfills for alternative processing. The first policy instruments in this regard were established in 1991 under Subtitle D of RCRA. Subtitle D established standards for "design, operating, and closure... and require[d] liners and ground-water monitoring" (U.S. EPA, 2002, p. 9). Subtitle D also solidified landfills as a state responsibility (U.S. EPA, 2002). These standards were designed to guide state action to meet targets related to air and water quality set by the Clean Air and Clean Water Acts. Congress made it clear with Subtitle D that:

"...states and local governments are the primary planning, permitting, regulating, implementing, and enforcement agencies for management and disposal of household and industrial, or commercial non-hazardous solid wastes." (U.S. EPA 2016f)

Enforcement of Subtitle D led to the closure of thousands of landfills across the country. In 1988, more than 6,500 landfills accepted municipal solid waste, by 2002, only a third remained (U.S. EPA, 2002).

While the U.S. does not have national organics diversion standards, it has established a different kind of standard, responding to a different problem frame. The U.S. has recently established organics targets that focus on food waste prevention rather than diversion per se. The U.S. EPA and USDA have partnered to establish a target of 50% food waste reductions by 2030 (USDA, 2015). This standard will serve to reduce the flow of organics into landfills, but it achieves this by characterizing the problem of food waste as one of "food security" or "justice" that must be redistributed. The idea is that if food waste is reduced, fewer people will go hungry. This "security" or "justice" frame focuses strategies farther up the pipe compared to landfill methane flaring programs. Preventing food waste and capturing uneaten food for human consumption is at the top of the EPA's food waste hierarchy (U.S. EPA 2016c) and is a necessary and historic step toward a closed-loop food system. If successful, it will also bring about more food security in a country where more than 48 million people live in food insecure households. But there will always be inedible scraps and spoiled food, and our closed-loop systems will demand systems of provision that can process these material flows into new system inputs and new relationships between households and their food waste.

**Policy Interventions Transform Systems of Provision.** In the previous section, I discussed examples of how problem-framing affects the policy response which in turn, shape the arrangement of the systems of provision. Bulkeley and Askins (2009) provide a useful framework to discuss the national-level responses, or "interventions" intended to influence

localized systems of provision. State-level<sup>15</sup> policy principles, instruments, and incentives guide local authorities to meet waste goals established by governmental rationality, or problem framing. This section examines examples of each type of intervention in the US and the UK and how the disparate problem-framing in each context results in disparate arrangements of the systems of provision.

***Policy Principles.*** The EU Waste Hierarchy is an example of a policy principle. First introduced in 1975, it had enjoyed little attention in policy development until the UK Waste Strategy in 2000 (Bulkeley & Askins, 2009; Davoudi, 2000). The strategy was developed in response to the EU Landfill Directive and encouraged local authorities to adopt the waste hierarchy. Prevention is at the top of the hierarchy, followed by reuse, then recycling and composting of materials. Landfilling is at the bottom of the hierarchy, with incineration and incineration with energy recovery just above. The higher on the hierarchy, the more desirable the waste management method (DETR, 2000).

The US EPA's food waste hierarchy parallels the EU Waste Hierarchy but focuses exclusively on the preferred food recovery methods (U.S. EPA 2016c). The least preferred being landfill and incineration, followed by compost and industrial uses (including AD). The most preferred methods are characterized by reducing and reusing food but prevention is best method followed by feeding hungry people and then animals. The EPA's food waste hierarchy acts as a policy principle to guide local and state efforts to reduce landfilling of food waste.

***Policy Instruments.*** Policy instruments set standards and identify indicators to encourage local authorities to move up the waste hierarchy (Bulkeley & Askins, 2009; Bulkeley, Watson, & Hudson, 2007). A unique example of policy instruments from the UK comes in the form of a sort

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<sup>15</sup> Because EU member-states do not have a government level comparable to states in the U.S., I use "state-level" here to encapsulate national (in the U.S. and the E.U. member states), and state (in the U.S.) level government. This is meant to be in contrast to municipal or private sector efforts.

of landfilled organics cap-and-trade. The Landfill Allowance and Trading Scheme allowed cities to sell credit they earn for being under their limit to other cities who are over their landfilled organics allowance (Bulkeley & Askins, 2009; Defra, 2007; Defra, 2005).

National landfill diversion targets in the EU also serve as policy instruments to guide local action. These targets were established to keep pace with the Landfill Directive targets. The directive set tiers of targets to reduce the amount of landfilled organics by member-states, first to 75% of 1995 levels by 2010, then to 50% by 2013 and 35% by 2020 (Bulkeley & Askins, 2009; European Commission, 1999). Targets established in the Waste Strategy 2000 required local authorities to reduce the amount of landfilled organics to 75% of 1995 levels by 2010, 50% by 2013, and 35% by 2020 (ETC/SCP, 2013). Thus far, the UK has met these targets and seems to be on pace to meet the 2020 target (ETC/SCP, 2013).<sup>16</sup> At lower levels of governance, diversion targets were then translated into "statutory performance standards for local authorities...according to [baseline] performance" (Bulkeley & Askins, 2009, p. 253). Following the lead of the Landfill Directive, the UK standards included targets for diverting organics from landfills (DETR, 2000; Defra, 2007).

"Given that the impetus behind the shift in [municipal waste policy] in the UK originated with the [EU] Landfill Directive and its concern to reduce the biodegradable fraction of waste being disposed in landfill, ...the resulting policy landscape in the UK has focused on the diversion of [biodegradable municipal waste]" (Bulkeley & Askins, 2009, p. 254)

Unlike the EU and the UK, the US does not have a target for landfill diversion of organics. As discussed at the outset of this section, the narrative of waste policy changed in response to different perceptions of risk. Looking to the roots of change in municipal waste policy, we see a different narrative than the UK. The Resource Conservation and Recovery Act

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<sup>16</sup> Biodegradable Municipal Waste has been reclassified in the UK as of 2010 to include commercial waste, significantly increasing the waste generation figures. The diversion targets have been adjusted to take this reclassification into account. (ETC/SCP, 2013)

(RCRA) of 1976, specified goals to protect human and environmental health, prevent waste, and as the name suggests, conserve resources (U.S. EPA, 2002). This first and most effective amendment to SWDA shifted the focus up the pipe toward reductions in hazardous and solid waste generation, but still no targets for organics in particular.

RCRA simultaneously increased the role of the federal government in regulating waste and defined solid waste as a local or state responsibility. The national standards set by RCRA were meant to guide states and local authorities as they implemented their own programs (U.S. EPA, 2002), maintaining a decentralized approach to waste management. Here, landfill diversion targets were established as policy instruments to drive lower-level government activities on waste. The focus, however, was not on organics but on limiting waste sent to landfills overall. (U.S. EPA, 2002).

The USDA indicated their pursuit of food waste reduction is "in order to improve overall food security and conserve our nation's natural resources" (USDA, 2015, p. 1). The food waste reduction target discussed above follows a series of initiatives by the US EPA and USDA that served as policy instruments to reduce food waste. In 2013, the EPA and USDA established a successful US Food Waste Challenge that "creat[ed] a platform for leaders and organizations across the food chain to share best practices on ways to reduce, recover, and recycle food loss and food waste" (USDA, 2015). The following year, the EPA released a web-based toolkit called the U.S. Food Recovery Challenge that empowers participating vendors to reduce their food waste. Participants in the entered data from a baseline food waste inventory, selected from suggested actions, set goals and track progress of their food recovery (U.S. EPA 2016b).

***Incentive and Promotional Programs.*** There are several UK programs designed to incentivize and promote organics diversion. The UK established a series of funds to support



curbside recycling and civic amenity sites for household recycling drop-off (Waste Minimization and Recycling Fund), innovation in disposal and diversion (Waste Performance and Efficiency Grant) , and to develop recycled-materials markets and public awareness (Waste Resources and Action Programme) (Bulkeley & Askins, 2009). The funds were designed to provide resources to local authorities to help them comply with targets established by the Landfill Directive and the UK Waste Strategies 2000 and 2007. Local authorities then innovated recycling schemes and waste-to-energy strategies (Bulkeley 2009 p 252).

There are no federal incentive programs for organics recycling in the U.S. aside from some support for on-farm composting (BioCycle, 2014a). The U.S. EPA does, however, identify benefits of composting including reduced methane emissions and chemical fertilizers, as well as the benefits of its use in soil remediation (U.S. EPA, 2016d). The agency has also established a series of promotional programs to connect local authorities with appropriate and proven models for waste management. The EPA recently released the Managing and Transforming Waste Streams toolkit designed to highlight policies and programs from around the country designed to reduce landfilling (U.S. EPA, 2016b). The toolkit covers a wide array of materials, and enables communities to identify the best approaches based on their contextual constraints and opportunities. Many of the listed programs and policies focus on organics including state and local landfill bans, zero waste goals for organics, and mandatory composting programs like those in San Francisco and Seattle (U.S. EPA, 2016b).

**Emergent Food Waste Problem Frames.** It is useful to bring together the conceptual tools of problem-framing, "interventions" (i.e. policy principles, instruments, and incentives), and the systems of provision that shape urban waste material flows. National and international policy-making serves to frame the problem, and so defines the possible solutions to the

problems. Food waste has been framed by different levels of government in different ways for the past century and a half--"disposal efficiency", "risk management", "social justice", and "value". Each of these frames shape the goal-setting to address the problem, and the (re)arrangement of the systems of provision. I have outlined the historical trajectory of the UK and the US to elucidate *how* different problem framing ultimately results in different systems of provision and national diversion rates.

Since the turn of the century in the UK, organic waste has been framed as an issue of "risk management". The goals and strategies have thus coalesced around reducing harm, defining organics as a significant contributor to risk. The Landfill Directive identified specific pathways of harm from landfilled organics (e.g. methane and leachate) that became the focus of national strategies to reduce harm by transforming the systems of provision to reduce organics in landfills. These strategies achieve the goals of reducing anthropogenic sources of climate change, and protecting human health from contaminated air, water, and soil. In this example, we see the adoption of policy principles (e.g. the waste hierarchy), instruments (e.g. organics landfill diversion targets) and incentive programs (Landfill Allowance and Trading Scheme) to guide local action on organics diversion. These steps are designed to achieve goals of reducing the risk that landfilled organics pose by establishing principles that prioritize alternative organics processing, instruments for penalizing authorities who fail to meet targets, and resources to finance new infrastructure or awareness-building.

Contrarily, while the U.S. did frame early waste policy in terms of "risk", it did not define organics as the source of concern. Instead, the context of significant environmental damage from industrial sites and open dumping of hazardous and solid wastes coupled with the swelling disposables waste stream directed attention elsewhere. The EPA later identified the same risks of

organics to water, soil, and air as the EU had in the Landfill Directive, but the goals and strategies focused on emissions reduction through improved landfill technologies rather than diversion. As discussed above, this in part owes to the source of the EPA's authority rooted in the Clean Air Act and the Emissions Guidelines targeting landfills therein. Unfortunately, the strategies devised (e.g. Landfill Methane Outreach Program) do nothing to close the loop on food systems.

Perhaps more critical at this juncture is for national and international problem-framing to characterize the problem of organics as one of an untenable linear food system. Then the transformation of the policy principles, instruments, and incentives could coalesce around a suite of goals and strategies to close the food system loop. The closed-loop problem frame still achieves goals of efficiency, risk management, justice, and value-capture. In the pursuit of goals to close the loop, the systems of provision could be arranged in a way that makes room for different scales and methods of food waste processing, from backyard to centralized facilities, from donation to compost to digestion. As cities continue to experiment with scale and method future research should endeavor to communicate findings from these experiments for late-adopters.

### **Federalism, Food Waste, and Urban Experiments**

Indeed, the drive toward organics diversion in the U.S. has come predominantly from state and even city-levels of governance. In anticipation of landfill closures for failure to meet new Subtitle D standards, more than 20 states banned yard trimmings from landfills in the 1980s and 1990s (BioCycle, 2014a). However, states were relieved of the pressure from limited landfill space as new landfills came online that were massive, regional, and most importantly, Subtitle D compliant.

More recently, a handful of states across the country have begun to establish standards that will push more of their cities to develop OCPs that include food waste. Vermont and Massachusetts have passed organics landfill bans. Both states began the first phase of the ban in 2014, targeting the largest food waste generators. In Vermont, all residential and commercial food waste generators must be separating by 2020 (Spencer, 2014). Yet, both of these states had cities where curbside OCPs were piloted or fully implemented prior to the statewide mandates. Burlington, Vermont has had success with commercial composting since 2008 (Potter, 2008). Cambridge, Massachusetts was the first city on the east coast to pilot a residential curbside OCP in 2014 after the success of their food scraps drop-off program (Cambridge DPW, 2014). Boston soon followed suit (Malamut, 2013).

Indeed, cities have taken the lead in establishing OCPs across the country. In 2009, San Francisco became the first city in the country to mandate source separated organics (SF Environment, 2013). San Francisco, Seattle, Portland, and New York each implemented OCPs in advance of state or national mandates compelling such actions (ILSR, 2012). These early-adopter cities transformed their linear food systems toward closed-loop systems by taking action with privately contracted waste haulers. They found innovative ways to navigate and or alter the existing framework of permitting, land use, and environmental regulation imposed by local and higher levels of government (i.e. state and federal).

While there is global recognition of the importance of cities in responding to the challenges of climate change (U.N., 2014; U.N. Habitat, 2011; World Bank, 2010), urban responses can no longer be considered an issue of municipalities alone (Castán Broto & Bulkeley, 2012). Take the OCP development in Costa Mesa, CA for example. Whereas waste hauling was previously the purview of municipalities who paid to dump waste at landfills

(Rogers, 2005), it was the partnership between private industry (i.e. CR&R) and the public agency (i.e. Costa Mesa Sanitary District) that led to the first OCP in the county.

Furthermore, these urban responses must be considered as enacted within a network of cities through which knowledge sharing can occur, rather than in isolation. Communicating the successes and failures of these urban responses to environmental challenges can alleviate the learning curve of late adopters or the Global South (Bressers & Rosenbaum, 2000; Layzer J. A., 2010).

"[S]haring of information and experience was also a necessary precondition for the eventual negotiation of international and regulatory regimes such as the Montreal Protocol for the protection of stratospheric ozone (Gehrig, 1994)" (Bressers & Rosenbaum, 2000, p. 528)

Sharing strategies not only improves the development of environmental policies in a network of cities, but has been shown to legitimize these strategies for establishing international standards.

**The Urban Laboratory.** Cities are increasingly the site of experimentation with new approaches to mitigating and adapting to climate change. In fact, a recent study of 100 'urban climate change experiments' across the globe indicated that cities engage in social and technical innovations across a series of sectors and target a range of resources (Castán Broto & Bulkeley, 2012). This study suggests that while infrastructure is the most common target for urban experimentation, insufficient attention is given to waste material flows and the social aspects of these infrastructures.

Cities have directed significant attention to urban infrastructures (32%) in climate change experiments including landfill gas capture and waste collection (Castán Broto & Bulkeley, 2012). However, of these infrastructural experiments energy (78%) was predominantly targeted over other kinds of resources. And of these, about two thirds targeted energy production rather than consumption. When it came to the urban infrastructure sector, moreover, cities were least

likely to use social innovations compared to other sectors (Castán Broto & Bulkeley, 2012). About a third of all experiments employed both technical and social innovations, but only experiments on the built environment (e.g. energy-efficient material use, building-integrated alternative water or energy) favored this combined approach. These findings suggest that while cities are increasingly the site of climate change action, significant gaps remain in addressing the social aspects of waste infrastructures.

In considering the types of cities likely to drive experimentation, the study found that membership in a transnational municipal network (e.g. ICLEI, C40) was a greater predictor than size, density, or economic wealth (Castán Broto & Bulkeley, 2012). Nearly all of the cities identified in the current study that developed OCPs ahead of state mandates (i.e. San Francisco, Seattle, Portland, New York) are members of ICLEI. Of course most of the cities in states with organics targets and outright bans will be developing and implementing OCPs in response to these state-level policies rather than initiating these changes themselves. Together, these factors seem to answer the call for knowledge sharing through urban networks (Bressers & Rosenbaum, 2000). Early adopter cities have the opportunity to experiment with and share new social and technical innovations that can inform the OCPs of more reactionary cities. The extent to which the reactionary cities do not have membership in these organizations, alternative communication pathways will be necessary for early adopter cities to serve as models for those who delay the pursuit of OCPs (Castán Broto & Bulkeley, 2012).

Of course, cities do not operate within a vacuum. In most states across the U.S., efforts to close the loop on urban food systems will require significant and possibly regional coordination of technical innovations in infrastructure. As discussed in Chapter 1, the lack of organics processing capacity is one of the most significant constraints in the expansion of OCPs across the

country. The 44 states who do have organics processing rely on relatively smaller-scale processing and primarily manage only yard trimmings (71%) (BioCycle, 2014a). While more than 180 communities in the U.S. have food scrap collection programs, food scraps or mixed organics comprise only 9% of the organics tonnage collected nationwide (BioCycle, 2014a). The most common (72%) existing facilities (3,285 nationwide) have capacity for just 5,000 tons or less each year (BioCycle, 2014a). Even if these facilities exclusively processed food waste, there would only be capacity for about 40,000 residents'-worth at the largest of the most common facilities. But most of these facilities are only permitted to process yard trimmings. Significant investment in infrastructure and streamlined permitting processes for food waste processing will be necessary to enable further adoption of OCPs (BioCycle, 2014a).

If current trends persist, OCP expansion will largely be achieved through public-private partnerships to develop large-scale, centralized organics processing facilities that manage regional organics flows (BioCycle, 2014a). This approach is also reinforced by the consolidation of the waste industry (Rogers, 2005). Private waste haulers will continue to pursue economies of scale possible through these regional processing facilities even if transporting wastes great distances contributes to the carbon footprint of wasted food. Public-private partnerships may also keep alternative approaches at the margins or altogether prohibited.

LA Compost, for example, was forced to reinvent their strategy for supporting community composting programs. Their original model was based on the success of Gainesville Compost (Widom, 2014) and relied on pedal-power. Residential and commercial food waste generators signed up for collection by trailer-totting bicyclists who delivered the spoils to community compost sites that the organization had helped establish, often at community gardens (Spurrier, 2013). Other communities have also had success with this approach (Bikes at Work,

2012). However, the brakes were put on this operation when the city enforced existing legislation prohibiting any non-contracted hauler from transporting food waste away from the site of generation. The organization was forced to shift their focus to establishing compost and garden programs at schools. At the time of this writing, LA Compost continues to work for changes in policy that would allow small-scale food waste hauling and thereby encourage community-scale alternatives to food waste processing (WCF Research Workgroup , 2014).

There are significant benefits to small-scale or even backyard composting operations. More green spaces, enhanced food security, less truck traffic from garbage hauling, and social capital and community building are among the most widely cited benefits to community-level composting operations (BioCycle, 2014a; ILSR, 2014). When coupled with fruit and vegetable gardening, backyard composting can enhance local soils and reduce food insecurity (BioCycle, 2014a; ILSR, 2014). Both of these approaches not only contribute to closed-loop systems and landfill diversion goals, they also reduce financial and environmental costs in hauling and processing the materials. These are among the reasons that the Institute for Local Self-Reliance prioritizes the promotion of backyard composting and community-scale composting operations over centralized large-scale facilities (BioCycle, 2014a; ILSR, 2014). Thus far, AD facilities are less common at small-scales those that do exist in the U.S. tend to be utilized for on-site processing at farms (CA Integrated Waste Mangement Board, 2008).

### **Distanced Disposal and Severed Feedback Loops**

Today, food products may travel thousands of miles, crossing state and national borders to be consumed. Cities have little if any power to control the materials that flow into the city, but when food goes uneaten it becomes a local responsibility to manage it as a waste material. This localized management is enshrined in policies and law in both the U.S. and the E.U. As



discussed above, the U.S. EPA has made explicit the responsibility of local authorities to manage material flows as waste (U.S. EPA 2002, U.S. EPA 2016f). Similarly, the Proximity Principle in the EU Landfill Directive also dictates that "waste should be disposed of as closely as possible to where it is produced" (European Commission, 1999). Yet millions of tons of waste are exported every year from developed countries including EU member-states and the U.S. (EEA, 2010) and across state borders (Rogers, 2005). In fact, EU member-states saw a four-fold increase in waste exports between 1997 and 2005, including 126 million tonnes of biomass in 2008 (EEA, 2010).

The "social and spatial distancing" (Princen, 1997; Conca, 2001) between the generation of waste and the processing of those materials can be reduced by localizing waste management. Local organics management internalizes negative externalities (Clapp, 2002; Dauvergne, 2008) and maintains important feedback loops that communicate the impacts of waste materials and consumption to the consumers (Princen, 2002; Conca, 2001). Technological advancements in smart cities as well as expanding urban networks may leverage a future where feedback on the impacts of waste can be communicated to the waste generators (Princen, 2002; Conca, 2001), and the lessons learned from urban experiments are communicated through urban networks (Bressers & Rosenbaum, 2000; Layzer J. A., 2010).

**Negative Externalities and Severed Feedback.** Global food markets have given rise to consumers who are increasingly "distanced" from the social and environmental costs of their consumption (Princen, 2002; Conca, 2001; Dauvergne, 2008) and disposal (Clapp, 2002). Princen uses the term "distance" to denote the "separation between primary resource extraction decisions and ultimate consumption decisions" (Princen, 1997, p. 244). Clapp (2002) extends this understanding to incorporate the "distance" between consumption decisions and impacts of ultimate disposal decisions. Decisions by consumers are increasingly distanced from the

“knowledge, information, and contextual understanding” of the regions where resource extraction, production, (Conca, 2001, p. 63) and disposal (Clapp, 2002) processes take place. Princen points to four fault lines along which distancing can occur; "geography, culture, bargaining power, and agency" (Princen, 1997, p. 244). These may also be thought of as "spatial" and "social" distancing (Conca, 2001). At the far end of the distanced spectrum, the distance between production and consumption "is global, cross-cultural, and among agents of disparate abilities and alternatives" (Princen, 1997, p. 244).

Prices of food and disposal in many communities in the U.S. are artificially low as they fail to reflect the negative externalities of the food and waste system. For instance, the purchasing decisions of the consumer are 'distanced' from the food production practices that yield wonton abuses of part-time and migrant agricultural laborers (both domestically and abroad) who do not enjoy the same benefits as other sectors of the labor market (e.g. federal minimum wage, overtime pay, and benefits). Furthermore, residents' disposal choices are also 'distanced' from the impact of these choices. Almost without exception in the U.S., materials are escorted away from the point of disposal, out of sight and out of mind for the resident. The environmental costs of landfilling food waste, for instance, is not accounted for in the cost of trash hauling programs. These points are explored in more detail below.

In focusing on consumption, Princen (1997) presents examples of grocery shopping at opposite ends of a spectrum; with farmer's market at one end and national grocery chains at the other. Walking the produce aisles of the latter, the consumer has no cues as to the harmful effects of pesticide use on farm laborers, or the eutrophication of waterways near the farm's over-fertilized rows. Princen (1997, p. 250) argues that "as key decisions are removed from primary producers and costs are externalized, feedback from the resource in both production and

consumption is severed." Likewise, the householder disposing of food in the home has no cues as to the harmful effects of methane and toxic leachate that result from landfilled organics. Nor have they any cues as to the costs of missed opportunities to transform organics into new system inputs. For instance, the consumer remains blinded to the environmental costs of using more synthetic fertilizer or petrol instead of compost and biogas, as well as the social costs of more hungry people to whom edible food might otherwise flow. On a basic level, the householder may not even perceive food waste as a potential resource. Households are distanced from the socio-ecological impacts of their discards and the social and environmental cost of material outputs (i.e. pollution) in a linear food system.

*Distancing* in disposal can be thought of analogously to consumption. Consider the spectrum from Princen's consumption scenario. We can instead imagine that at one end of the food disposal spectrum is a home's backyard composting system, and a regional landfill--or other organics processing facility) at the other end. In the former, the householder maximally engages with the materiality of their wastes. Not only do they enact sorting practices in the kitchen, they labor over the processes that transform waste material into soil, turning compost piles, managing balanced material content, maintaining appropriate heat and moisture levels. The backyard composter has an intimate socio-ecological relationship with the food material flows that pass from 'household output' to 'compost bin input' to 'compost bin output' to 'garden input', and so on. The householder is also most directly impacted by negative externalities (i.e. internalities?) that arise from the composting process such as odors or pests.<sup>17</sup> With the intent to use this end-product as an input in another process (e.g. home vegetable garden), their interest in preserving quality and preventing contamination is peaked. This household is at "zero-distance" by

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<sup>17</sup> The household composter may not be *the most* directly affected if the compost bin is more proximal to a neighbor's home than to their own. Though in this case, the household composter is likely to get 'feedback' from the molested neighbor.

engaging in production and consumption (Princen, 1997) as well as disposal and processing of organic materials.

Contrast this with the opposite end of the food waste spectrum, or "maximally distanced" disposal. Single-stream curbside collection for landfilling household wastes at a regional organics facility is arguably among the most distanced a householder can be from the social and environmental impacts of their material waste. As discussed above, the household has no signals as to the pollution and opportunity costs resulting from landfilling organics. In fact, the household is not even faced with the task of sorting their materials in a single-stream system. Disposal can occur with little or no thought as to the impacts of the linear system.

In considering where on the spectrum curbside OCPs that direct household food waste material flows to regional organics processing facilities<sup>18</sup> (ROPF) might belong, they seem to occupy some sort of middle-ground. Here, the householder engages in sorting practices in the kitchen, but the effects of spatial distancing are akin to landfilling. The environmental impact of household disposal choices are distanced from their household, even if the impacts are diminished compared to landfilling. The householder is neither exposed to the negative externalities of their disposal practices, the processing itself, nor are they benefited by the products resulting from the processing method. For the householder in this scenario, the externalities are externalized (Dauvergne & Lister, 2012), feedback effects are lost, and the labor-input is high.

Distancing effects of food waste disposal is greater with ROPFs than backyard composting. In the latter scenario, contaminated feedstock can cause problems in paradise,

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<sup>18</sup> For the purposes of this dissertation ROPFs include regional compost facilities and anaerobic digesters but not regional landfills even if they accept organics. This classification is meant to contrast these large-scale operations that divert and process food waste from landfills with more localized approaches to food waste diversion and processing. It is useful here because the distancing effects resulting from different scales are the subject of interest.

problems that are immediately experienced by the householder. Conversely, the feedback effects are severed with ROPFs. There are nearly no consequences if the householder contaminates the organic material stream with glass or plastic because the labor of transformation is performed by someone (or something) else. Furthermore, by the time contamination is discovered the householder often enjoys a level of anonymity not available in the backyard composting scenario. As with Princen's consumption example, the "key decisions are removed" from waste generators. So the feedback from the waste processing does not inform the waste generators and separators. Further research is needed to understand the process by which feedback from waste processing informs waste generators. Is personal labor and responsibility of materials management necessary for householder buy-in, or is some perceived or real public good sufficient to garner participation in OCPs destined for ROPFs?

## **Conclusion**

Whatever the scale or the source of the innovation, efforts to bring about a closed-loop system will demand understanding of the incentive structures that allowed landfilling to proliferate in the first place. By definition, a closed-loop food system necessitates the capture and reuse of food that goes uneaten to become an input in another process. Whether for human or animal consumption, compost or biogas generation, food materials must be kept out of landfills and transformed into input for another process in the system. We have seen the significant transformation in organic landfilling develop in areas where efforts to keep organics out of landfills come from above, as in the EU (e.g. state-level policies and targets), and from below, as in US cities (e.g. city-initiated OCPs and household behavior change). Different definitions of the problem lead to an emphasis on different solutions. Ultimately, though, the entrenched

incentive structures that have promoted a world in which landfilling organics has become the norm must change. It seems this change must come from above and below.

The policy principles, instruments and incentives discussed in this chapter work to arrange the systems of provision toward achieving state-level goals based on the framing of organic waste as a problem. The tendency of these "interventions" has been to focus primarily on innovations in the systems of provision rather than social interventions targeting household practices. Subsequent chapters will outline how these "interventions" can and should target household behaviors in addition to systems of provision. I will show in the following chapter that immediate gains can be made by taking advantage of the behavioral wedge (Dietz, Gardner, Gilligan, Stern, & Vandenberg, 2009).

The progression of U.S. organics policy has taken a more bottom-up approach compared to the UK. Perhaps as additional cities experiment with these programs, more states will see OCPs as a viable solution to achieve several goals at once (e.g. air and water quality standards, landfill diversion targets, economic growth, etc). If conventional recycling is any indication, however, national organics recycling standards are not on the horizon in the U.S.

In the following chapter, I will explore the social aspects of food waste. The discussion will link back to concepts examined here. In particular, I will interrogate the how various waste regimes have shaped social relationships to waste as a household material. The chapter will review theories and empirical evidence for predicting and influencing household behavior from social sciences. The goal is to provide an exposition of how household behavior must be transformed along with the systems of provision in closing the loop on urban food systems.

## CHAPTER 4

# Transformative Change Part II

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## Household Behavior

## **The Systems of Provision and Household Behavior**

The previous chapter examined how state-level problem-framing and 'interventions' (i.e. policy principles, instruments, and incentives) transform the arrangement of the systems of provision. Yet this dissertation aligns with others scholars in arguing that local waste management is co-constituted both by the systems of provision and by household practices (Bulkeley & Askins, 2009; Evans, 2014; Gregson, 2007). Others have also argued that the household plays a linchpin role in sustainable, and especially closed-loop waste management policies (Martin, Williams, & Clark, 2006; Price, 2001; Perrin & Barton, 2001).

This chapter will first outline different scenarios in which the household takes a role of greater and lesser importance in successful transitions toward a closed-loop system. Using the urban metabolism model to examine the household unit, this chapter then explores drivers of food waste generation at the stages of household food input, metabolism, and output. Here I discuss specific theories from social psychology that inform the analysis of the experiments in the following chapters; namely the Theory of Planned Behavior for predicting household food waste separation behavior and Social Influence Theory for transforming household behavior. This chapter closes with a brief recap of the theories informing the empirical chapters to follow.

Subsequent sections in this chapter will consider how agencies can transform household behaviors to improve urban metabolism. Here I will endeavor to paint a picture of different scenarios, some of which do not seem to depend on changes in household behavior to achieve goals of reducing the environmental impact of urban systems. While others do. This chapter will ultimately argue that in the pursuit of closed-loop urban food systems, household behavior change is a necessary component in tandem with changes in the systems of provision.



For many material flows and demographic and economic contexts explored in the previous chapter, targeting the systems of provision is a necessary first step to closing the loop (Daigger, 2009). Examples abound for energy and water resources. Consider renewable energy mandates that set quotas for the portion of energy to be produced from renewable sources. In 2015, California Gov. Jerry Brown signed a bill that requires 50% of California's electricity be from renewable sources (Baker, 2015). These mandates will drive further changes in infrastructure such as new wind turbines or solar fields, as well as transmission lines that deliver energy from the source to users, and storage facilities. Additional changes to institutional arrangements may involve streamlining siting and permitting processes for the new infrastructure. The end result is a more sustainable energy system by transforming the systems of provision, without household practices having to budge.

Parallel examples can be found in the case of water systems. When the Orange County Water District completed a large scale wastewater recycling system in 1977, success of the program did not rely on household behavior change. New systems of provision were designed to capture water from various sources, treat the water in a system that mimics natural filtration processes, and make the recycled water available for potable use. In fact, the Water Factory 21 was the first to treat wastewater to levels that "meet, and in some cases exceed state and federal drinking water standards" (U.S. EPA 2016h). Treated water is pumped back into groundwater supplies that are used for drinking water across the district (U.S. EPA 2016h, OCWD 2016). Again, the shift toward a closed-loop system constituted changes in the systems of provision without a part for householders to play.

By contrast, we can also imagine efforts to close the loop on urban resources that are dependent on, or vulnerable to household practices of adoption, resistance, and what's known as

the rebound effect. The rebound effect describes a scenario in which desired gains in energy reduction from increased energy efficiency are not realized due to increases in energy use overall (Khazzoom, 1980). Consider new technologies designed to reduce residential energy and water use. Energy efficiency standards in home appliances are promoted and monitored by government agencies (e.g. Energy Star). Previous research in economics and social psychology detected rebound effects undermining expected energy efficiency gains in household heating appliances (Abrahamse, Steg, Vlek, & Rothengatter, 2005; Greening, Greene, & Dfiglio, 2000).<sup>19</sup> Households in these studies increased their use of household heaters as the energy efficiency of the heaters increased. At a cognitive level, this increase in energy use may be a result of the financial savings by the user, freeing up more money to choose to use more energy. Or it may be a result of a cognitive process called "moral self-licensure" (Merritt, Effron, & Monin, 2010).

"Moral self-licensing occurs when evidence of a person's virtue frees him or her to act less-than-virtuously" (Effron & Conway, 2015, p. 33). Think of it as being relieved of the guilt of cheating on your diet on Saturday because of your discipline during the week. The effect of moral self-licensing can also arise across domains. In an experimental design to improve water conservation, researchers found that users who reduced water use increased energy use during that same period (Tiefenbeck, Staake, Roth, & Sachs, 2013). In each of these examples, the net resource use will not decrease by the expected margins because of user-effects. The outcome of reduced consumption is dependent not only on improved systems of provision, but also on household practices.

When it comes to redirecting the flow of household food waste materials from one stream to another (i.e. from landfills to feedstock in compost processes), household behavior change

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<sup>19</sup> It should be noted that the reduced gains from the rebound effect are thought to be small (0-15%) (Berkhout, Muskens, & Velthuisen, 2000)

may represent more of a linchpin compared to other urban material flows (Perrin & Barton, 2001). In particular, consider organic household waste and efforts to reclaim it as an input for food and energy systems. Of course, changes in institutional and infrastructural arrangements (i.e. systems of provision) will (re)shape the urban flows of this material, as is the case with other resources. Yet in order to realize reduced environmental impact of household organic waste streams, changes *must* occur at the household level. The systems of provision for OCPs in the U.S. are largely being organized around providing source-separated collection infrastructure. Separate bins and collection fleets for organic material streams are being deployed to support households in separating their food waste. Source-separation is utilized because it greatly improves the ability of organic materials to be transformed into new products like quality compost and biogas (Saft & Elsinga, 2006). All of this is predicated upon millions of householders transforming their materials management practices in the home and at the curb. If household-level changes are not achieved, however, these systems of provision will be but hollow scaffolding for closing the loop on food systems.

Even considering solutions at the "top of the pipe" we see household practices in food and waste systems take a linchpin role. Legislation may be passed that limits food packaging and gives consumers more control over the portions they purchase. Or changes in zoning may allow more grocers to settle in residential areas, making it easier for households to make more frequent trips rather than stockpiling perishables. Perhaps "Best By" labels would become regulated, or even abolished, leading to less discarding of perfectly edible foods.<sup>20</sup>

But all this does not address the constraints on time, space, and knowledge that households experience as they shop, prepare, eat, store, and reuse leftovers. Even with

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<sup>20</sup> Each of these components has been found to contribute to the generation of household food waste (Evans, 2014; Bloom, 2010; Thyberg & Tonjes, 2016; Quested, Marsh, Stunell, & Parry, 2013)

significant changes to the systems of provision, or the material contexts of food provision described in the previous paragraph, individuals would need to make significant changes. They would need new tools to estimate how to portion food purchases new shopping frequency, location, and perhaps even brand of store. Individuals would also need to trust new standards for "Best By" dates after awareness spread of the unregulated nature of existing ones, or have the knowledge to determine food spoilage in their absence.

These changes to the systems of provision also fail to address notions of identity that are tied up with the flow of food as a resource through our homes. The desire to be seen as a "good provider", for example, is typically characterized by always having plenty of food around "just in case" visitors drop by, and by preparing a variety of healthy, fresh, scratch-made foods (Evans, 2014; Visschers, Wickli, & Siegrist, 2016). Culture and holidays, preferences and taste, these factors affect household food purchasing, preparation, storage, reuse, and donation behaviors (Evans, 2014).

These examples are meant to characterize the shortcomings of focusing only on the systems of provision to change the flows of food and food waste. Contrast this with water and energy flows where there are several solutions based on systems of provision alone that have significant and direct impact on closing the loop on household material flows (e.g. targets and infrastructure for alternative energy sources or reclaimed water systems). In these ways, shifts toward closed-loop food systems are especially dependent on household behavior change. In the following sections, I discuss the stages of household food metabolism and key drivers of food waste generation therein. Subsequently, I discuss theories on transforming household behavior to serve as a foundation for the experiments in the following chapters.

## **Determinants of Household Food Waste and Sorting Behavior**

The transition to closed-loop urban food systems will demand changes to household behaviors. As discussed in the previous section, the role of household behavior may be especially critical for food and food waste material streams compared to other materials. Understanding the determinants of behavior related to household food metabolism is paramount to developing innovative policy interventions that target the social and material aspects of household food waste.

A great deal of ink has been spilled in the nontrivial pursuit of understanding the drivers of household food waste. Structural changes to the food supply chain (Thyberg & Tonjes, 2016), demographic (Quested, Marsh, Stunell, & Parry, 2013), cultural (Rozin, 2005), and psychological factors (Visschers, Wickli, & Siegrist, 2016), as well as habits (Evans, 2014), and skills (Strasser, 1999) all shape household food waste generation and sorting behavior. Structural factors including the modernization of the food system (Thyberg & Tonjes, 2016), the built environment (e.g. urban design, store layout, transit), and food packaging (Quested, Marsh, Stunell, & Parry, 2013) were discussed in the introductory chapter. Here I will focus instead on household-level factors that shape household food waste behaviors; namely demographic, psychological, and habitual. A closed-loop food system must prevent, sort, redistribute, and recycle food waste. The discussion will then focus on providing a foundation for identifying leverage points to transform household behaviors toward those goals. Together with transformations in the systems of provision, these changes can enable urban transitions toward closed-loop systems.

Urban metabolism is a useful framework for understanding the flows of materials into, through, and out of cities. This framework also aptly captures these flows using the household as

the unit of analysis. Similar to urban-scale systems, households can emulate linear or circular systems in terms of energy and material flows. In the linear household food system, there are inputs (i.e. food products from gardening or shopping practices), metabolic processes (i.e. food preparation, storage, reuse), and outputs (i.e. spoiled or uneaten food placed in conduits of donation and disposal). Of course, the linear household is nested within larger systems that manage food provision and waste processing (Bulkeley & Gregson, 2009). A closed or circular system would include household-level food production and waste management where nutrients in food waste are returned to the soil for further food production. The discussion that follows will focus on a linear household system as it predominates the urban landscape in developed countries.

**Household Food Inputs.** In the linear system, household food is transformed into waste at each stage; inputs, metabolism, and outputs. Processes related to household food input are a key point of food waste generation. Before a resident has even left the house for the grocery, shopping practices are shaping food waste generation. Planning meals (Quested, Marsh, Stunell, & Parry, 2013), accounting for household food inventory before shopping (Evans, 2014), and even cultural values of moderation (Rozin, 2005) have been associated with generating less food waste.

Leaving the home en route to the store, a host of new variables come into view. More frequent trips to the grocery (Neff, Spiker, & Truant, 2015) by more price-conscious consumers bringing home smaller armloads of groceries (Rozin, 2005) also correlate with less food waste generation. Higher levels of food waste can be predicted once inside the store on account of habitual behaviors (i.e. purchasing the same food each visit regardless of household inventory)

(Evans, 2014), impulse-buying (Visschers, Wickli, & Siegrist, 2016), and purchasing more fresh produce than frozen (Questaed, Marsh, Stunell, & Parry, 2013; Thyberg & Tonjes, 2016).

Of course, these drivers interact with structural factors to shape outcomes. Briefly speaking, the built environment including zoning, urban design, and transportation can support or constrain frequent trips. If homes are within walking distance, for example, the built environment supports more frequent trips because the cost (i.e. in time and transport energy) of each trip is lower. The built environment inside the store can also promote impulse buying, especially of less healthy foods (Pollan, 2007).

**Household Food Metabolism.** Back at home with groceries in hand, household metabolic processes convert food into stored nutrients. Food is stored as ingredients in the pantry or refrigerator, or as leftovers. From there it is either stored as energy in the body or in bins preparing to embark the waste stream. Crowded refrigerators and kitchen pantries (Neff, Spiker, & Truant, 2015) are the patient graveyard of forgotten food. This makes intuitive sense, as food that cannot be seen is more likely to be forgotten and left to spoil on the shelf. Less food becomes waste in households that practice proper food storage (Bloom, 2010), effectively using the different parts of the refrigerator for the needs of different food --colder in the bottom, dryer in the drawers--without obscuring the contents.

The demographic factors of the folks doing the metabolizing, of course, also shape food waste generation. Larger households tend to waste less per capita than smaller ones (Questaed, Marsh, Stunell, & Parry, 2013), with singletons generating the greatest amount of food waste per-capita (Thyberg & Tonjes, 2016). Though households with more children tend to waste more than those with fewer kids (Parizeau, von Massow, & Martin, 2015). While income and food budget are positively correlated with the amount of food waste (Parizeau, von Massow, &

Martin, 2015; Quested, Marsh, Stunell, & Parry, 2013), age has a negative association (Thyberg & Tonjes, 2016). It remains to be seen, however, whether the latter is an effect of cohort--with those living through the Great Depression and the World Wars being less likely to be profligate with food (Quested, Marsh, Stunell, & Parry, 2013)--or an effect of age.

This question of cohort versus age haunts another finding in research on food waste drivers. Householders with knowledge and skills in food preparation (e.g. preparing good-tasting food, not burning food) and leftover reuse are found to waste less food (Strasser, 1999). Strasser articulates how the domestic acquisition of these skills has largely faded into a memory of a bygone era. And that with more meals eaten outside the home (Strasser, 1999; Parizeau, von Massow, & Martin, 2015) and traditional recipes and food rituals lost (Rozin, 2005; Pollan, 2007), it may be that even as the younger generations age, they will continue to lack the preparation skills that were so commonplace among their grandparents' generation. Thus the lower levels of food waste that stem from these skills and practices seem to be a cohort, rather than an age effect.

Yet even the best intentions of food inventory, meal planning and preparation, and proper food storage can be undermined by spontaneity, social ties, and psychological factors. Unplanned outings for meals with friends or colleagues may sacrifice household food to social relationships (Evans, 2014). Psychological factors such as performing and maintaining a "good provider identity", moreover, have been linked with higher food waste generation (Visschers, Wickli, & Siegrist, 2016; Evans, 2014). The desire to perpetually have enough food on hand of a wide variety when serving a meal or in case of unexpected visitors contributes to stockpiling an abundance of food and ultimately waste (Evans, 2014). Concerns over 'purity' rooted in the good provider identity also create more waste through a heightened concern over food risks and the



pursuit of produce perfection (Visschers, Wickli, & Siegrist, 2016; Evans, 2014). Households that use more criteria to determine whether to discard food or have inaccurate knowledge about food date labeling are more likely to send more food to the waste stream (Thyberg & Tonjes, 2016).

**Household Food Outputs.** Food that is not consumed, becomes an output in the linear household. Ethnographic research has explored the complex processes of "binning" and "ridding" of all manner of household materials (Gregson, 2007; Hetherington, 2004), including food (Evans, 2014; Metcalfe, Riley, Barr, Tudor, Robinson, & Gilbert, 2013). Evans (2014) used participant observations with middle-class households in Manchester, U.K. to uncover some of these processes. For the households in Evans' study, food becomes 'surplus' when it is not immediately useful, but it is still possible for it to be revalued (i.e. used in some way that the resident values). 'Surplus' includes unused ingredients or leftovers. In terms of household metabolism, surplus items are the forgotten food--if temporarily--that are 'stored nutrients' in kitchen pantries and refrigerators. These materials are not yet waste, they have entered what Evans calls the "gap in disposal" (Evans, 2014). Evans distinguishes 'surplus' from 'excess' in that surplus things still have value albeit in some other place or time, whereas when materials enter 'excess' they become worn out or disgusting, without value (Gregson, Metcalfe, & Crewe, 2007).

"If surplus things become excess then they will be disposed of in ways that constitute them as waste; however, if they remain in the category of surplus, they will exit the "gap" to be disposed of in ways that save them from wastage...surplus food slips rather readily into the category of excess" (Evans, 2014, p. 61).

Though most food passes from this gap into the bin and forgotten, these materials are "moved, handled, and thought about" in ways that reveal household anxieties (Evans, 2014).

Anxieties about health, finances, and even waste permeate these behaviors as households in the study would often eat unhealthily (e.g. overeating to avoid leftovers), or spend money on more ingredients to use up unused items. Food materials in the 'gap' are moved to be better preserved, to be reminded of their presence, to be considered for possible uses, but also to bury, hide, actively forget, and deny their waste (Evans, 2014). The latter set of motivations for "moving" food simultaneously eliminates their potential revaluing. So anxieties related to being a good provider (Visschers, Wickli, & Siegrist, 2016), and keeping an orderly home (Douglas, 1966; Shove, 2003) shape the processes by which households place surplus food in the bins, or the "conduits of disposal" (Evans, 2014).

***The Problem with Pantries.*** Food moves from the gap to bins for disposal or to be recovered<sup>21</sup> from disposal through gifting or donation (Evans, 2014). Though less common by far, food may be recovered from the gap through supportive systems of provision for gifting and household practices, effectively redirecting the flow of this material from output to input in another part of the food system. A slew of infrastructural and institutional barriers constrain opportunities to donate or gift edible household food. For instance, the location of food pantries and the limited hours they keep inhibits this flow.<sup>22</sup> Working families with tight schedules may not be available to deliver their donations to pantries that are only open for a few hours per week.

Furthermore, misconceptions about the legality of donations for whole classes of food is widespread. The Good Samaritan Food Donation Act protects individuals, organizations, and companies from liability when they donate (even prepared) food in good faith (USDA, 2016).

Yet many Americans believe that they can only donate canned goods. Of course, in order to

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<sup>21</sup> Note that "recovered" here does not mean recovered out of bins to be donated. Instead, it means prevented from entering bins or other conduits of waste.

<sup>22</sup> These factors also limit the ability to link food loss at grocery stores and restaurants with needy populations. Most pantries are not open to receive donations at the hours that grocers and restaurants close, while others only operate for a few hours each week.

accept perishable items for donation, a pantry must have the proper facilities onsite including refrigeration and adequate storage space. Many pantries, furthermore, are only open a for one to two days each week and only for a matter of hours.

Yet, even if individuals had accurate beliefs about the legality of their donations, and sufficient knowledge of the closest pantry's hours and facilities, and the time and means to get the food to the right place during limited hours of operation whenever food surplus occurred, individuals still face social-psychological barriers to redistributing uneaten food to those in need and further closing the loop on our food system. Ethnographic research on household food behaviors suggests that people are apprehensive to donate food they have prepared or even purchased for fear that their own tastes will be judged. Evans (2014) found that over and over again, householders in his study reported anxiety over donating or "gifting" surplus food. Participants were, however, less reticent to donate when the conditions of donation were anonymous, as with a canned-food drive by the local school, or when their social relations with the receiver were close enough that they would not feel their private lives and tastes had been exposed to new scrutiny (Evans, 2014). In short, people worry about their tastes being judged for leftover lasagna they threw together for a weeknight dinner, but are happy to share their "famous" apple pie all dressed up for a potluck.

More commonly, food that enters Evans' 'gap' in disposal is bound for the waste stream. Food becomes part of the waste stream through storage or "placing" (Evans, 2014) in kitchen bins and ultimately curbside carts until it is collected by components of the larger systems within which households are nested (e.g. collection fleets of OCPs). Household food waste generation at this stage, as with household inputs, is dependent on these nested systems. It is at the points of

household input and output that the household's connection with these larger systems is most evident.

In the case of municipal OCPs, the linear household's food material output are connected to the larger urban metabolic systems through the curbside cart. The cart is the link, or the interface, between the micro and the macro, the household and the city systems (Bulkeley & Askins, 2009).. Even for closed household food metabolisms directing food material flows to backyard compost bins the connection of the household to the larger systems of provision is still evident. Households are able to practice backyard composting because of sufficient space on a private or shared lot to establish the compost bins and a local or regional regulatory framework that is open to such practices.

Indeed, household behaviors interact with the systems of provision to co-create food waste management (Bulkeley & Gregson, 2009). Even with sufficient space and supportive ordinances, residents must have sufficient time, knowledge, and physical capacity (not to mention interest) to establish backyard composting. These barriers are somewhat reduced with OCPs as will be discussed in the following section. However, this dissertation contends that supportive household behaviors are the linchpin of successful curbside programs. "Perrin and Barton (2001) note that the key link in increasing recycling rates is the householder" (c.f. Martin, Williams, & Clark, 2006 p. 359).

One might expect that indicators that predict recycling behavior would be similar for predicting food scrap separation. Both are instances of households engaging with household material streams in order to connect them with larger (often municipal) systems of collection and processing. However, these material streams have very different material realities that may shape household willingness and capacity to manage them appropriately over time, even for separating

in OCPs. Specifically, food waste is organic and begins the decomposition process before the material even enters the curbside cart. Recyclable materials, conversely, will remain in their same state of "plastic bottle" or "aluminum can" for the duration of the householder's interaction with it. Meanwhile, food waste left to sit in kitchen pails may be transforming into putrescent slop; mold, odors, and even pests come to characterize its material presence in the home. Food waste, thus threatens to undermine efforts to "keep house" and protect "order and purity" (Strasser, 1999; Evans, 2014). While these same materials exist in the commingled waste bin, it is precisely their mingled state that prevents its offense. But anyone who has left the kitchen bin too long after a night of shrimp cocktail or brown stew fish, (nose) when the waste has crossed that line. What is the greatest offense of an in-kitchen recycle bin? Faint odors of stale wine or beer after a dinner party, or an unsightly collection of cardboard.

The following section examines determinants of food scrap separation behavior through the lens of the Theory of Planned Behavior (TPB). The empirical analysis in the subsequent chapters examines the predictive strength of this theory for the relevant behavior. While significant research has been conducted using the TPB to predict other pro-environmental behaviors, including some food-related behaviors, there are limited examples of research on the determinants of food scrap separation behavior per se (Ghani, Rusli, Biak, & Idris, 2013). The current research is the first to apply the TPB model to food scrap separation behaviors in an OCP overtime.

**The Theory of Planned Behavior.** The experiment in the following chapters will use the Theory of Planned Behavior (TPB) to explore the fit of this model in predicting household food waste separation. This section serves as the foundation for the empirical chapters to follow. The TPB is a social-psychological model that attempts to explain volitionally controlled behavior

(Ajzen, 1991). It claims first, that the intention to perform a behavior is the most significant direct predictor of behavior (Ajzen, 1991). Subsequently, intention is determined by three constructs; perceived behavioral control, attitude toward the behavior, and subjective norms regarding the behavior. The theory is apt for household food waste management as separation is volitional, and likely subject to resident perceptions of control, as well as attitudes and perceived norms toward separation.

Perceived behavioral control both affects behavior directly and indirectly by affecting intention. This construct measures the extent to which one believes they have the ability to perform the behavior (Ajzen, 1991; Abrahamse & Steg, 2009; Yazdanpanah & Forouzani, 2015). Positive attitudes toward the behavior and the perception of others' approval of the behavior (i.e. subjective norms) also affect the individual's intention to perform the behavior (Ajzen, 1991; Visschers, Wickli, & Siegrist, 2016). In sum, residents who have a positive attitude toward food waste separation, who believe that others engage in the behavior, and that they have the power to perform the behavior themselves should have strong intentions to perform the behavior and be likely to actually do so.

The TPB model has been used to explain behavior in a broad array of domains including health (Watson, Johnston, Entwistle, Lee, Bond, & Fielding, 2014), transportation choice (Heath & Gifford, 2002), and pro-environmental behavior such as energy conservation (Abrahamse & Steg, 2009). Research in the domain of food and waste has largely applied this model to household recycling behaviors (Tonglet, Philips, & Read, 2004; Terry, Hogg, & White, 1999), organic food purchasing (Yazdanpanah & Forouzani, 2015; Vermeir & Verbeke, 2008), food waste reduction (Visschers, Wickli, & Siegrist, 2016), and backyard composting (Ghani, Rusli, Biak, & Idris, 2013).

Perceived behavioral control and attitudes tend to be the most significant predictors of intention and of engaging in the pro-environmental behavior (Abrahamse & Steg, 2009). Previous scholarship on food waste suggests that subjective norms tend not affect behaviors related to food waste because they are invisible to others (Quested, Marsh, Stunell, & Parry, 2013). Indeed, "Tucker (1999)...found that for social norms to be influential in recycling behavior, the visibility of the behavior had to be high" (c.f. Martin, Williams, & Clark, 2006, p. 362). Findings from the current research discussed in subsequent chapters suggest that when the otherwise private food waste separation behavior of others is made public, residents are more likely to engage in separation themselves.

The TPB provides an apt model to predict participation in curbside OCPs, as food waste separation is an intentional behavior. Furthermore, the model makes room for situational and behavior-specific factors (Ajzen, 1991). In order to examine food waste separation for instance, the analysis in the following chapters includes variables for household characteristics (e.g. household size), use of in-home separation devices (e.g. kitchen caddies), and previous experience with composting. The empirical chapters that follow will determine whether these additional variables improve the explanatory power of the TPB model for food scrap separation behavior. These tools can help policy-makers understand determinants of household behavior.

This dissertation, however, will go beyond description of determinants to attempt to influence this behavior. The remainder of this chapter examines scholarship on social innovations to transform household behavior. First, I examine how entities attempt to transform household behavior using supply-side and demand-side approaches. I explore these efforts in material, individual, and social contexts. Throughout, I discuss the links between the extent

research and the current intervention experiment to increase participation in OCPs and ultimately enable the transition toward closed-loop urban food metabolisms.

### **Transforming Household Behaviors**

Previous scholarship has identified different approaches to transforming household behaviors. An important distinction has been outlined in the scholarship between *supply side* and *demand side* approaches (Vlek & Steg, 2007), a distinction that aligns with approaches that focus on *material* and *social* (or *individual*) contexts identified by others (Southerton, McMeekin, & Evans, 2011). *Supply-side* approaches alter the physical environment or financial (dis)incentives thus "modifying choice situations" (Vlek & Steg, 2007, p. 12). In the same vein, programs engaging the *material* contexts focus on the physical infrastructure, technology, and objects (Southerton, McMeekin, & Evans, 2011). In short, these approaches target the systems of provision (Bulkeley & Askins, 2009). The previous chapter discussed these efforts as they pertain to waste. Additional examples include a city attempting to reduce emissions by establishing new bike lanes, and electric car charging stations, or a rebate for purchasing electric cars.

Conversely, *demand-side* approaches target consumer attitudes and knowledge (Vlek & Steg, 2007). This approach includes tools such as testimonials of trusted representatives or education campaigns on the environmental benefits and how to overcome barriers to the desired behavior. Using the same emissions-reducing example, the city using *demand-side* approaches could promote the environmental and health benefits of bike-riding for transport or educate communities where existing electric vehicle charging stations are located. These tools target *individual* contexts (Southerton, McMeekin, & Evans, 2011) attempt to change the decision-making of individuals by influencing their knowledge or attitudes.



Here, Southerton et al. (2011) add an important facet in considering policy approaches to transforming behaviors. In their review of international case studies of existing behavior-change programs, Southerton et al (2011) identified a third context in which these programs operate; *material, individual, and social*. Programs that address *social* contexts then deal with "the social norms, cultural conventions, and shared understandings of consumer practices" (Southerton, McMeekin, & Evans, 2011, p. 1). Thus we may consider that social innovations (Castán Broto & Bulkeley, 2012) within *demand-side* approaches (Vlek & Steg, 2007) may target either *individual* or *social* contexts (Southerton, McMeekin, & Evans, 2011). The experiment in the following chapter engages first the material contexts then the social contexts of food waste separation behavior in curbside OCPs.

Southerton et al. (2011) found a disproportionate focus on the individual context in programs targeting household behavior. This is despite findings that focusing on the individual context alone "excludes social contexts in which individual decisions, attitudes, and choices are often understood and framed" (Southerton, McMeekin, & Evans, 2011, p. 2). The experiments in the following chapters target these social contexts in an effort to test the efficacy of these tools in creating successful OCPs. The following sections consider supply- and demand-side approaches to changing household food waste behaviors, and the material, social and individual contexts targeted by different approaches. I close the chapter by discussing findings from social psychology and social marketing that especially inform the experimental design of the intervention experiment in the following chapters.

**Supply-Side Approaches, Material Contexts.** In the case of household organic waste, municipalities establishing OCPs in the U.S. have almost exclusively taken a supply-side approach (Castán Broto & Bulkeley, 2012), focusing on "modifying the choice situation" (Vlek

& Steg, 2007) by the altering material or physical infrastructure (Southerton, McMeekin, & Evans, 2011). OCPs provide supportive physical infrastructure for the desired behavioral change; namely, curbside organics carts and kitchen pails for in-home food waste separation. This new physical infrastructure, including the provisioning of collection and waste processing services, modifies choice situations by reducing supply-side constraints and increasing opportunities for food waste separation behavior. Providing supportive infrastructure for food waste separation has been shown to have long-term efficacy in diverting food waste from landfills (Bernstad, 2014). Recent waste characterization studies suggest, however, that the available source-separation infrastructure for organics goes under-used with more than half of landfill streams constituted by readily compostable or recyclable materials (SF Environment, 2013b).

**Demand-Side Approaches, Individual Contexts.** Demand-side approaches in the waste management context require that municipalities 'cross the threshold' (Bulkeley & Gregson, 2009) by more directly engaging with the individual and social aspects of waste generation and management. While most cities working to reduce their environmental impact focus on material contexts (Castán Broto & Bulkeley, 2012), even those that do engage with demand side approaches tend to target individual contexts rather than social ones (Southerton, McMeekin, & Evans, 2011). Tools that target individual contexts include educating consumers, providing financial incentives, and instituting punitive measures to achieve sustainability goals. Education campaigns, for instance, attempt to inform residents of what materials belong in which bins and the environmental benefits of recycling. On the other hand, financial incentives and punitive measures are intended to tip the scales of an individual's cost-benefit analysis toward the desired behavior.

The basic premise of these efforts, however, is that humans are wholly rational actors. Education campaigns assume that if only residents had additional knowledge, they would make the rational decision to behave in a pro-environmental manner (Bernstad, 2014; Schultz P. W., 1998; Oskamp, Burkhardt, Schultz, Hurin, & Zelezny, 1998). However, extensive research on what drives human behavior has revealed that humans often fail to embody the image of a rational actor seeking to maximize "the good" through calculated actions (Ariely, 2009; Gardner & Stern, 2002; Osbaldiston & Schott, 2012). Moreover, interventions based on an assumed knowledge deficit have largely yielded unsatisfactory results (Osbaldiston & Schott, 2012; Goldstein, Cialdini, & Griskevicius, 2008; Schultz P. W., 1998). In a meta-analysis on behavioral interventions, Osbaldiston & Scott (2012) found that not only were financial incentives or "rewards" not the most effective, but that behavior changes were not durable after incentives were terminated.

Worse than disappointing, approaches targeting individual contexts alone have proven counterproductive in some cases (Carrico, et al., 2011; Southerton, McMeekin, & Evans, 2011; Osbaldiston & Schott, 2012). Consider the good-intentioned financial incentives. Recent research suggests that the use of incentives or disincentives may lead to "motivational crowding, which occurs when external rewards undermine intrinsic motivation, resulting in a reduction in the desired behavior" (Carrico, Vandenberg, Stern, Gardner, Dietz, & Gilligan, 2011, p. 63). For example, findings from a daycare showed that imposing a late-pick-up fee resulted in an *increase* in tardy parents because the fee freed them from the guilt involved in showing up late (Carrico, Vandenberg, Stern, Gardner, Dietz, & Gilligan, 2011). Worse, the tardiness remained even after the fee was removed. Whether or not to engage in tardy behavior had previously been evaluated within a social context laden with feelings of duty and guilt (Ariely, 2009). But the

new incentive cast the behavior in a market-based decision-making framework in which the value of being tardy outweighed the cost (Ariely, 2009). Social or moral obligation did not weigh on this scale.

**Demand-Side Approaches: Social Contexts.** Social psychology understands human behavior as an interaction between individual psychological or mental states and the influence of the social context (Allport, 1985). In contrast to viewing humans as strictly rational agents, social psychological theories recognize that the social contexts in which individual behavior is enacted is shaped by that context, often in undetected and uncalculated ways (Schwartz, 1977; McKenzie-Mohr, 1999; Gardner & Stern, 2002; Carrico, Vandenberg, Stern, Gardner, Dietz, & Gilligan, 2011; Osbaldiston & Schott, 2012). For instance, social psychology recognizes that decisions about being tardy to pick up children from day care are influenced not just by conscious internal mental states or personality, but also by socially understood, if undetected, moral obligations to others. The current research draws on theories of social impact (Latané, 1981) and social norms (Cialdini, Reno, & Kallgren, 1990), as well as the Theory of Planned Behavior (Ajzen, 1991).

The social-psychological literature on pro-environmental behavior change is largely characterized by laboratory-based and in situ experiments examining the social influences on individual behaviors and leverage points for systematic behavior change. Comparative analyses examine different tools for influencing behavior change. Many studies examining normative social influence on pro-environmental behavior from a social-psychological lens have focused on travel behaviors (DeGroot & Steg, 2007; Steg, Geurs, & Ras, 2001) energy and water conservation (Carrico & Riemer, 2010; Dietz, Gardner, Gilligan, Stern, & Vandenberg, 2009; McKenzie-Mohr, 1999), litter prevention (Cialdini, 2007) and recycling (Hooper & McCarl

Nielsen, 1991; Schultz, 1998; Ohtomo & Hirose, 2007) among others. As discussed in the previous section, a handful of scholars have more recently examined food-related behaviors within a social context (Evans, 2014; Parizeau, von Massow, & Martin, 2015), but fewer still have examined food behaviors from a social-psychological lens (Visschers, Wickli, & Siegrist, 2016; Yazdanpanah & Forouzani, 2015). Save a few recent examples (Ghani, Rusli, Biak, & Idris, 2013; Bernstad, 2014), this body of research has largely overlooked the domain of food waste separation, in particular. The current research seeks to fill this gap.

***Social Influence Theory.*** Norms are “sets of beliefs about the behavior of others” (Schultz P. W., 1998, p. 26) or about the most common behavior for a given situation (Cialdini & Trost, 1998) that informs individual behavior. Social norms are thought to influence individual behavior through two human desires; the desire to be right and the desire to be liked by others (Deutsch & Gerard, 1955). When an individual is uncertain about the appropriate behavior for a situation, they will look to others for cues. This has been termed *informational social influence* as the individual is looking to the behavior of others for additional information about how to act correctly (Deutsch & Gerard, 1955). On the other hand, *normative social influence* drives conformity to the observed behavior via the human desire to be liked and accepted by others (Deutsch & Gerard, 1955). For the purposes of the experiments in the subsequent chapter, I will focus on normative social influence in part because the public agency has designed an OCP that provides information on how to properly engage in household food waste separation.

Normative social influence can occur either in natural settings where individuals observe others engaging in behavior, or it can occur via direct (or "official") communication of the behavior of others. In the latter scenario, an intermediate entity such as a city or an employer communicates the normative behavior of the group to the individual in an overt attempt to

influence behavior via normative social influence. This is also called *social norms marketing* (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). This communication of norms directs the attention of individuals on the social norms that govern a particular situation (Deutsch & Gerard, 1955). The influence of those norms is thus activated and will tend to conform the individual to that behavior (Cialdini, Reno, & Kallgren, 1990; Deutsch & Gerard, 1955).

In comparative experiments testing more than one approach to influence behavior change, directly communicating normative social influence has proven more effective than other approaches for an array of behaviors and scenarios. Using information about environmental impact alone, for instance, has yielded significantly worse results than communicating what other people actually do or what other people think is the right thing to do (Carrico & Riemer, 2010; Goldstein, Cialdini, & Griskevicius, 2008; Schultz P. W., 1998; Gardner & Stern, 2002; Hooper & McCarl Nielsen, 1991). For example, in an experimental design testing different methods to increase the reuse of towels by hotel guests, Goldstein et al. (2008, p. 477) found environmental messaging to be less effective than normative messaging. In the study, some rooms had signs with an environmental message extolling the benefits of reusing your towels, while signs in other rooms communicated group norms by stating that 75% of other guests reused their towels. Ultimately, the guests with the norm messaging reused their towels at 150% the rate of guests with environmental messaging. These hotels were able to save water and energy, not with large capital investments, but merely by communicating these group norms.

Two types of normative influence are distinguished in the literature; *descriptive* and *injunctive* norms (Cialdini, Reno, & Kallgren, 1990; Schultz P. W., 1998). Descriptive norms pertain to beliefs about the actual behavior of others, whereas injunctive norms reflect beliefs about the expectations of others (Cialdini, Reno, & Kallgren, 1990). In the hotel-towel-reuse

experiment above, the experimenters communicated descriptive norms about how many guests actually engage in the behavior. A series of experiments have found similar results for the direct communication of these types of norms (Schultz P. W., 1998; Cialdini R. B., 2007; Carrico & Riemer, 2010).

Descriptive norms have shown some success in increasing the desirable behavior, particularly when communicating that some majority of a group engages in the behavior, as in the hotel towel study (Goldstein, Cialdini, & Griskevicius, 2008; Hooper & McCarl Nielsen, 1991; Gardner & Stern, 2002; Carrico, Vandenberg, Stern, Gardner, Dietz, & Gilligan, 2011). However, descriptive norms have shown mixed results when using the average behavior of the group (e.g. average number of alcoholic beverages per week) to communicate the common or typical behavior (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). Folks who find themselves performing poorly relative to the average, tend to conform to the mean, unfortunately those whose performance is above average do the same. This is called the *boomerang effect* (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007) and has been shown to be ameliorated by incorporating injunctive norms.

"[F]or people who were initially low in energy consumption, ...descriptive normative information combined with an injunctive message of approval [of low energy consumption] led to continued consumption at the desirable low rate, rather than a significant move toward the mean" (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007, pp. 432-433).

The experiment in the subsequent chapters uses descriptive norms to communicate the percent of residents who engage in the desired behavior (i.e. "separating all of their food waste into the curbside organics cart"). Framing the descriptive norm in this way should also avoid the undesirable boomerang effects as there is no average above which residents could find themselves. Instead, they will see themselves relative to the group in terms of whether or not

they represent the normal "separators", or the abnormal "non-separators." This approach leverages the individual's desire to be accepted and see their own behavior as normal rather than abnormal.

***Social Impact Theory.*** Social impact theory contributes important nuance to our understanding of the processes by which social norms influence individual behavior. The theory suggests that social norms, including the communication of descriptive and injunctive norms described above, will have a greater impact depending on the strength, immediacy, and number (i.e. size) of the relevant social group enacting the normative behavior (Latané, 1981). That is, the more important the group is to the individual, the greater the impact of social norms. Likewise, the more physically immediate the group is to the individual actor and the larger the size of the group, the more likely the communicated (or observed) social norm will impact the individual's behavior.

In contrast, Goldstein et al. (2008) found that the identities that individuals reported as "more important to them" were not predictive of the actual normative influence these group's behavior would have on the individual. In the hotel-towel-reuse experiment, Goldstein et al. (2008) tested the effects of different reference groups to influence behavior. The authors found that even though respondents considered "guests who stayed in the same room" to be the least important to them, this referent group had the greatest normative effect on towel reuse (Goldstein, Cialdini, & Griskevicius, 2008). The normative behavior of this group ( as communicated through descriptive norms on signs in the room) had a greater impact than referent groups based on gender or citizenship (Goldstein, Cialdini, & Griskevicius, 2008). The authors suggested that this could be because situational commonalities wield an influential normative influence not captured by personal commonalities.



The empirical work in the subsequent chapters is grounded in these understandings of the impact of social norms via the referent group. The descriptive norms communicated to individuals are of other community members. Neighbors, while of differing importance to the individual, are a social group that is consistently proximal to the enactment of individual household waste behaviors.<sup>23</sup> They are also the largest. In this way, the current intervention treatment leverages immediacy, number, and for some individuals, strength (Latané, 1981) of referent group in communicating social norms. In line with Goldstein et al.'s (2008) findings, the referent group may be thought of as sharing situational commonality, if not personal commonality. Where others in your community may hold salient very different identities, they will each be adjusting to the new curbside carts and the new expectations of food scrap separation in their kitchens for the OCP. This perceived shared experience may leverage normative social influence based on situational commonalities.

Osbaldiston and Schott (2012) found that social-psychological processes such as those discussed here ranked among the greatest effect sizes for intervention types; specifically, social modeling through norm communication, cognitive dissonance, and group commitment.<sup>24</sup> Cognitive dissonance registered as one of the largest independent effect sizes of behavior-change tools and involves

"assess[ing] the pre-existing beliefs or attitudes and attempt[ing] to make participants behave in ways that were consistent with those beliefs to reduce the dissonance" (Osbaldiston & Schott, 2012, p. 273).

Consider a man who identifies as an environmentalist, but loves to buy new clothes, shopping almost weekly for the latest fashion. He learns through a public awareness campaign that the life-cycle impacts of buying new clothes, especially if frequently done, is harmful to the

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<sup>23</sup> The only *more* proximal social group would be other members of the household itself.

<sup>24</sup> As opposed to strategies that targeted individual contexts such as education campaigns.

environment. This would create dissonance that the man would seek to eliminate, especially in the case of dearly held identities (Festinger, 1964). Cognitive dissonance can be powerful, but also difficult to measure or even control. Because cognitive dissonance is a perception about how consistent our beliefs or behaviors are, it is not an easily observable phenomena (Festinger, 1964). Furthermore, there are several coping strategies employed by people seeking consonance, and not all of them result in the desired behavior. For instance, remembering our shop-aholic, rather than reducing consumption of new clothes, he may instead over-inflate the value of donating clothes to charity in order to continue valuing both shopping and environmentalism.

In terms of group commitment, several scholars have found it to be an effective means of transforming behavior compared to other tools like pleas to action and education campaigns (Carrico, Vandenberg, Stern, Gardner, Dietz, & Gilligan, 2011; McKenzie-Mohr, 1999; Gardner & Stern, 2002). In fact, Carrico et al. (2011, p. 62) found that personal commitment and social norms, account for more of the variation in pro-environmental behavior than do factors such as cost. Additionally, social marketing research suggests two ways through which employing group commitment can increase pro-environmental behavior. First, when individuals take a small action, such as committing in writing to change a particular behavior, they begin to see themselves as the kind of person who cares about that behavior (McKenzie-Mohr 1999). Second, people have a strong desire to be seen as consistent in the eyes of others and will alter their behavior to fit with their commitments. McKenzie-Mohr cites a study done to increase curbside recycling in Salt Lake City, Utah in which securing a signed commitment resulted in greater participation than “receiving a flyer, telephone call, or personal contact alone” (1999, p. 52).

Schultz (2014) builds on the findings from Osbaldiston and Schott (2012) in delineating scenarios in which particular behavior change tools will be maximally effective. This classification is in part a response to the somewhat heterogeneous effects of the intervention strategies found in the meta-analysis (Osbaldiston & Schott, 2012). That each tool exerted variable effects on behavior suggests that there is some other moderating effect (Schultz W. P., 2014). Schultz's classification attempts to capture those effects by classifying the most effective tools based on the barriers to and perceived benefits of the behavior in that population.

The classification (See Table 1) presents four scenarios in which different behavior-change tools should be employed; low and high barriers, and low and high perceived benefits. Barriers are anything that prevent the individual from engaging in the pro-environmental behavior; physical infrastructure or financial constraints are often the culprit. Perceived benefits relate to the positive outcome an individual ascribes to a given behavior (Schultz W. P., 2014). Different social-psychological tools are assigned to one scenario in a four-way matrix of these scenarios based on their highest expected effectiveness in the context of perceived barriers and benefits (Schultz W. P., 2014). Less than any particular behavior would consistently fit into one of these cells, but that conditions on the ground would help the practitioner decide which tools to use based on the scenario that fits the particular behavior for a particular population.

	<b>Low Benefits</b>	<b>High Benefits</b>
<b>High Barriers</b>	Incentives, Contests	Make it Easy, Commitments
<b>Low Barriers</b>	Social Modeling, Social Norms	Cognitive dissonance, education, feedback, prompts

Table 1. Contextualized Behavior Change Tools. The table presents the behavior change tools hypothesized to work best for each Benefits-Barriers Scenario (Schultz, W.P. 2014)

High Barrier, High Benefit behavior-scenarios are those in which individuals believe there are benefits to performing the behavior, but the physical, financial, or other barriers are quite high. For these, Schultz' classification suggests approaches that "make it easy" and that leverage group commitments. Low Barriers, High Benefit behavior-scenarios are those that are easy to perform and are perceived to have a positive outcome. These behaviors are best addressed using cognitive dissonance, prompts, regular feedback, and education. Schultz identifies behaviors that have High Barriers and Low Benefits to be among the most challenging to address. Purchasing electric vehicles, for example, may not be perceived as of great benefit to the individual who must be motivated with additional benefits such as financial incentives or contests. Finally Low Barriers, Low Benefit behavior-scenarios are easy for the relevant population, but are perceived to have little benefit. According to the model, these sorts of behaviors, such as avoiding idling a car's engine, are best addressed with social modeling and social norms in which the norms governing a behavior are made salient to the individual.

Schultz provides here a needed framework for simplifying our understanding of the array of social-psychological tools at our disposal for pro-environmental behavior change, and the appropriate contexts in which to apply them. As Schultz (2014) notes, however, further empirical evidence testing the contextualized effects of these social-psychological tools are needed to verify the efficiency of the model. The current research seeks to explore one of the behavior-scenarios posited by Schultz's model.

By transforming the systems of provision, the curbside OCP attempts to "make it easy" for households to divert food waste from landfills by providing a curbside service to process the materials at a facility, rather than relying on backyard composting alone. For most householders, backyard composting poses significant barriers in terms of time, space, and physical capacity to

name a few. Furthermore, many in the population may still regard food decomposition as an innocuous process and so see little benefit to the added task of separating food waste. Thus there should be a significant increase in food waste separation behavior with the implementation of the curbside OCP.<sup>25</sup>

Once the barriers have been reduced, however, any further non-participation would need to be addressed with different tools according to Schultz' model. I argue that after "making it easy" the behavior-scenario for food waste composting shifts from a High Barrier, Low Benefit to a Low Barrier, Low Benefit cell in the matrix. Thus the appropriate behavior change tools to further increase participation according to Schultz's classification involve Social Modeling and Social Norms. The current study provides empirical evidence for this in the intervention experiment in Phase B in which the treatment group receives norm communication after the effects of curbside carts that "make it easy" have been accounted for (i.e. in Phase A).

### **Summary of Theoretical Foundation**

Throughout the preceding chapter I have discussed the key theoretical perspectives from social sciences upon which the experiments in the subsequent chapters will be based. Here, I endeavor to summarize these points to guide the reader through the methods and results that follow in the next chapter. Of key interest are the concepts from social influence theory and social impact theory that inform the intervention experiment, the classification model of behavior change that informs the appropriate treatments, and the household urban metabolism model that illuminates the points of leverage within the household that must be targeted to shift toward a closed loop system.

In order to close the loop on urban food systems, cities must transform the systems of provision as well as household behaviors, this chapter has shown that this is especially true for

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<sup>25</sup> The natural experiment in Phase A in the subsequent chapters tests this claim.

food as a material flow. Curbside OCPs are a critical development to redirect these food waste flows to be used as inputs in other processes, but cities must entrain households as actors in these programs and cities must engage with the social aspects of waste. Toward this effort, this chapter examines household food material flows through the lens of urban metabolism to understand the social context in which household waste separation occurs as part of a suite of food-related behaviors. This understanding is meant to support the development of policy interventions to improve shift cities toward closed loop food systems.

First, the experiments in the following chapters are designed to detect the influence of a) transforming the systems of provision, and b) household behavior-change tools in motivating participation in a curbside OCP. This chapter discussed important distinctions in policy approaches that target the material and social (and individual) contexts using supply- and demand-side approaches. The first experiment will test the effect of targeting the material contexts of the systems of provision in a supply-side approach to closing the loop. The curbside bins, collection services, and processing facilities of the OCP constitute significant transformations in the supportive infrastructure, the material contexts. The second experiment then tests the effect of engaging with the social aspects of waste separation using norm communication. By leveraging the social context, these tools embody a demand-side approach to achieve environmental goals. Taken together, cities can, and arguably must use supply- as well as demand-side approaches to close the loop on urban food systems.

Second, the experiments in the subsequent chapters test whether the direct communication of the new community norms of food waste separation will influence participation in curbside OCPs. Social influence theory suggests that people are likely to conform their behavior to that of others, whether observed or directly communicated, in order to

be right (i.e. *informational social influence*) or to be accepted (i.e. *normative social influence*) (Deutsch & Gerard, 1955). The intervention experiment communicates descriptive norms, or the actual behavior of others (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007), and leverages the community as the referent group. Social impact theories suggest that the strength, immediacy, and size (Latané, 1981) as well as the situational commonalities (Goldstein, Cialdini, & Griskevicius, 2008) of neighbors as a referent group should ensure the descriptive norms will influence individual householder's behavior.

Third, the analysis will examine whether the TPB model has explanatory power for food waste separation behavior as it has for other volitional behaviors (Ajzen, 1991; Visschers, Wickli, & Siegrist, 2016). Cross-sectional analyses will determine whether residents have a greater intention to separate food waste if they believe they have positive attitudes toward and perceived control over the behavior, and believe others will separate their food waste. Subsequently, the analysis will determine whether this intention and additional variables (i.e. environmental concern and previous composting behavior) predict actual separation behavior.

Finally, the experiments discussed in the following section draw on new developments in the literature attempting to classify the appropriate behavior-change tool based on the perceived benefits and barriers of the particular population (Schultz W. P., 2014). By testing first the effects of the new curbside OCP, the study is designed to determine whether "making it easy" will change the behavior of householders. The extent to which residents do not change their behavior, it may be evidence that barriers remain that were not addressed with the supportive infrastructure (e.g. the "ick" factor). Contrarily, it may be evidence that the behavior-scenario (see Table 1) has shifted to the 'Low Barrier, High Benefit' cell demanding that social modeling,

including social norms are the appropriate behavior. The extent to which additional gains in participation occur, this may be evidence in support of the latter explanation.

The following chapter will present the case study in which the author partnered with the Costa Mesa Sanitary District as they prepared to implement the first curbside OCP in the county. The chapter will then discuss the experimental designs including sampling, procedures, and the questionnaires. The chapter closes by discussing the findings from the natural and intervention experiments in Phase A and B respectively, as well as the results of the TPB model fit. This empirical addresses several gaps in the social science literature and provides evidence for the applicability of these findings to improve efforts to close the loop on urban food systems.



## CHAPTER 5

# Technical and Social Innovations

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## Methods and Results

The previous chapters outlined the theoretical framework that supports the experimental designs that follow. This chapter will first present details of the case study to provide critical understanding of the context for the community-based experiments, the hypotheses, and ultimately the findings. The Methods section will discuss the sample, experimental design, and questionnaire. Procedures pertaining to the experimental design include the focus groups and the trial recruitment conducted in preparation for the experiments themselves. The chapter closes by presenting results from the experiments and the Theory of Planned Behavior cross-sectional analyses. Discussion of the analysis of these results will be presented in the following chapter.

### **The Case Study**

Costa Mesa is a city of 112,000 residents in over 40,000 households located in the central coast of Orange County in Southern California. The Costa Mesa Sanitary District (CMSD) that serves storm water and solid waste needs for 20,000 residents of single family homes and small multi-family units. Costa Mesa is the first in the county to offer a curbside organics collection program (OCP). The challenges in this context are significant. Dense housing stock, heavily renting populations, and a 70 year legacy of single-stream household waste collection characterized the population set to receive new curbside organics carts as early as June 2015.

Over half of the housing stock in this city are multi-family with 2 or more units per structure. This is more than 50% higher than the county and state average for multi-family housing stock, both are closer to 32% (U.S. Census Bureau, 2014). Costa Mesa has nearly twice the population density with over 7000 persons/mi<sup>2</sup> (2,702 persons/km<sup>2</sup>), compared to Orange County average 3807 persons/mi<sup>2</sup>, 1470 persons/km<sup>2</sup>. This is a pertinent consideration as multi-unit structures tend to provide more challenges for waste-separation schemes. In other contexts such units would be characterized by high resident turnover and dumpster waste services, losing

individual accountability that per-household carts provide. For multi-family residents served by CMSD, the greatest concern is sufficient curbspace for the new bins.<sup>26</sup> Less space, more resident turn-over, and less individual accountability often make multifamily units the final frontier in municipal organics programs.

The new curbside OCP program will ask all CMSD clients to switch from using one bin for all rubbish to a two-bin system: one for food scraps and yard waste, and one for everything else. Transitioning to separating food waste can be a challenge even when transitioning from a waste collection service that already asks residents to separate recyclables. Unlike residents served by CMSD who have placed all household material outputs into a single stream of waste, residents with source-separated recyclables are already in the practice of storing and maintaining separate bins for recyclables and trash. Though even starting with source-separation of some material streams does not guarantee success.

A recent study by the San Francisco Department of the Environment indicated that more than half of landfill bin contents are readily recyclable or compostable (SF Environment, 2013b). This is one of the factors that makes CMSD an interesting case study; they may be the first to adopt an OCP without first having implemented a source-separated recycling program. Given the tenure of the single-stream waste system and the transition to organics collection, CMSD is at once an anomaly for cities in Southern California and more typical of other cities around the country where separate bins for recycling have yet to be instituted.

CMSD hires private contractors for many of the services it offers, including waste hauling. CR&R Environmental Services (CR&R) is the sole waste hauler contracted in the district. CR&R has finished construction of the region's largest Anaerobic Digester (AD) facility

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<sup>26</sup> Multi-family units in CMSD are often arranged along an alleyway that connects to the main residential street with extremely limited curb on either side of the entrance.

to process the organic waste that it will begin collecting in several cities in Southern California. Until now, the single-stream of waste was collected and sorted for recyclables at a facility 15 miles away in the City of Stanton, CA. This process, called post-collection separation has achieved a 54% landfill diversion rate as of 2011. By separating food waste, a primary culprit of contamination in recycling streams--especially paper--CR&R and CMSD expect the post-collection separation processes to yield better rates.<sup>27</sup>

CMSD has set a goal of 75% diversion by 2015; five years ahead of the AB 341 state mandate requiring 75% diversion across California (CMSD, 2014; CalRecycle, 2012). CMSD estimates that the adjusted diversion rate will be closer to 42% (Carroll, 2014) after AB 1594 goes into effect in 2020; eliminating the 'diversion credit' of green waste used as alternative daily cover of the open face of the landfill (CalRecycle, 2012; Assemb. Bill 1594, 2013-2014). Constituting as much as 30% of all MSW, organic waste diversion presents an opportunity for CMSD to achieve their diversion goals, both self-imposed and state-mandated. Of course, CMSD achieving these goals will require transforming the systems of provision as well as household behaviors.

## **Hypotheses**

The experiments that follow rely on data collection at three time points across six months and test a series of hypotheses. The natural experiment in Phase A will examine how household food scrap separation practices change after receiving curbside organics carts. Based on previous research suggesting some level of household behavior change with new supportive infrastructure (i.e. the systems of provision), I expect that that (H<sub>1</sub>) household food scrap separation will increase after receiving the curbside organics carts. These gains are likely to level off over time; that is the initial increase after residents receive their carts (Time 2) will plateau in the months

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<sup>27</sup> The overall diversion rate will increase, of course, by keeping organics out of landfills.

following (Time 3). The intervention experiment in Phase B tests social innovation tools based on social influence theory to increase the desired behavior beyond the plateau; namely household food scrap separation behavior. Thus, I hypothesize that (H<sub>2</sub>) norm communication will increase participation between Time 2 and Time 3.

## **Methods**

**Sample and Experimental Designs.** The hypotheses were tested using a two-part community-based experiment between June 2015 and December 2015. Through the months of July and August 2015, approximately 20,000 single-family households served by the Costa Mesa Sanitary District (CMSD) received a curbside organics cart. A complete list of these addresses was obtained from CMSD and a random sample of 7,400 was selected based on power calculations (UCSF, 2015), anticipated response rates, and estimates of attrition over the 6 month study period were used to determine the necessary sample size.<sup>28</sup>

**Trial Recruitment.** A trial recruitment was first conducted to determine whether print surveys would improve response rates and representativeness.<sup>29</sup> A sub-sample of 400 residents was selected to receive either a digital-only response option or a print and digital response option. The digital-only response group had significantly lower response than the print and digital response group (3% and 14% respectively). The representativeness of respondents to the general population was also poor in the digital-only group, over-representing younger residents with higher education. Ultimately, print and digital response options were used in the recruitment anticipating a 14% response rate in the full recruitment efforts.

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<sup>28</sup>Power calculations indicated that to detect an effect size of 0.3 between two groups (with alpha .05) would require about 350 total in the final sample (i.e. at the end of Phase B) (UCSF, 2015). I then estimated the recruitment sample size based on a response rate of 15% and an expected attrition rate of 50% in the second survey and 30% in the third. Thus I sampled 7,400 resident addresses from the complete list who would receive recruitment materials in order to have approximately 400 residents in the final sample.

<sup>29</sup> I used power calculations to determine that in order to detect a significant difference of 10% between two groups (print vs. print and digital response options), I would need a sample size of 180 in each group (UCSF, 2015).

***Phase A: Natural Experiment.*** The recruitment mailer for this study included a welcome letter, a six-page survey, a postage-paid return envelope, and a link for the online version of the survey. This gave residents the option of completing the survey online or using the print version. Residents were asked to complete three surveys over the course of six months in exchange for a \$10 grocery-store gift card for each survey; one in June, September, and December (Times 1, 2, and 3 respectively). For completing all three surveys, participants would also be eligible to be randomly selected for one of four \$75 grocery-store gift cards (two selected from the treatment group and two from the control group). One reminder postcard was sent to non-responders after two weeks. The Recruitment Survey in June served as the pretest for the natural experiment and the Post-Program Survey in September, the posttest. For this natural experiment, the curbside cart itself was the treatment.

CMSD incorporated technical innovations targeting material contexts (Southerton, McMeekin, & Evans, 2011) to alter the flow of food waste materials in urban systems by implementing a curbside OCP with rolling carts, collection fleets, and organics processing facilities. Individual contexts (Southerton, McMeekin, & Evans, 2011) were engaged by CMSD through informational Town Hall meetings, and awareness campaigns on the radio and in the newspaper. The natural experiment in Phase A will test Hypothesis 1 that changing the systems of provision (Bulkeley & Askins, 2009) will result in an increase in food waste separation behaviors. Further gains however, as will be tested in the intervention experiment, will require engaging with social contexts (Southerton, McMeekin, & Evans, 2011).

***Phase B: Intervention Experiment.*** The Post-Program Survey (Sept) also served as the pretest to the Intervention Experiment in Phase B. The final survey in December (i.e. Post-Intervention Survey) served as the posttest to the intervention. Each respondent in the Post-

Program Survey was randomly assigned to a treatment or control group for the intervention. The treatment group completed one short survey during each of the eight weeks of the intervention between September and December. The weekly surveys asked respondents what portion of their food waste they had separated into the curbside organics cart and how often they removed food scraps from their kitchen to the cart. The treatment was the direct communication of descriptive norms of food scrap separation by community members. Each week, treatment group participants received the message that "75% of households in Costa Mesa separated all of their food scraps this week." This percentage varied at random values between 75-84% across the intervention period. The intervention experiment tested Hypotheses (2) that without further action, participation levels will level off, and (3) norm communication will increase participation.

Time	Survey	June	July/ Aug	Sept	Oct	Nov	Dec	Final Sample
1	Recruitment Survey <i>Treatment: Curbside Organics Carts</i>	O	X					
2	Pre-Intervention Survey <i>Treatment: Norm Communication</i>			O		X <sub>T</sub> X <sub>T</sub>		
3	Post-Intervention Survey						O	
	Sample Size (n)	1,089		583			399	363
	Retention Rate			53%			37%	33%

Table 2. Experimental Timeline. This table shows the timeline for the three surveys, treatments for the two experiments, and the sample size and retention rates at each observation. Where O is Observation, X is Treatment, and X<sub>T</sub> is Treatment only applied to Treatment Group. Final Sample includes only those who completed all three surveys.

**Questionnaire.** The six-page survey included several survey items and a series of constructs with most items repeated in all three surveys.<sup>30</sup> The constructs relevant to the current research are as follows: perceived behavioral control, attitudes toward separating food waste, subjective norms, and environmental concern. These constructs are used in the analysis of the

<sup>30</sup> A complete list of constructs and survey items is available in Appendix A

TPB model. Each of these constructs is comprised of several survey items. Survey items included in the model are self-reported food waste separation behavior, intention to separate food waste, and use of a separation device in the kitchen. Food waste separation behavior is measured using a survey item asking participants how often they "separate their food waste from the regular trash" on a five-point Likert scale from "Never" to "Always". All other survey items were rated on a five-point Likert scale with higher scores indicating greater agreement with the statements.

Finally, the questionnaire included demographic questions based on the U.S. Census categories for age, education, and race.<sup>31</sup> Ten age response options ranged from 18 to 65 and over using five-year intervals. Education response options ranged from "Less than high school" to "PhD" and "JD/MD". Categories for race allowed participants to "Select All that Apply" and included White, Black, Native American / Alaskan Indian, Asian / Pacific Islander, and Other. A separate question asked respondents whether they are ethnically Hispanic or not.

**Focus Groups.** I used a focus group method to test and improve the questionnaire. Focus group participants were recruited through a congregation in Fountain Valley, a neighboring community. Importantly, while Fountain Valley is proximal to Costa Mesa, none of its residents are served by CMSD, and so they would not be at risk of being included in the full study. Fountain Valley also shares some socio-economic and demographic characteristics with Costa Mesa. I conducted two focus groups with 6 participants each. Participants volunteered to review the survey materials before meeting as a group to discuss survey items and their household practices with food waste. Each focus group lasted about an hour and was organized around improving clarity, comprehension, and completeness of the survey items and effectiveness of recruitment method. Participants received a \$25 grocery gift card for their time. This approach

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<sup>31</sup> Race and ethnicity responses were omitted from analyses in part because of high nonresponse rates.



has the benefit of improving community comprehension and cultural competence of all materials without the potential of contacting Costa Mesa residents until the materials are ready.

## Results

In the following section, I discuss the results from the two-part community-based experiments. I will first provide descriptive statistics focusing on the sample used for all three time points (i.e. June, September, and December surveys). Because not every respondent took all three surveys, steps were taken to ensure that for the purposes of analysis, the sample was comprised of a consistent population across time. I will then present results from Phase A and Phase B experiments.

**Descriptive Statistics.** The study successfully recruited 1,089 (15% response rate) residents in June.<sup>32</sup> In September all respondents received the posttest survey and in December 2015, the follow-up. The Post-Program received 583 respondents (53% retention rate) and the Post-Intervention survey had 499 participants responding (86% retention rate). Of these, 363 remain in the final sample (33% retention rate overall) in that they completed all three surveys and the relevant survey items.<sup>33</sup> Appendix B presents demographic data for the final sample and the attrition population. The attrition population are those who completed some combination of surveys (e.g. first and third or first and second), but who did not complete all three. The attrition population did not significantly differ from the final sample population on any of the demographic variables listed in Appendix B (i.e. sex, age, education race and ethnicity, household size and presence of children). The remainder of the data below, will be for the final sample (i.e. those residents who completed all three surveys) unless otherwise stated. Likewise,

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<sup>32</sup> Of the 1,089 respondents in the recruitment survey, 800 used the print survey and 240 completed it online. More than 75% of the print respondents indicated in the survey that they would prefer an electronic survey for the remaining two surveys.

<sup>33</sup> The Post-Intervention Survey was distributed to all residents who completed the Recruitment Survey (1,090). Approximately 130 Post-Intervention Survey respondents completed the Recruitment Survey, but not the Post-Program Survey in Sept. These respondents were not included in the Final Sample.

the treatment and control group had no significant differences in demographic, or other independent, or dependent variables.

The final sample is characterized by residents who are more likely to be female, older, White and more educated than the general population. In the final sample, more than 65% of respondents were female (n=236) and just over 30% (n=109) male. More than half of the final sample (n=207) is aged 55 and over. That the mean age is higher than the general population is unsurprising considering the target population is residents in single family homes, and young people are less likely to occupy these residences whether renting or owning. The vast majority of respondents identified as Non-Hispanic White (82%, n=279), followed by 6% Non-Hispanic Asian or Pacific Islander (n=21). Finally, the majority of participants had completed a Bachelor's degree (35%, n=123), followed by "Some College" (20%, n=69), a Master's degree (17%, n=60), and Associates (15%, n=52). About 7% of the final sample had higher post-graduate degree (n=24), and 5% had completed high school or GED (n=17).<sup>34</sup>

Household size and the number of children present did not differ greatly from that found in the most recent US census for the city or the state. The average household size was 2.6 with the majority of residents living with no children in the home (74%, n=254). This may be accounted for in part by the older age of the population. Most participants lived in two-person households (41%, n=143), followed by three- and single-person households (19%, n=65; 17%, n=58 respectively). Households without children followed a similar pattern with two adults being most common (54%, n=138) and single-adult (23%, n=58) and three-adult households (15%, n=37) following. Among households with children, one or two children were the most common

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<sup>34</sup> For the purposes of analysis, this measure was made dichotomous where 1 is having earned a Bachelor's degree or higher (60%, n = 207) and 0 is less than a Bachelor's degree.

(47%, n=42; 39% n=35). More than 90% of residents over the age of 50 lived in households with no children (n=214).

While some significant differences remain between the final sample population and the general population, those who began and dropped out of the study are not significantly different from those who remained. Both of these points have important implications for the limitations of the study findings that will be discussed in the limitation section in the following chapter.

Critical to the intervention experiment, there are no significant differences between the treatment and control group. Overall, the final sample is older, whiter, and more likely to be female and have a bachelor's degree than the rest of the population. Despite these differences, the results are similar to other studies based on mail-out surveys (Visschers, Wickli, & Siegrist, 2016). The implications for representativeness and other concerns related to the sample are discussed in the limitations section in the following chapter.

**Phase A: Natural Experiment.** The natural experiment surveyed residents before (June) and after (Sept) receiving the curbside organics cart from CMSD in July or August. The experimental design used the community-wide implementation of the OCP as treatment and offers some confidence in determining causal relationships with changes in household behavior. One-sample two-tailed t-tests were conducted to test ( $H_1$ ) that household food scrap separation would increase. I also used this test to determine whether residents increased their support of the curbside program and beliefs that separating food scraps is the right thing to do.

Participants increased food scrap separation between Time 1 (June) and Time 2 (Sept). Approximately 20% of participants separated their food scraps in the household prior to receiving the organics cart.<sup>35</sup> Separation behavior increased to 66% after the OCP

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<sup>35</sup> Many of these used backyard compost or vermicompost systems, and some delivered their food scraps to another location for processing (e.g. community garden, friend or family member's bin).

implementation ( $t=-17.01$ ,  $df(377)$   $p = .000$ ), supporting  $H_1$  that transforming the systems of provision can support behavior changes to close the loop on food systems. After receiving the curbside cart, participants also increased policy support and the belief that separating food waste is the right thing to do. Participants reporting that they support the curbside program in Costa Mesa and that other cities should also offer such programs increased from 60% to 69% ( $t=-2.34$   $df(372)$   $p = .01$ ) during the natural experiment. Participants were also more likely to report that they believe separating food waste is the right thing to do (67-77%) after receiving the organics curbside cart ( $t=-1.93$ ,  $df(371)$   $p = .03$ ).

**Phase B: Intervention Experiment.** The intervention experiment tested that ( $H_2$ ) norm communication would increase reported food scrap separation behavior. To analyze the change in separation behavior between the pretest and the posttest, difference scores were calculated. First, dichotomous variables were generated for separation behavior in both the Phase B pretest and the posttest. Responses were coded as "1" if respondents indicated that they separated "Almost all" (4) or "All" (5) of their food waste into the organics cart, and "0" if "None" (1), "Almost none" (2), "Some" (3). This same coding scheme was used for both Time 2 and Time 3. The difference between these dichotomous separation-behavior variables (i.e. Time 3 - Time 2) generated values of -1, 0, or 1.

Using these difference scores, I conducted a chi-squared analysis to determine whether changes in separation behavior were significantly different between treatment and control groups. Indeed, after receiving norm communication the treatment group increased their food waste separation significantly more than the control group during that same time ( $\chi^2(2) = 6.38$ ,  $p = .041$ ). Participation rates increased from 66% (Time 2) to 77% after the intervention (Time 3). This suggests that communicating the new norms of food waste separation will result

in increased participation when the population would otherwise plateau in their uptake of separation behaviors.

Interestingly, the treatment group was also more likely not to give up on separating food waste. The data suggests that some folks who began separating food scraps between Time 1 and Time 2 stopped separating between Time 2 and Time 3. For participants in the treatment group, this attrition rate was significantly diminished. Receiving normative messaging about separating food waste reduced the likelihood that participants would stop separating food waste after they started ( $\chi^2(1) = 4.50, p = .034$ ). The treatment group was also significantly more likely to increase their support of the curbside OCP (69-81%) ( $t = 3.99, df(367) p = .05$ ) compared to the control group. Receiving norm communication also correlated with significantly greater increases in the belief that separating food waste is the right thing to do (77-79%) compared to the control group ( $t = 2.12, df(367) p = .019$ ).

**TPB: Hierarchical Regression Across Three Time Points.** This section reports results from analysis testing the fit of the Theory of Planned Behavior for predicting food scrap separation. The components of the TPB model and the additional variables were measured using scales that were comprised of several survey items (see Appendix A). The internal reliabilities for each construct scale were calculated and are presented in the appendix. Each had a high Cronbach's  $\alpha$ . Principal component factor analysis using Promax rotations (Abdi, 2003) resulted in a single variable for each construct. The scales were then generated using a row-mean for each observation to account for missing variables. Four scale items were used; perceived behavioral control ( $\alpha = .73$ ), attitudes toward food waste separation ( $\alpha = .95$ ), subjective norms ( $\alpha = .86$ ), and environmental concern ( $\alpha = .68$ ) (See Appendix A).

The results of all three time points are presented below, each using a four-step hierarchical regression model. Likelihood Ratio tests were used to determine whether the additional variables of each step explain significantly more variation than the previous model. All models use self-reported separation behavior as the dependent variable with the step-wise independent variables following the TPB model. The first model of each time point begins with demographic and household characteristics including sex, age, education and household size. The second includes the first set of TPB model variables; perceived control, subjective norms, and attitudes toward food waste separation. The third models add intention to separate food waste and the final models include the relevant additional variables.

***TPB: Time 1.*** The recruitment survey was collected prior to the receipt of curbside organics carts, thus those who indicated they were separating food waste did so in a backyard compost system of some kind, or delivered the food waste to another location where small-scale composting was performed. The models presented in Table 2 indicate that the TPB model is not a good fit for food waste separation behavior where respondents depend primarily on at-home or small-scale composting.

Several variables, however, stand out as significant predictors of this behavior. Namely, age, perceived control, and positive attitudes toward food waste separation remain significant predictors in each of the step-wise models in which they appear. This suggests that the older a resident, the more likely they are to separate food waste in the absence of a curbside collection program, though this is likely to be a non-linear relationship where the elderly would be less likely to compost on their own as physical capacity decreases. By contrast, intention to perform the behavior was not a significant predictor of the actual performance of the behavior and failed to explain additional variance in separation behavior. This indicates that the TPB is a poor fit for

food waste separation in this context. In fact, only the addition of the first set of TPB model variables (i.e. control, attitudes, and norms) significantly improved the variance explained by the model ( $R^2 = 0.13$ ,  $\text{lr-chi}^2(3) = 28.91$ ;  $p = 0.000$ ).<sup>36</sup>

**Table 3:** Time 1 Theory of Planned Behavior Results. The table shows results of linear hierarchical regression models on self-reported food waste separation behavior with unstandardized betas.

	Model 1		Model 2		Model 3		Model 4	
	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>
Female	0.29	0.17	0.18	0.17	0.16	0.17	0.16	0.17
Age	0.16***	0.04	0.17***	0.03	0.16***	0.03	0.16***	0.03
Bachelor's or higher	0.31	0.17	0.26	0.16	0.27	0.16	0.27	0.16
Household Size	-0.01	0.07	0.03	0.07	0.20	0.07	0.02	0.07
Behavioral Control			0.33***	0.10	0.29**	0.10	0.29**	0.10
Attitude Toward Behavior			0.22**	0.08	0.20*	0.08	0.20*	0.08
Subjective Norms			-0.08	0.10	-0.11	0.10	-0.11	0.11
Behavioral Intention					0.13	0.08	0.13	0.08
Environmental Concern							-0.01	0.01
Adj. R-squared	0.06		0.13		0.14		0.14	
Likelihood Ratio Test	-		(3) 28.91***		(1) 2.61		(1) 0.24	

\*\*\* $p < .001$ , \*\* $p < .01$ , \* $p < .05$  |  $n = 363$

**TPB: Time 2.**<sup>37</sup> The first model finds that demographic characteristics do not explain much of the variance in separation behavior ( $R^2 = 0.15$ ). As in the models for Time 1, age is a positive significant predictor of separation behavior. Here, female also significantly increases the likelihood that a resident will separate food waste in the first two models ( $\beta_1 = 0.46$ ,  $p_1 = 0.001$ ;  $\beta_2 = 0.30$ ,  $p_2 = 0.015$ ).

<sup>36</sup> Neither intention and environmental concern did not significantly improve the model.

<sup>37</sup> Time 2 is the September Post-Program Survey. This survey served as the posttest for the natural experiment in Phase A as well as the pretest for the intervention experiment in Phase B.

**Table 4:** Time 2 Theory of Planned Behavior Results. The table shows results of linear hierarchical regression models on self-reported food waste separation behavior with unstandardized betas.

	Model 1		Model 2		Model 3		Model 4	
	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>
Female	0.46***	0.14	0.30*	0.12	0.19	0.10	0.16	0.10
Age	0.20***	0.03	0.16***	0.03	0.11***	0.02	0.09***	0.02
Bachelor's or higher	0.02	0.15	0.03	0.13	0.01	0.10	-0.04	0.10
Household Size	-0.01	0.06	-0.24	0.05	-0.04	0.04	-0.04	0.04
Behavioral Control			0.31***	0.07	0.13*	0.06	0.11*	0.06
Attitude Toward Behavior			0.20***	0.06	0.20	0.05	0.00	0.05
Subjective Norms			0.40***	0.08	0.15*	0.07	0.16*	0.07
Behavioral Intention					0.66***	0.05	0.64***	0.05
Previous Behavior (T1)							0.15***	0.03
Environmental Concern							0.02	0.03
Adj. R-squared	0.15		0.37		0.61		0.63	
Likelihood Ratio Test	-		(3) 102.64***		(1) 165.51***		(2) 22.98***	

\*\*\*p<.001, \*\*p<.01, \*p<.05 | n = 363

Adding the TPB variables to the model significantly increased the variance explained ( $R^2 = 0.37$ ;  $lr\text{-}chi^2(3) = 102.64$ ;  $p = 0.000$ ). Here, age and being female remain positively correlated with separation behavior, and each of the TPB variables is significant. Increases in perceived control, positive attitudes, and positive subjective norms toward food waste separation each predict increased separation behavior ( $\beta = 0.31, 0.20, 0.40$ ;  $p = 0.000, 0.001, 0.000$  respectively). This indicates that individuals are more likely to separate food waste if they believe they have control over separation behavior, have positive attitudes toward the behavior, and believe that others engage in it as well.

The full TPB model is highly predictive of separation behavior ( $R^2 = 0.61$ ). In this model only age, control, and norms ( $\beta = 0.11, 0.13, 0.15$ ;  $p = 0.000, 0.25, 0.044$ ) remain significant behind intention to separate food waste ( $\beta = 0.66, p = 0.000$ ). The addition of *intention* significantly



improved the model ( $R^2 = 0.61$ ,  $lrtest(1) = 165.51$ ,  $p = 0.000$ ). The final model considers variables extraneous to the TPB model related to food waste separation behavior. In particular, the data suggest that while having higher pro-environmental concern (i.e. NEP scale) does not predict separation behavior, having previously separated food waste where one lived is a significant predictor ( $\beta = 0.15$ ,  $p = 0.000$ ). Adding these additional variables also significantly improved the predictability of the model ( $R^2 = 0.63$ ;  $lr\text{-}chi^2(2) = 22.98$ ;  $p = 0.000$ ). The data indicate that the TPB model, including behavior-specific variables, is a good fit for predicting self-reported food waste separation behavior in the context of a curbside organics collection program.

**TPB: Time 3.**<sup>38</sup> At Time 3 (Dec) many of the relationships persist that were evident at Time 2 (June). For instance, age remained positively predicting separation behavior throughout all four models ( $\beta_{1-4} = 0.18, 0.13, 0.10, 0.08$ ;  $p_{1-4} = 0.000$ ) indicating that older respondents are more likely to separate food waste than younger ones. Female was only significant in the first model testing the predictability of demographic characteristics ( $\beta = 0.32$ ,  $p = .024$ ). The demographic model alone did not, however, explain much of the variance in separation behavior ( $R^2 = 0.12$ ). With the addition of the first step of the TPB variables in the second model, we see that control, attitude, and norms were predictive of separation behavior as in the Time 2 model ( $\beta = 0.46, 0.37, 0.33$ ;  $p = 0.000$ ), and that these variables significantly improve the variance explained by the model ( $R^2 = 0.46$ ;  $lr\text{-}chi^2(3) = 179.01$ ;  $p = 0.000$ ). Table 4 displays these results.

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<sup>38</sup> Time 3 is the December Post-Intervention Survey. This survey served as the posttest for the intervention experiment in Phase B.

**Table 5:** Time 3 Theory of Planned Behavior Results. The table shows results of linear hierarchical regression models on self-reported food waste separation behavior with unstandardized betas.

	Model 1		Model 2		Model 3		Model 4	
	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>
Female	0.32*	0.15	0.16	0.11	0.03	0.10	0.02	0.09
Age	0.18***	0.03	0.13***	0.02	0.10***	0.02	0.08***	0.02
Bachelor's or higher	0.00	0.14	0.01	0.12	0.06	0.10	0.04	0.09
Household Size	0.02	0.06	0.02	0.05	0.03	0.04	0.02	0.04
Behavioral Control			0.46***	0.06	0.28***	0.05	0.25***	0.05
Attitude Toward Behavior			0.37***	0.06	0.06	0.05	0.05	0.06
Subjective Norms			0.33***	0.08	0.13	0.07	0.13*	0.06
Behavioral Intention					0.61***	0.05	0.60***	0.05
Previous Behavior (T1)							0.11***	0.03
Treatment Group							0.02*	0.09
Environmental Concern							0.21	0.08
Adj. R-squared	0.12		0.46		0.64		0.65	
Likelihood Ratio Test	-		(3) 179.01***		(1) 134.51***		(3) 19.31***	

\*\*\*p<.001, \*\*p<.01, \*p<.05 | n = 363

Model 3 indicates that incorporating *intention* to separate food waste, the final stage of the TPB model, improves the variance in separation behavior explained by the model ( $R^2 = 0.64$ ;  $lr\text{-}chi^2(1) = 134.51, p = 0.000$ ). Here, we see that perceived control and intention to separate are the only significant predictors of actual separation behavior from the TPB model ( $\beta = 0.28, 0.61$ ;  $p = 0.000$ ). Finally, Model 4 explains significantly more variation than previous models ( $R^2 = 0.65$ ;  $lr\text{-}chi^2(3) = 19.31, p = 0.001$ ), though the increased variance explained is less than the TPB model variables added. This model indicates that residents who have previously performed food waste separation are more likely to participate in curbside programs ( $\beta = 0.11, p = 0.000$ ), but that concern for the environment is not a significant influence. The final model also reinforces the findings from the experiment in that residents who received norm communication in the

treatment group were significantly more likely to participate in the OCP ( $\beta=0.21$ ,  $p=0.12$ ) than the control group.

The following chapter will discuss the significance of these results. The implications of these results will be discussed in terms of their contribution to theories in social-psychology, urban political ecology, and to practitioners. The limitations for this research will also be discussed with an emphasis on efforts to mitigate these effects in the current research. The chapter will close with next steps and new research questions for future research to address.

## CHAPTER 6

# Technical and Social Innovations

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## Discussion

This chapter will endeavor to interpret the results from the previous chapter and their significance for theory and practice alike. The findings have important implications for efforts to shift toward closed-loop systems as well as for social-psychological theories attempting to understand and predict human behavior. As to the former, the experiments suggest that these shifts will demand transformations of the (H<sub>1</sub>) systems of provision as well as (H<sub>2</sub>) household behavior. As to the latter, the findings support the extension of theories on social influence (Cialdini, Reno, & Kallgren, 1990), social impact (Latané, 1981; Goldstein, Cialdini, & Griskevicius, 2008), and the Theory of Planned Behavior (Ajzen, 1991) to the domain of food waste separation behavior, in the context of curbside OCPs. Specifically, normative social influence (Deutsch & Gerard, 1955) can be leveraged by communicating descriptive norms (Cialdini, Reno, & Kallgren, 1990) of a large, immediate, (Latané, 1981) and situationally-relevant social group (Goldstein, Cialdini, & Griskevicius, 2008) to increase food waste separation behavior.

Insight into the determinants of household food waste separation fit the Theory of Planned Behavior model best in the context of supportive infrastructure (i.e. curbside organics collection). The findings indicate that food waste separation may not be a volitional behavior where residents must overcome the physical, economic, and temporal constraints of backyard composting. The poor fit of the TPB model before receiving the curbside bin and the excellent fit of the model afterwards suggests that curbside bins increase the perceived control residents have over separation behavior and enables their intention to separate to determine participation. In the context of a curbside organics program, residents who believe they have the power to separate food waste, that others also do so, and who intend to separate food waste themselves are significantly more likely to engage in the behavior than others. These findings further support

arguments in the literature that shifts toward closed-loop food systems will demand both changes to the systems of provision (i.e. altering residents' perceived control) (Bulkeley & Askins, 2009) as well as to the social aspects of waste (i.e. altering the perceived normative behavior) (Evans, 2014; Visschers, Wickli, & Siegrist, 2016).

The results of the experiments also contribute to literature on social-psychological approaches to affecting behavior change. Specifically, this work addresses previous calls for empirical examinations of classifications for behavior change tools (Schultz, 2014). The classification based on perceived barriers and benefits of the behavior to the population is supported by the data. "Making it Easy" by providing curbside bins and collection services improved behavior for the given population that perceived high benefits and high barriers to diverting food waste from landfills through backyard composting. Secondly, Phase B showed that once these barriers are reduced with curbside OCPs, additional gains are possible through social modeling (i.e. norm communication). The two-part experiment suggests that researchers and practitioners must consider the state of perceived barriers and benefits as dynamic rather than static. New programs and efforts may shift the perceived barriers as in this case from high to low (See Table 1), or persuade the population of the benefits of food scrap separation. The dynamic perceptions of the population will best be addressed with feedback loops enabling dynamic program response.

Furthermore, the findings support an intellectual home in urban political ecology for understanding and motivating circular urban food waste flows. Urban political ecology recognizes that human systems are of nature, not separate from it. To put this another way, human systems depend on and have an impact on the ecosystems. The social-ecological relationship of society and nature has been defined by market-based motivations for the

circulation of people and goods (Swyngedouw, 2006). Transforming the systems of provision and household behaviors toward a circular urban metabolism will demand new social-ecological relationships both at a micro-level (i.e. in the household) and at a macro-level (i.e. city and regional infrastructure and institutional arrangements). The motivations of circularity cannot be understood outside the need for human systems to sustain themselves over time. The political goals of circulation must be grounded in 'circularity at a human scale', market-based motivations may undermine these ends. Transitioning toward a closed-loop urban food system will not only leverage principles of ecosystems, but engage the workings of a city and indeed, the everyday behaviors of residents, in the ongoing circulation of food waste flows for their transformation into inputs for another part of the system (i.e. the making and remaking of the social-ecological urban metabolism).

Below, I will first focus attention on the natural (Phase A) and intervention (Phase B) experiments in discussing the contributions to social-psychological theory. Then, I will discuss the findings from the Theory of Planned Behavior model for the longitudinal analyses. This will include contributions to the litany of research examining predictors of volitional food-related behavior. The chapter closes with limitations and suggestions for future research in this regard.

### **Analysis of Experimental Results**

Taken together, the experiments support the claim that shifts toward a closed-loop urban food system will demand (H1) technical as well as (H2) social innovations.. In the first experiment, the data suggest that transforming the infrastructural and institutional arrangements (i.e. the systems of provision) by offering curbside organics collection and off-site organics processing significantly increased food waste diversion from landfills.<sup>39</sup> Recall that the residents participating in at-home food waste separation increased from 15% before receiving the curbside

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<sup>39</sup> For the natural experiment in Phase A from June-September

organics carts to 66% after. This suggests that the barriers to backyard composting are great enough to keep a significant portion of the population who would otherwise engage in food waste separation from doing so (i.e. approximately 50% in this case). Thus we should accept the hypothesis that that supportive infrastructure will increase household food waste separation behavior (H1).

These findings are consistent with previous scholarship where supportive infrastructure resulted in significant improvements in food waste diversion from landfills (Bernstad, 2014; Bulkeley & Askins, 2009). Using technical innovations (Castán Broto & Bulkeley, 2012), most cities with OCPs effectively engage the material contexts (Southerton, McMeekin, & Evans, 2011) of household food waste by transforming the systems of provision (Bulkeley & Askins, 2009). However, the results from Phase A also parallel previous research in that significant gains will remain out of reach despite this supportive infrastructure (SF Environment, 2013b). Consider that 34% of households in the sample reported little or no food-waste separation even after receiving the curbside organics carts.

In the second experiment, we saw social innovations could significantly increase participation beyond this plateau. Communicating the new norms of food waste separation increased participation by 17% and reduced OCP drop out significantly more than the control group. Thus we should accept the second hypothesis (H2).<sup>40</sup> This finding suggests that social influence theories have a home in the domain of food waste.

These findings support previous research in normative social influence while filling gaps in this research pertaining to food-waste-separation behaviors. Previous research has examined the use of norm communication to promote other pro-environmental behaviors (e.g. alternative transportation use, energy and water conservation, and recycling), but this is the first study to

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<sup>40</sup> Directly communicating descriptive norms will increase food waste separation behaviors



extend theories of normative social influence to the uniquely challenging domain of food waste separation behavior in residential OCPs.<sup>41</sup>

Together, these findings suggest that while cities may see an initial uptake in OCP participation by targeting the material contexts of waste systems (Southerton, McMeekin, & Evans, 2011), improvements beyond this level will demand innovations that engage with the social aspects of household food waste separation (Southerton, McMeekin, & Evans, 2011; Bulkeley & Askins, 2009).

**Social Influence Theories.** The experiments in this dissertation were rooted in social psychological theories of behavior and behavior change including social influence and social impact theory. Previous research has suggested that social norms lack the expected influence on the volitional behavior of food-related behaviors by virtue of the private nature of these behaviors (Quested, Marsh, Stunell, & Parry, 2013). Where casual observation of public behaviors by individuals serves to informally communicate the social norms governing that behavior, this research suggests that official, or direct communication can have a similar effect. This should be striking to the reader. Imagine if the social norms governing cigarette smoking led people in the privacy of their own home to feel they had to reduce or hide their habit.

Directly communicating the new norms of food waste separation had the effect of bringing this otherwise private behavior into the public sphere. It would be as if you were given x-ray goggles walking down your block, able to see into everyone's kitchen you notice that the majority of your neighbors were separating their food waste. Internalizing this prevalent behavior as the normatively appropriate behavior, the x-ray-goggled-individual would be more

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<sup>41</sup> Food waste, as discussed in Chapter 4, exhibits material realities that likely serve as additional barriers to engagement compared to recycling or water and energy conservation.

likely to engage in separation. Of course, the approach taken in the experiment is significantly more cost-effective (not to mention ethical) for cities to put into practice.

The experiment used descriptive norms of the "actual" behavior (Cialdini, Reno, & Kallgren, 1990) of the community. In this case, the experimental tools were able to side-step the boomerang effects that plague comparative descriptive statistics often used in normative feedback studies (Schultz P. W., 1998). Instead, the norm messaging reported the percent of residents who separated all of their food waste. If the norm communication resulted in boomerang effects, the data would show that folks who were separating food waste before receiving the curbside organics cart would have reduced their separation behavior. The fact that the treatment group participants were significantly more likely not to drop out during the intervention period serves as evidence that the boomerang effect was mitigated.

The results suggest, moreover, that the reference group in the norm communication was sufficiently relevant to the participants and the behavior. Previous research suggests that the significance of the reference group to the individual will mitigate the effect of communicating the group norm (Goldstein, Cialdini, & Griskevicius, 2008). Indeed, teasing out the effects of different reference groups was beyond the scope of this study.<sup>42</sup> However, this study does provide evidence of efficacy in using other residents in the community as a reference group regarding group norms in curbside OCP participation. This may be a result of Latané's (1981) criteria of *immediacy* and *number*, and possibly *strength*. The neighboring community is, in fact, proximal to the behavior, large in number, and for some, strong social bonds may exist with immediate neighbors or broader community members.

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<sup>42</sup> Data were not collected regarding the significance of the reference group (i.e. "Costa Mesa residents") to participants, nor comparative treatments using different reference groups.

The evidence of influence from the reference group may additionally be related to Goldstein et al.'s (2008) *situational commonality*. Rather than common identities based on gender or citizenship, the reference group shared situational conditions (Goldstein, Cialdini, & Griskevicius, 2008) of receiving organics carts and being expected to separate household food waste. It is reasonable to expect that residents knew that everyone else in the community was receiving these curbside organics carts<sup>43</sup> and that many others would be adapting to the new "official" expectations to separate food waste. Being made aware of, or being made to focus on (Cialdini, Reno, & Kallgren, 1990), the normal behavioral response of others in a similar situation (i.e. receiving new curbside organics carts), may have exerted a normative social influence via individuals' desire to be accepted, or perceived as normal (Deutsch & Gerard, 1955).

**Classifying Behavior-Change Tools: Right Tools for the Job.** We can also examine these results in light of Schultz' (Schultz W. P., 2014) behavior-scenario classification. First, we can see that for about half the population who was not already backyard composting, 1) the perceived benefits and barriers were high and 2) the supportive infrastructure of the OCP reduced these barriers. This is shown by the fact that 1) positive attitudes toward food waste separation was a significant predictor of the behavior for Time 1 and 2 (See Table 2 & 3), and that 2) 50% of the population who were not backyard composting at Time 1, began separating food waste with the implementation of the OCP.<sup>44</sup> Thus at Time 1, our population constituted a High Benefit, High Barrier population, and "making it easy" is the appropriate tool suggested by Schultz' model (See Table 1).

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<sup>43</sup> In most curbside OCPs, indeed of most any collection scheme, the same material collection services are offered for all households. CMSD, moreover, had run a public awareness campaign to inform residents of the district-wide changes. Whether through promotional materials or driving down the street on trash day, residents were likely to be aware that their neighbors are part of the same waste scheme.

<sup>44</sup> Percent of residents separating food waste increased from 15% at Time 1 to 66% at Time 2.

However, the city was still faced with motivating the remaining 34% to participate in order to close the loop on food systems. How can Schultz' model account for the unchanged households? Perhaps additional barriers remain for this population (e.g. odors and pests, maintenance tasks)<sup>45</sup> and additional efforts to "make it easy" would be needed. Maybe this population perceives not only continued high barriers, but also does not perceive the benefits of the behavior to be as great as those who adopted separation behaviors with the curbside scheme. Indeed the fact the perceived behavioral control directly predicted actual separation behavior indicates that those who do not believe they have control over separation (i.e. perceived barriers), are not likely to perform the behavior. In this high barriers, low benefits scenario, Schultz' model would suggest CMSD adopt incentives or contests to motivate the benefits. Or if these perceived barriers were coupled with positive attitudes in the population toward separation behavior yet this population still failed to participate, the model would suggest feedback, prompts, or additional education.

On the other hand, suppose that whenever cities provide infrastructure to reduce barriers (i.e. "make it easy") for a population that perceives the benefits of the behavior, they simply change the behavior-scenario such that it becomes Low Barrier, High Benefit. If this holds, then each time a city transforms the systems of provision to make it easy, the extent to which their residents have positive attitudes of the behavior, the city should also use social-modeling or norm communication tools.

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<sup>45</sup> Separating food waste, as with separating recycling, requires household storage of the separated materials until such time as household members relocate the collected materials by placing them in the curbside cart where they await collection day. In the case of recycling, this relocation schedule from kitchen to cart may be organized around *maximum capacity*, where the amount of recyclable bottles and cans reaches the maximum holding capacity of the in-home bin. This reduces the daily labor demands of the household because out-of-home disposal is not necessary every day. In the case of food, however, the relocation schedule is largely guided by the natural processes of putrefaction and a tolerance for the nuisances it embodies (i.e. odors and pests). These material realities elicit an "ick" factor not inherent in socio-material relationships wrapped up in recycling plastic bottles and tin cans.

## Analysis of Theory of Planned Behavior

The results of the TPB analysis informs the household metabolism model in which I examined the determinants of food waste separation behavior. To the author's knowledge, no study has examined the fit of the TPB model for predicting actual food waste separation behavior in curbside organics collection programs (OCP). The current project begins to fill this gap. The longitudinal results indicate that the TPB model is not a good fit for predicting household food waste separation in the context of backyard composting, but that supportive infrastructure improves the model fit. Put another way, providing supportive infrastructure (i.e. compost bins and collection services) enables respondents to act on their *intentions*. This is evidenced in the contrasted role of *intention* at baseline and subsequent surveys. Not only is intention not a significant predictor of separation behavior at Time 1, it provides no added explanatory power; yet after receiving the curbside bins, intention is both a strong predictor and improves the model fit for Time 2 and Time 3. In the context of a curbside OCP, residents are more likely to engage in at-home food waste separation if they intend to separate, perceive that they have control over , and believe that others engage in separation behavior. However, before the supportive infrastructure, respondents who perceive control over and have a positive attitude toward separation behavior are more likely to do so, but intention to separate does not influence their behavior.

In the case of backyard composting (Time 1), the TPB model does not predict household food waste separation. Specifically, while adding the first stage of the TPB (i.e. control, attitudes, and norms) did significantly increase the variance explained by the model, the addition of *intention* did not. Indeed, intention to perform separation was not predictive of actual behavior prior to the curbside OCP. This indicates that intention to separate food waste is not enough to

successfully divert food waste from landfills, and that cities who rely on backyard composting to achieve this goal will fail to meet diversion mandates. Indeed, it may be that food waste separation should not be thought of as a volitional behavior in the absence of supportive infrastructure. Furthermore, given the greater model fit of the TPB after residents received the curbside carts, I argue that while intention is not enough to successfully divert food waste from landfills, providing supportive infrastructure does improve the predictive value of intention. This underscores the importance of the built environment in constraining or supporting social aspects of food systems. This finding should be further explored in other behavioral domains (e.g. transportation, green purchasing).

The data furthermore suggest that receiving a curbside organics cart increases the perceived control over separating household food waste from landfill streams between Time 1 and Time 2 ( $M_1=3.8$ ,  $M_2=3.9$ ,  $df=349$ ,  $t=-2.53$ ,  $p=0.007$ )<sup>46</sup>. Indeed perceived behavioral control was also the best predictor of separation behavior after "intention" in the Post-Intervention survey at Time 3 (standardized  $\beta=0.19$ ,  $p<.001$ ). These findings suggest that perceived control has an effect on intention to perform the behavior, as well as a direct effect on the performance of the behavior. This finding is in line with previous TPB research on food-related behaviors (Yazdanpanah & Forouzani, 2015; Visschers, Wickli, & Siegrist, 2016). The Post-Intervention survey (Dec) was collected four months after residents received their curbside carts and indicated an increase in perceived control over separating food waste compared to the Post-Program survey (Sept), just after receiving the organics cart ( $M_2=3.94$ ,  $M_3=4.08$ ,  $df=354$ ,  $t=2.47$ ,  $p=0.007$ ). This suggests that as time passes, and presumably as residents gain additional

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<sup>46</sup> A two-tailed paired-sample t-test was conducted to determine whether the mean perceived control at Time 2 was significantly different from the mean at the Time 3

experience with separating, they will tend to feel a greater sense of control over at-home separation.<sup>47</sup>

**Age versus Generation Effects.** While the demographic model did not provide sufficient explanation of the variance in separation behavior (i.e.  $R^2 < 0.15$  at all three time points), some attention to the role of age is warranted given that it remained significant throughout the stepwise models at all three time points. Positive correlations indicate that older residents were more likely to separate food waste both with and without supportive infrastructure (i.e. before [T1] and after [T2 & T3] the curbside OCP). Indeed, age remained a significant predictor of food waste separation even after accounting for perceived control, attitudes, subjective norms, and intention to separate. The interpretation of these results will differ based on whether this is an effect of age or cohort.

If the effects are a function of aging, or life-cycle, then on average people would increase in separation behavior as they get older, whereas a generational effect is one in which some shared event shaped the particular generation in this particular culture making them more likely to engage in separation behavior. Van Liere and Dunlap (1980, p. 183) describe a generational or cohort effect as one in which significant environment-related events occur at a formative stage in the development of young people's lives, ultimately forming "an ecology-minded generation whose commitment to environmental reform should not disappear as they move into adulthood." Rachel Carson's *Silent Spring*, Love Canal, Three Mile Island and Chernobyl are but a few of the environmentally significant events occurring when the majority of the sample population<sup>48</sup> were teenagers. Unfortunately, the current study has insufficient time series data to conduct a cohort

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<sup>47</sup> The treatment and control group do not significantly differ in their perceived behavioral control at any of the three time points according to two-tailed two-sample t-test.

<sup>48</sup> more than half of the sample population is aged 55 and over.

analysis to test for generation effects. I will, nevertheless, present previous research that has examined the issue.

At first blush, the literature on the relationship between age and pro-environmental behaviors seems mixed. Previous research has found both that age is positively correlated with behaviors such as prevention of food waste (Visschers, Wickli, & Siegrist, 2016) and reduced clothing disposal (Lang, Armstrong, & Brannon, 2013), and playing only a minor role in predicting behaviors such as e-waste recycling (Saphores, Ogunseitan, & Shapiro, 2012). In the latter, convenience, knowledge, and previous e-waste recycling experience were the strongest predictors of the behavior rather than demographic variables. The disparate findings may support a generational argument in that different generations may be more likely to recognize certain behaviors as environmentally significant. For instance, older generations may be less likely on average to identify behaviors related to new technologies (e.g. e-waste recycling) as having environmental impact. Whereas behaviors associated with conventional environmentalism (e.g. nature conservation, waste and litter reduction) may be more intuitively recognizable as environmentally significant to an older generation.

Despite these individual differences in the literature, a recent meta-analysis covering forty years of research on the relationship between age and pro-environmental behaviors indicates that there is a positive relationship overall, especially in terms of conservation of natural resources, avoiding environmental harm, and interacting with nature (Wiernik, Ones, & Dilchert, 2013). While the authors could not conduct a cohort analysis as the multi-decade study was based on different samples, they did detect a period effect in that studies conducted after 1995 were more likely to result in significant relationships between age and conservation



behaviors than those conducted before 1995. This supports arguments for a generational effect explaining increased pro-environmental behavior in older populations.

A study of Norwegian values, beliefs, and behaviors found further evidence for cohort effects using in nationally representative longitudinal dataset that spanned the 1990s. Hellevik (2002) found the differences in age-group's concern for the environment widened over the twelve year period. That is, as the younger generation aged, they became more politically willing to "give priority to environment over growth" while the older generation became less willing during that same period (Hellevik, 2002, p. 16). Nevertheless, the opposite trend for 'willingness to engage in pro-environmental behavior' emerged as the younger generation became less likely to alter their everyday behavior to reduce environmental impact during the study period while the older generation increased this willingness over the same period (Hellevik, 2002). The longitudinal scope of this study enables the examination of changes in attitudes and behavior over time between two different age groups. That the older and younger populations' attitudes and behaviors moved in opposite directions during the same period suggests that something more than aging alone explains these changes, further supporting arguments for generational effects.

Cross-national comparisons support these generational arguments further still. In a study of the over-50 age group in the UK, Germany, Japan, and Hungary, age revealed mixed effects on pro-environmental consumer behavior (Sudbury Riley, Kohlbacher, & Hofmeister, 2012); positive correlations in some contexts, negative in others. If pro-environmental behavior were a factor of age, then it should be robust to different cultural and economic contexts. Instead, these behaviors vary widely among the same older-age group based on exposure to these contexts.

Lacking sufficient time-spans of data to make empirical claims, the current research can only speculate and call for further research in the area of food waste, age, and cohort..

**TPB: Extended Variables.** This study extended the TPB model to include previous composting behavior and environmental concern as measured by the NEP scale (Dunlap, 2008). Previous composting behavior was a significant predictor of current food scrap separation behavior and included backyard composting, participation in a community garden compost pile, or previously living somewhere that had a curbside OCP. This finding is encouraging for practitioners because it suggests that residents who begin separating in one location are more likely to separate in future locations. That means that cities with significant turnover or transplant populations will increasingly benefit from other cities' OCPs, as residents relocating from these cities bring their separation habits with them.

That environmental concern (i.e. NEP) did not predict food-waste separation behavior is good news for cities attempting to close the loop on food waste systems. These findings suggest that residents need not be concerned about the environment in order to engage in food waste separation. Broad-based participation is critical for successful curbside OCPs and for approximating the closed-loop food systems they support. If this supportive infrastructure only resulted in "hippies doing hippy things", it would be unremarkable indeed. However, based on these findings there is hope that significant improvements in urban environmental impact can be achieved without enrolling every resident in the environmentalist cause.

### **Analysis through Urban Metabolism Framework**

The experimental data have significant implications for theory and practice to aid urban areas in transitioning to circular urban metabolisms. Results from Phase A strengthen arguments that providing supportive infrastructure, or transforming the systems of provision (Bulkeley & Askins, 2009) sets the stage for circular food systems. Private and public sectors at different scales are critical actors engaged in altering these material contexts. This dissertation contends

that the success of circular food systems ultimately depends on these actors as well as overlooked actors in the household to mobilize new labor and practices in the re-directing of food waste flows to (re-)produce circular urban metabolic food systems. Source-separated organics programs not only alter the material context of waste flows from the home, they demand new labor by residents. The results of the natural experiment in Phase A suggest that cities can expect significant engagement in this new labor by residents in the context of supportive infrastructure of curbside OCPs. The data also suggest, however, that these gains will plateau over time.

I argue, along with previous scholarship (Bulkeley & Gregson, 2009; Southerton, McMeekin, & Evans, 2011; Evans, 2014; Gregson, Metcalfe, & Crewe, 2007), that cities must also engage with the social-ecological context of household food waste separation behaviors in the development and implementation of curbside OCPs. The results of the intervention experiment in Phase B provide evidence of the efficacy of norm communication tools for increasing the spread, duration, and normalization of the new household labor necessary for source separated organics. This suggests that cities and private haulers who leverage the social aspects of food and waste flows through the household will see improvements above and beyond programs that target material contexts along.

**Nested Urban Metabolic Systems.** When a policy is implemented to divert food waste into separate streams, we not only aim to alter the metabolism of the city, we demand a change in the metabolism of the household itself. Household waste management emulates the macro "social mobilization of metabolic processes" that Heynen et al. (2006, p. 5) and others identify. These micro-level household processes (re-)produce the social organization of the household and

its relationship to the larger systems within which it is nested. Household labor, as with the urban system, is organized "under capitalist and market-driven social relations."

OCPs demand a transformation of the (micro-level) household metabolism to fulfill the goals of the (macro-level) closed-loop urban metabolism. Municipalities erect waste management systems of provision that, perhaps through their very presence communicate the nature of the relationship between household and city, micro and macro (Bulkeley & Gregson, 2009). The curbside bins represent the conduit (Evans, 2014), the material relationship between the municipalities or haulers and householders (Bulkeley & Gregson, 2009). OCPs, then, are new terms in the relationship, new labor and assemblages of practices in the household that must be enacted, new arrangements in collection and processing by the hauler that must be enacted.

Households, however, do not enjoy the financial incentives or the fruits of their labor (i.e. direct benefit of compost or biofuel) in many of these new arrangements. New household labor must be motivated under non-capitalist frameworks. If anything, the idea that household labor in separating food waste generates revenue for private haulers leaves residents with a bad taste in their mouths. Town hall commentary and qualitative responses to open-ended survey items suggest that it may serve as a disincentive for some. Instead, campaigns have largely engaged discourses of purity (reduce pollution from waste in landfills), environmentalism (landfilling is bad for the environment), or localisms (selling compost to local farmers) to enroll households in the task of food waste separation.

**New Socio-Ecological Relationships.** Changes in the nested urban food metabolism results in new socio-ecological relationships. When cities and private haulers provide new conduits (Evans, 2014) of re-circulation of household food waste flows<sup>49</sup> they seek to create new

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<sup>49</sup>I.e. through curbside bins, collection services and off-site processing facilities via composting or anaerobic digestion

'socio-ecological' arrangements (Swyngedouw, 2006). That is, they seek to transform the relationship between social (i.e. human) systems and ecological (i.e. natural) systems. This transformation is mobilized at the macro organizational levels as well as more micro household levels. At a macro-level, public agencies like CMSD, for instance, are transitioning from socio-ecological arrangements that prioritize the expeditious removal and accumulation of organic materials from households to landfills.<sup>50</sup> These new socio-ecological arrangements reorient the macro social relationship with organic materials. Rather than the organizational perception of food waste as a necessary ill that contaminates post-collection recycling efforts<sup>51</sup>, the organizations now perceive food waste as a valued resource.

Curbside OCPs also demand new metabolic processes at the household level, transforming the relationship between the social and the ecological at a micro-level. Source separation of organics demands that households adopt new arrangements of labor in household materials management. Households must directly engage in the labor of (re-)directing household material flows into conduits of recirculation (i.e. organics carts bound for processing facilities). The householder must perform an intentional, perhaps more intimate, management of household organic material flows, a practice that may reconnect householders' experience of the urban with natural systems. Organic separation practices differ from non-organic separation of recyclables in important ways. The presence and appearance of food has deep evolutionarily developed effects on the human brain. Whereas food is immediately perceived for its potential to nourish our bodies or sustain our family, bottles and cans were created to become trash. Food has value to humans outside the market while bottles and cans only earn a marginal value through the machinations of social systems, in this case CRV.

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<sup>50</sup> These values were also reflected in state-level goals and problem-framing.

<sup>51</sup> CMSD previously utilized a single-stream waste system where facilities attempted to remove (non-organic) recyclable materials from all other waste materials after they were collected in a commingled bin at the curb.

The new socio-ecological arrangements prioritize the re-circulation of organic materials as soil amendment or as fuel through new metabolic processes (e.g. composting or AD). This reflects new political-ecological understandings of organic materials, reframed as a resource to be captured and transformed into a marketable product, a transformation that remakes the urban.

Urban political ecology considers the 'making of the urban' as:

"a giant socio-environmental process, perpetually transforming the socio-physical metabolism of nature...though generally portrayed as a technological-engineering problem [it] is, in fact, as much part of the politics of life as any other social process." (Swyngedouw, 2006, p. 35)

While this transition to circular urban food systems is not merely a technological feat, the political-economic transformation should not be overstated. These transformations in the systems of provision may move urban spaces toward a circular food metabolism, but their current manifestations largely reproduce rather than rebuff the capitalist political-economic framework. Urban political ecologists argue that the dominant social organization of matter is one of 'commodity for human use within a capitalist economy' (Swyngedouw, 2006; Heynen, Kaika, & Swyngedouw, 2006). It should be no surprise, then, that transformations in the food waste systems of provision have emerged toward this end. Private haulers have been motivated to establish OCPs by the prospect of profit from the metabolizing and re-circulating of transformed organic material. Their relation to organic material flows is understood and mobilized through this capitalist framework.

Technological developments may have created the conditions that enabled private haulers to develop massive composting and AD facilities, but the institutional arrangements (i.e. contractual agreements with cities) and transformed household labor are social-political developments. These latter developments do not, however, represent a transformation of the guiding capitalist framework so much as a re-production of it. The new socio-ecological

relationships between haulers, cities, and householders with(in) urban spaces, infrastructures, and food waste material flows are arranged because of, and toward the production of a marketable commodity. Goals and strategies continue to be arranged within the capitalist framework rather than a framework of circular urban metabolisms, for example.

**Anthropocentric Circulation.** The argument in this dissertation is for the transition of the human mobilization of materials and energy toward circular systems to reduce our impact and secure our future dependence on these ecosystems for the larger goal of continued human existence. Inherent in this argument is the valuation of the arrangement of socio-ecological relationships to preserve human existence. Indeed, the earth is a closed system already (save for the sun's energy), but on a geologic scale. Given enough time, the materials that humans and other species use as inputs and outputs to sustain life will regenerate or transform, but human interest in circularity is necessarily on a human scale.

The rate at which human urban systems are using resources, including nutrients, outpaces the ecosystem's ability to regenerate those nutrients and recover from their extraction. The rate of resource disposal also outpaces the ability of ecosystems to absorb outputs and recover from pollution to continue supporting human life. The motivation for humans to concern themselves with circularity is in order to support an ecosystem in which humans may thrive. Our policy goals will likely continue to presupposes the existence and inherent value of human systems, but they must also recognize the dependence and impact of human activity on these life-giving ecosystems.

**Critique of the Urban Metabolism Model.** Social scientists have borrowed the concept of "metabolism" from the natural sciences to try to understand and explain urban settlements and its materials flows. But can concepts that capture physical phenomena be applied to social

phenomena? This question has been the subject of great debate among scholars for centuries. On one side of the debate we find those cautioning the adoption of concepts, processes, and theories from the natural sciences by the social sciences at the risk of violating a kind of barrier between the two. Scholars such as Ido Oren (2006) and Nancy Cartwright, expertly summarized by Bechtel and Hamilton (2007, pp. 397-398), would argue that the two sciences occupy different domains governed by different laws and epistemologies. Most critically, is that despite the positivist tradition that has until recently characterized most social sciences, Claude Henri de Saint-Simon argued there lacks a certain "precision in the answers, or the universality in the results" (Oren, 2006, p. 73). A position no less tenable today as it was 200 years ago when de Saint-Simon made the claim.

"Political research has failed to accumulate into stable, widely shared bodies of knowledge of the kind common in at least some of the natural sciences during periods of 'normal' progress." (Oren, 2006)

Later, scholars in the postmodern tradition such as Alexander Wendt insist that the "intellectual activity is epistemologically different than that engaged in by natural sciences" (Oren, 2006, p. 75).

John Stuart Mill and Karl Marx, Oren argued, would be found on the other side of this debate calling for the unification of science, even though they would disagree about how this unification would be accomplished. For Mill, "moral science" would be cured of its shortcomings by subjecting it to the rigors of the "physical sciences." Contrarily, Marx envisioned that "the natural science will in time subsume the science of man just as the science of man will subsume natural science: there will be *one* science" (Oren, 2006, p. 74, original emphasis).



More recently, efforts to develop theories that would serve to do the work of unifying the sciences seem to take two steps forward and one step back. Tracing the debate as far back as Aristotle, Bechtel and Hamilton (2007) highlight modern manifestations of this effort. For example,

"general systems theory emphasized the organization of parts into wholes and maintained that the same principles of organization, such as negative feedback, would be found applicable in physics, chemistry, biology, the social sciences, and technology" (Bechtel & Hamilton, 2007, p. 383)

Bechtel and Hamilton note that while general systems theory is less prolific as a unifying theory than its progenitors had hoped, new theories are advancing the unity of science front today. The authors point in particular to complexity theory, dynamical systems theory, and more recently network theory. The last of which has been used to explain organizational forms and functions of "actors in feature films, the electrical power grid of the western U.S., and the neural network in a nematode" (Bechtel & Hamilton, 2007, p. 383).

As it pertains to urban metabolism as a conceptual framework or analogy, the social-natural science bridge has its uses. After all, as an analogy, urban metabolism may serve the basic function of using concepts that are familiar to us to help us visualize and understand the subject under study. "Every model has a more or less explicit commentary spelling out which aspects of the model domain "count" and which ones are discounted" (DeVries, 2014, p. 150). DeVries writes on the life work Wilifrid Sellars, a modern American philosopher of science who argues that this discounting is often done through empirical examination that can lead to better and better "models" for explaining the phenomena. Sellars used the example of scientists trying to explain the atom when the electron was first discovered; J.J. Thomson first likened it to plum pudding and later Rutherford evoked a solar system to demonstrate atomic structure (DeVries, 2012, p. 58).

Of course, Thomson did not mean that atoms were literally like a bowl of plum pudding. Instead, Sellars would argue that scientists use these analogies to "generate new conceptual schemes that might prove explanatorily useful and be subject to empirical test" (DeVries, 2012, p. 58). Just as previous urban studies scholars did not think the city was literally an organism (Burgess, 1925), a human body (Warren-Rhodes & Koenig, 2001), a machine, or a melting pot. But these concepts have shaped generations of scholarship and practice, with some concepts being outright abandoned with new understandings of how the city functions.

Several studies in the urban metabolism literature have set out to quantify and test the fit of urban metabolism as an analogy for the flow of materials into, through, and out of a city (Hendriks, et al., 2000; Warren-Rhodes & Koenig, 2001; Forkes, 2007). Less attention, however, has been paid to the interrelationships of social groups within the city through the lens of urban metabolism. I discuss this shortcoming and the need for future research in this regard below and in the final chapter.

Some argue, that in fact, the urban metabolism concept cannot be used to analogize the city to an ecosystem, because the city *is* an ecosystem (Golubiewski, 2012). That you could no more achieve greater understanding of the nature of a Porsche 911 by explaining that is similar to a coupe. It is not similar to, it *is* a coupe. Golubiewski and others (Newman, 1999) have argued that "the urban system is just another type of ecosystem, such as grassland or forest, with the unique quality that it is controlled and, in part, constructed by humans" (Golubiewski, 2012, p. 756).

This strikes upon a key shortcoming of applying the natural science understanding of the urban metabolism concept to social phenomena; namely, natural ecosystems do not exhibit social controls on the flows and feedback of material and energy. Humans control the flows of

materials and energy through a city via multi-scalar agency as individuals, organizations, agencies, and man-made infrastructure (Golubiewski, 2012). In this case, it seems that less than a *discounting* of urban metabolism as a conceptual framework, to use Sellars terminology, we must do an accounting of the blind spots of the model and assess whether they are severe enough to abandon this concept as truly trans-boundary science altogether. Golubiewski (2012, p. 760) seems to take a step in that direction as she argues that "urban metabolism does little more than quantify the resources required by the economy."

Here I amplify Golubiewski's articulation of the shortcomings this "black box" approach of the urban metabolism model in which only the inputs and outputs are the phenomena of interest. This approach, according to Golubiewski (2012, p. 758), "does not make the city a part of the ecosystem nor consider the spatial heterogeneity and multiple socio-ecological controls influencing material and energy flows in air, water, and land." This is especially true in the industrial ecological approach to urban metabolism, the intellectual project of which has largely been to quantify inputs and outputs of the city (Wachsmuth, 2012).

To remain a viable concept in social theory, urban metabolism must be able to capture the effects of historical social conditions that continue to shape the human experience. For instance, the quantified flows of materials as urban inputs explains neither the social conditions of agricultural laborers, nor the disproportionate access to the fresh fruits and vegetables of their labor by income, race, and zip-code once those "inputs" enter the city. Nor does it illuminate the disparate likelihood of proximity to landfills, incinerators, recycling plants along the same dividing lines. Can the urban metabolism concept provide greater understanding of how different social groups are impacted differently by disturbances in the food system (e.g. drought, flood, high fuel prices), with different response resources and levels of resilience?

Just as the industrial ecological project in urban metabolism falls short of capturing socio-ecological controls, the urban political ecologists have their own shortcomings. While the urban political ecology project in urban metabolism has successfully leveraged Marxist concepts of labor, capital and the inherent power relations, this macro-level conceptualization of urban metabolism ignores the household as a subsystem (to use the terminology of urban metabolism of ecosystems (Golubiewski, 2012)) within the larger city system. The household is reduced to the "black box" model of metabolism (Golubiewski, 2012) in which only the inputs and outputs are of interest.

Yet, these points of critique seem to chastise disciplines for leaving out objects of study that they lack the appropriate tools and training to study. Would we criticize the plumber who cannot solve complex hydrodynamic equations? Maybe this level of understanding would improve the plumber's work, but is it necessary to do good plumbing? That is to say, if the industrial ecologist has overlooked the social and historical context of the city, or if the urban political ecologist has ignored household-level dynamics that underlie their model assumptions it might matter, and it might not. The scenario in which the omitted factors matter results in flawed models and poor understanding of the phenomena under study. The alternative scenario is one in which incorporating the omitted factors fails to improve our understanding of the subject under study. In this case, the absence of the omitted factors does not indicate flawed models within the discipline of industrial ecology or urban political ecology respectively, even if they fail to answer questions that social scientists or behavioral scientists are interested in answering.

If the urban metabolism concept can improve our understanding of household dynamics, that must be determined by behavioral scientists and interdisciplinary researchers. To a small extent, I hope to have contributed to this intellectual effort in this chapter. The household model

described herein borrows the urban political ecologists' language in the urban metabolism concept. The model here illuminates the fact that new household labor must be mobilized to successfully redirect the flows of food waste out of the home through particular conduits that will ultimately lead to the transformation of food waste into compost or biogas. Importantly, the data show that different social groups are impacted by and respond to these changes differently. Specifically, the data indicate that women are predominantly responsible for food purchasing and preparation, and so are disproportionately impacted by the new labor demanded of curbside OCPs. From a historical perspective in which women have been responsible for a larger portion of domestic, and especially food purchasing and preparation tasks even after entering the workforce, this disparity is unsurprising. Moreover, the data also indicated that age was a predictor of OCP participation, that younger householders may prove more reticent to separating food waste.

Rather than an exhaustive work explicating the role of power relations that impact household dynamics in materials management, the task at hand is to call attention to these household-level dynamics so that future researchers and policy-makers will recognize it as an important component in understanding why these systems succeed or fail. Policy-makers who fail to consider the household as more than a black box into and out of which information, materials, and energy flow, will miss important components of policy adoption and resistance.

### **Limitations**

The following section will discuss the limitations to the experimental designs, its measures, and the generalizability of the results.

**Internal Validity.** Additional limitations lie in the self-report measurement of behavior. The extent to which self-reported separation of kitchen food waste is disconnected from actual

separation behavior, construct validity is threatened. Food and waste studies of this sort tend to rely on self-report surveys alone (Visschers, Wickli, & Siegrist, 2016), or paired with door-to-door bin inspection (Schultz, 1998), with a handful of ethnographic studies employing long-term direct observation (Evans, 2014). The current study utilized self-report measures alone. Attempts to incorporate data from the waste hauler proved insufficiently disaggregated waste data for the purposes of the study.<sup>52</sup> Self-report measures are subject to social-desirability bias in which participants respond in a way that they think will represent them positively rather than accurately.

The challenges to obtaining accurate and disaggregated direct measurement of food scrap separation data are significant. In an ideal scenario, reports, data, and feedback could be generated using real-time automated household-level measurement. This has been achieved through metering for household water and energy, but has yet to infiltrate the waste domain in most of the developed world. The following section on future research will touch on advancements in South Korea's waste management systems that are moving toward a metered food-waste world.

**External Validity.** Several threats to the external validity of this study were anticipated, others evolved in the course of implementation. In this section I will discuss each as well as the efforts to address them. Selection effects are a common threat to external validity. Selection effects threaten the degree to which results are generalizable to the broader population by introducing confounding explanation for observed outcomes. For instance, if the observed increase in food waste separation were only attributable to folks who are already concerned and

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<sup>52</sup> CR&R only collects and reports daily truck load weights for routes on the respective days. Trucks return to the sorting station once their truck is full before returning to the point where they left off their route. Thus, any and all households with a Tuesday trash collection day would be included in the weight data, making evidence of the treatment group behavior change difficult to detect.

knowledgeable about food waste, the study could say little about the effect of norm communication on the general population.

To mitigate the anticipated selection effects, the study design utilized random selection in recruitment and random assignment of participants into treatment and control groups. First, each eligible resident had equal opportunity to be selected for the study. Second, random assignment assured that any confounding variation in the sample had equal chance of occurring in the treatment group as the control.<sup>53</sup> Third, incentives were provided in the form of grocery store gift cards in order to encourage responses from those who might otherwise not take the time. This increased the likelihood of receiving responses from residents who are not already interested in the issue at hand. Finally, the trial recruitment determined that adding a print response option in addition to the digital response method improved response rates and the representativeness of the sample.<sup>54</sup>

The sample is nevertheless suboptimally representative. Despite efforts to encourage response by all community members, residents in the sample were more likely to be older, female, and without children in the home compared to the general population of Costa Mesa and California. This is not uncommon to mail-out surveys (Schultz P. W., 1998; Visschers, Wickli, & Siegrist, 2016) where households with women, especially stay-at-home or older women are more likely to be represented. The results of the survey should therefore be regarded with consideration to these limitations in that cities with more young and highly educated populations may find different results. However, previous research suggests that these populations are even more likely to participate in pro-environmental behavior. So while the sample may not be fully

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<sup>53</sup> Confounding variation in this case could include pre-existing concerns about food waste in terms of quantity, cost, or environmental impact, previous composting behavior, or random effects.

<sup>54</sup> As discussed in the Methods Section, providing the print response option increased the under-representation of older and less educated residents who were less likely to respond to the digital-only response option.

representative of the general population, it does represent a population that is particularly challenging to gain the support of in these types of programs.

Perhaps the greatest threat to the representativeness of the sample lies in the language spoken in the home and the racial-ethnic make-up. In part due to time and financial constraints, study materials were only provided in English. The two largest non-white populations in the city of Costa Mesa are Hispanic and Asian populations (35% and 8% respectively) (U.S. Census , 2015). The most recent census suggests that nearly 38% of households have some language other than English spoken in the home (U.S. Census , 2015). Indeed the percent of non-whites in general, and Hispanic and Asian populations in particular, is significantly lower in the sample than the general population. Generalizing results of this study to broader, racially diverse populations should be done with caution.

Far from the liberal hippy-haven that several other cities across the state have gained a reputation as, Costa Mesa is a likely to be a more conservative population overall with conservative elected officials in both state representatives seats as well as a conservative mayor.. In terms of waste, the Costa Mesa Sanitary District (CMSD) has relied on a single-stream of waste for its entire 70 year tenure. Where the majority of cities across the state have long been separating recyclables and yard waste, CMSD clients have had a single bin for the curbside.<sup>55</sup> In this way, and in terms of resident experience, CMSD appears more akin to typical cities in less progressive parts of the country than the greener parts of California. While this may limit the

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<sup>55</sup> As previously discussed, however, post-collection separation systems are utilized to separate recyclables from waste. In fact, the curbside OCP is expected to improve these efforts by keeping organics out of the waste stream.



generalizability of the results to cities where other forms of separation are typical, cities transitioning from single-stream waste may be able to expect similar results.<sup>56</sup>

Residents served by CMSD have also been exposed to different efforts targeting food waste over the years. This may limit the generalizability of results in that environmental issues surrounding food waste and awareness of alternatives to landfill may be more present in the minds of CMSD residents than in other cities. Starting in 2010 with a grant from the OC Waste & Recycling, CMSD promoted backyard composting to reduce food waste in the material stream by offering discounted backyard composting bins (CMSD, 2015).<sup>57</sup> In the past, the Sanitary District also encouraged residents to use their in-sink disposal to reduce the burden on landfilling organics. In fact, a full 15% of the recruitment sample (167 residents of 1,089) and 18% of the final sample (66 residents of 363) did some sort of composting at home. An additional 0.01% of the recruitment sample (10 of 1,089) and 0.02% of the final sample (8 of 363) reported regularly bringing their food waste to another location to be composted (e.g. compost bins of a friend or family, at work, or community garden).<sup>58</sup> However, it is unclear how many residents engaged in this behavior as a result of previous CMSD promotions.

The subsequent waves of programs targeting food waste may have rendered the motivations for the curbside OCP more salient than they would otherwise be in other cities. Indeed, correlation matrices indicate that believing that food waste has a negative effect on the environment is significantly correlated with OCP participation at Time 2 (0.21,  $p=0.000$ ) and

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<sup>56</sup> Separating recyclables is strongly correlated with separating food waste at all three time points, but these results must be interpreted with caution as the barriers to separate and deliver recyclables to appropriate facilities are significant in this community, and residents who engage in this sort of behavior are highly motivated to begin with.

<sup>57</sup> CMSD later incorporated the cost of providing discounted bins into their operational budget. All bins purchased under the program since 2010 have been sold, and in Fiscal Year 2014-2015 alone, CMSD sold 361 bins to different households.

<sup>58</sup> These participants were retained in the study as the curbside OCP offered collection of items that are not compostable in small-scale or backyard systems such as meat, bones, dairy, fats, oils, and greases. Separation of these items into the organics cart was encouraged in tandem with other small-scale efforts rather than an exclusive alternative.

Time 3 (0.16,  $p=0.003$ ). This suggests that while there is an effect of knowledge related to the impacts of food waste, it is a weak one. Thus, the fact that CMSD had run food waste-related campaigns in the past, possibly heightening resident awareness of the negative impacts of food waste, this previous exposure would not account for much of the variation in OCP participation.

## **Conclusion**

This chapter interpreted the findings from the two-part community-based experiment and linked these findings to the larger issues discussed in this dissertation. Namely, that household behavior change is a necessary component of OCPs, and that norm communication tools will improve household participation in these programs that work to close the loop on urban food systems. The findings provide evidence for the use of social sciences to improve environmental policy and confirm that norm communication tools can be extended to the domain of household food waste. The urban political ecology lens for urban metabolism furthermore provided insight into how the new labor demanded of households in OCPs transforms socio-ecological relationships at the household-level as well as at the city-level. The following chapter will discuss the policy implications of these findings before concluding the dissertation.

## CHAPTER 7

# Policy Implications & Conclusion

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The findings of this dissertation support the argument that social innovations should be paired with infrastructural changes to increase the effectiveness of programs designed to close the loop on urban food systems. This is underscored first by differences in TPB results over time indicating that "intention" to separate food waste from landfill streams is not a significant predictor of actual behavior in the absence of supportive infrastructure, but "intention" becomes significant with OCP implementation. Furthermore, making the new community norms of separation salient to residents will activate social influence over otherwise private behavior.

The findings in this dissertation have significant implications for policy and practitioners, especially given the applied nature of the empirical portion of the dissertation. Partnering with the CMSD provided not only greater understanding of the real world challenges of developing and implementing a curbside OCP, but also a direct link for new knowledge to be applied to a broader population. The policy implications reach beyond this particular study for practitioners and theorists alike. This will be the subject of the first part of this chapter. I will then close the chapter by revisiting the key points of the argument and findings from the dissertation.

### **Policy Implications**

This dissertation opened with an examination of the negative impacts of the contemporary linear food system. The contention at the heart of this project has been that striving for continued human existence in a finite world, these systems must be transformed into circular systems that will continue to support the survival, indeed the flourishing, of the species. The inputs to urban systems, including nutrients, are finite, as are the places where outputs can be stored and urban pollution absorbed. So it is that urban systems and the actors therein must endeavor to reduce wasted nutrients by eliminating inefficiencies that create food waste, redistributing uneaten food to the needy, reusing food that has been prepared for other

purposes<sup>59</sup>, and capturing food waste in source separated schemes such that it can be put to its highest and best use first, be that compost or AD. This research has shown that urban spaces must transform the systems of provision as well as household behaviors in order to close the loop on urban food systems, and that to do so will require technical and social innovations.

**Transforming Household Behavior.** The findings from the experiments suggest that cities can expect a non-trivial portion of the general population to adopt food waste separation practices using supply-side approaches (Steg & Vlek, 2009) that target the material context (Southerton, McMeekin, & Evans, 2011) of food scrap separation (i.e. the systems of provision), namely curbside OCPs. This rate of increase, however, will plateau after the initial gains in participation are made with the addition of the new curbside organic carts. The findings show that cities can move beyond this plateau in recruiting additional participation, indeed in maintaining participation, using demand-side approaches (Steg & Vlek, 2009) that target the social context (Southerton, McMeekin, & Evans, 2011) of food scrap separation. Specifically, cities can increase participation by directly communicating descriptive norms (Cialdini & Trost, 1998) of community separation.

It is critical, here that in order to replicate these findings, cities use descriptive norms that characterize the percent of the population engaging in the behavior, rather than using an average figure against which the individual can compare themselves.<sup>60</sup> In these cases, residents may be subject to the boomerang effect where those performing better than average regress toward the mean (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2008). Furthermore, cities should frame the behavior in specific and positive terms when communicating the community norms

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<sup>59</sup> This pertains to the knowledge and practice of using food scraps or re-imagining the use of leftovers such that they will be eaten rather than placed into conduits where they will become waste.

<sup>60</sup> As when the norm is communicated with information related to the individual's position relevant to the "normal" behavior of others (i.e. above or below some average).

(McKenzie-Mohr, 1999). For instance, rather than promoting that "70% of residents weatherize their homes," program managers should be specific about the actual behavior; "70% of residents installed weather-stripping to all their window and doors."

In terms of implementing the direct communication of these norms, financial barriers may face cities that do not provide monthly bills upon which the norms could be communicated as O-Power has done (Allcott, 2011). CMSD for example, charges residents just once per year through their property taxes. In these cases, cities may do well to target their interventions to new residents or specific areas challenged by non-participation. Technological advancements discussed in the future research section will also ease this effort.

The results from the Theory of Planned Behavior also have implications for policy-makers. For instance, recall that perceived control over separating food waste significantly predicted both the intention to separate and separation behavior directly. Cities should work to give residents a greater sense of control over diverting their own food waste. This can be achieved through multiple models of food waste capture. Cities can facilitate connections between existing local operations such as community gardens, schools, community-level food waste collection groups (e.g. pedal-powered operations discussed in previous chapters), and groups that offer workshops on at-home composting. Providing pathways for developing local networks and knowledge sharing initiatives will lead to greater diversion, improved local soils, and social-capital building. In addition, offering curbside OCPs may be the best model in contexts with populations that are older, have high-turnover, or live in highly dense housing as these communities are less likely to have backyard compost or community gardens. Just as in other models, cities can facilitate peer-to-peer learning or provide testimonials from residents who have overcome challenges in OCP participating. Curbside programs should be preceded by

efforts to educate the community on permitted items,<sup>61</sup> maintenance best practices (e.g. for curbside bin and kitchen pail), and program motivations.<sup>62</sup> This may serve both to garner support for the program and help residents feel ready to 'hit the ground running', so to speak. The findings herein build on Schultz' (2014) behavior-scenario classification suggesting that cities may find the best use of pairing norm communication with infrastructural improvements to be for behaviors in populations that already have a positive attitude toward that behavior. In the case of food waste separation schemes, this study provides evidence that the greater gains can be made by incorporating both new supportive infrastructure and direct norm communication. The extent to which cities can estimate the community's perceived benefits of and barriers to OCPs they will be able to select appropriate behavior-change tools based on the conditions on the ground.

Adopting approaches that engage with the social aspects of waste will be a crucial component of municipal OCPS, especially those in states like California that will be facing short timelines for landfill diversion mandates. By 2020 in California, cities will need to prevent a full 75% of waste from entering landfills, and using behavior-change tools like norm communication is a cost-effective means to garnering significant participation in new and old OCPs. As the single largest material stream entering landfills from cities and compounding environmental and social problems along the way, organics diversion is the lowest hanging fruit with the sweetest harvest.

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<sup>61</sup> Using graphics rather than words can overcome language barriers. Graphics should be relevant to the types of organic materials the users are likely to generate. For instance, different sets of graphics would be used for residential and commercial separation schemes.

<sup>62</sup> The data suggest that support for the program was correlated with knowledge that the curbside OCP would improve recycling efforts.

**Transforming Systems of Provision.** As we have seen in the preceding chapters, significant barriers remain for implementing OCPs across the country. The lack of sufficient organics processing facilities has been identified as the single greatest barrier to cities adopting their own curbside program (BioCycle, 2014a). Statewide grant and loan programs stand to level that playing field in places like California. Once these facilities are up and running, however, cities must be ready to engage cost-effective technical and social innovations to successfully close the loop on food systems. The current research provides insights into the effects of pairing these innovations in the appropriate context, in part, addressing gaps in the literature of the potential for social innovations in urban infrastructure projects (Castán Broto & Bulkeley, 2012). As others have argued, cities are a great living laboratory, and networks of cities must share their lessons-learned to ease the learning curve of cities with limited financial capacity to meet the challenges of the 21st Century (Bressers & Rosenbaum, 2000; Layzer, 2010).

***Scale for Change.*** Cities are in a unique position to share and implement new approaches to environmental problems ahead of oft lethargic national or international mandates. Especially in a climate of polarized and even filibustered political action to address the ecological crisis at our doorsteps, cities may be in a unique position to move forward on closing the loop of nutrient flows before state-level governance can put pen to paper. The call to action is arguably ringing at all scales and manifestations of governance; from civic environmentalism (Knopman, Susman, & Landy, 1999; Kraft & Mazmanian, 1999), to ecosystems-based management (Layzer J. A., 2008), and global civil regulation (Cashore, 2002; Vogel, 2010; Dauvergne & Lister, 2012) to municipal development ordinances. While it is no doubt that trail-blazing cities will continue to lead the charge in different corners of the globe, the onus cannot fall squarely on their shoulders



without reproducing the same disproportionately distributed externalities of environmental degradation and social disadvantage that we see today.

***Problem-Framing.*** State-level problem framing must capture the ordered priorities of preventing inefficiencies that lead to food waste, empowering local communities to take control of their own food systems, redistributing uneaten food to those in need, and capturing source-separated food waste to be transformed into new inputs. Current problem-framing falls short of this. The U.S. EPA and USDA purports to be a stepping toward a new problem framing for organics as one of *justice to be distributed*, but their actual goal of reducing food waste by 50% by 2020 does not set priorities for how to accomplish this goal. Without addressing the ordered priorities of waste reduction approaches, the agencies risk undermining needed long-term vision for closed-loop food systems. The framing of the problem must blend long-term concerns for human flourishing (e.g. local food empowerment, highest and best use) and the concept of circular urban food metabolism (e.g. source-separated nutrient recycling). This frame can and should encompass the goals that have come before it (i.e. efficiency, risk management, value-capture) as they have not lost importance.

The effects of state-level problem framing cannot be overstated. It is without question that we need urban innovators and we need networks of communication to translate lessons learned into new and urgent contexts. Just as necessary is unequivocal state-level problem framing to guide the widespread transformation of urban institutions and infrastructural arrangements (i.e. the systems of provision). We have seen significant and widespread transformation of the systems of provision with shifts in state-level problem-framing.

As these state-level changes has occurred, different solutions and standards have been identified in response, and different policy 'interventions' (i.e. policy principles, instruments, and

incentives) have been aligned to support the achievement of those standards. This was evident in the transitions of problem-framing for organic waste from one of *disposal efficiency* to one of *risk management*. New standards were developed and implemented in landfill technology in the U.S. to mitigate the harmful effects of organics decomposing in the anaerobic conditions of the landfill. The shift to *risk management* as the problem-frame for organics led to thousands of landfills across the country closing their doors after failing to meet the new Subtitle D standards (U.S. EPA, 2002). Cities and haulers began innovating new prevention and recycling solutions in the wake of the closures<sup>63</sup> and the subsequent trend with landfills has been fewer, but larger fills coming online since Subtitle D.

***Reduced Distancing in New Socio-Ecological Relationships.*** This trend toward large-scale waste management facilities is reflected in organics. Centralized regional organics processing facilities (ROPF) are just one of many ways to close the loop on the flow of nutrients through urban spaces, but they are not the only and they may not be the best way. These large regional facilities require significant investment and can cause significant environmental nuisance or degradation if something goes wrong. Because of the upfront cost and maintenance of the facilities, cities and private haulers often enter long-term contracts setting terms for quantity and quality of feedstock<sup>64</sup> thus limiting the flexibility to adapt to sudden changes in environmental or social conditions and demands, or even better technology.

Relying on curbside collection and large scale facilities may have other shortcomings. In chapter 4, I argued that the concerns raised by Princen (2002), Conca (2001), and Clapp (2002) regarding the *distancing* effects of consumption and disposal go unheeded in this model of waste

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<sup>63</sup> Unfortunately, this had the unanticipated effects of hastening the consolidation of the waste industry, in part because the cost of building an 'up-to-code' landfill was so great that economies of scale tipped the balance in favor of large, regional fills.

<sup>64</sup> As was the case with large incineration facilities in the Netherlands.

management. Curbside programs with commingled waste and far-off processing facilities keep the resident disconnected from the impacts of their consumption and disposal decisions; where they might behave otherwise if it was in their own backyard.

Curbside OCPs that require source separation of household organic waste may reduce this distancing effect by engaging the householder with their own material flows, demanding new social-ecological relationships in the home as households contend with the materiality of food waste. I argued in chapter 4 that this materiality of food may have a distinct effect on separators as it demands that household members arrange their schedule to that of the immediacy of organic decomposition, while conventional recycling materials patiently await their expulsion in a static state. Thus while the negative effects of large scale composting are as distanced from the householder as landfill storage (i.e. both geographically and psychologically), source separation schemes that require separating and handling organic wastes in the home may resonate with separators in more fundamental and perhaps lasting ways than material handling in recycling or commingled waste schemes. Ultimately, cities must recognize and engage with the social aspects of waste as they implement curbside OCPs. There must be understanding that if these policies are to be successful, they must "cross the threshold" (Bulkeley & Gregson, 2009) and demand new socio-ecological relationships (Swyngedouw, 2006) between householders and food material flows.

Furthermore, ROPFs only serve to reinforce the market-oriented relationship with organic materials. The high cost of these state of the art facilities places significant pressure on companies to recover that cost in the processing of organic materials into salable product. It is only a question of *when* not *if* those goals supersede those of promoting circular urban metabolisms to support human flourishing. For instance, the value of edible uneaten food to the

private hauler is not in reducing food waste, nor redistributing it to those in need, but only insofar as it is useful as feedstock in compost and AD processes. While this would technically close the loop, it undermines the values of highest and best use promoted by the U.S. EPA and the EU (U.S. EPA 2016c, European Commission 1999). Yet the ubiquitous adoption of transforming organics into compost or biofuel is a critical component of closed loop food systems that will not be achieved solely on the backs of committed backyard composters. Municipalities and public-private partnerships must continue to support the innovation of social systems to empower local food systems, to redistribute uneaten food and to capture food waste for useful transformation. The systems most resilient to disruption will be those in which a diversity of scales and processing methods are utilized.

### **Successful Organics Collection Programs**

Successful OCPs can, no doubt, take many forms. What the current research can contribute to lessons for how to achieve a successful OCP is constrained by contextual elements. To be specific, the current research cannot provide analysis of the effects of the choice in collection model, processing methods, or facility scale and siting. These elements, along with the role of community stakeholders, were fixed in the context of this study. The subsequent section of future research suggests a line of inquiry to address these factors such that communities considering implementing an OCP can have more information upon which to base their decisions. That being said, the current research is particularly informative for communities that are adopting curbside OCPs.

**Infrastructure Matters.** Before discussing some programmatic components, it is important to underscore the importance of infrastructure. The current research indicates that infrastructure matters, not only in terms of reducing barriers such that "intention may be allowed

to influence separation behavior (as indicated in the TPB model), but also in terms of fit for household waste demands.

Cities interested in widespread diversion of food waste from landfills will not be able to achieve this through backyard composting efforts alone. The poor fit of the full TPB model at Time 1 (especially non-significant *intention*) suggests that household food waste separation is not in fact a volitional behavior. Instead, the data indicate that significant barriers remain in that perceived control continues to have a direct positive effect on separation behavior. Providing supportive infrastructure significantly increased participation among participants by reducing barriers inherent in backyard composting (e.g. space, physical capacity, time, and need for compost). After the curbside OCP was in place, *intention* became a significant predictor of behavior, indicating that the supportive infrastructure had reduced barriers and allowed behavioral intention to result in actual performance.

Both curbside and in-kitchen infrastructure are important elements of OCPs for cities to consider. The private hauler that Costa Mesa contracted with offered only two sizes of curbside bins (32 and 64 gallon) so that the automated claw on the collection trucks could collect the bins in the same way as regular trash was collected. However, several participants indicated in open-ended response options that even the smallest bin was far too large for the amount of food waste their household produced in a week. This discouraged weekly placement of the curbside bin for collection which led to hardened residuals at the bottom of the bin that are difficult to remove and create a nuisance for the resident. Those who placed the bin for collection each week despite the measly quantity reported feeling foolish or that their contributions did not matter. Avoiding the negative experiences that residents have with the program, especially early on, can reduce drop-out. Beyond encouraging appropriate curbside placement, cities may gain a more positive

response by offering a wider variety of bin sizes to match household waste generation. But these gains should be weighed against collection logistics.

Infrastructure inside the home is also an important component of successful OCPs. The data from the current research indicates that more than one third of the population used some improvised device as a container to collect food waste in the kitchen before disposing it to the curbside bins. And a minority took the scraps directly out to the bin when they finished preparing food and to dispose of table scraps. Improvised devices included items that the household already owned such as Tupperware-type containers or bowls of varying size. Respondents also reported using repurposed items such as an empty tub from yogurt or an egg carton, in the latter case, they could then dispose of the scraps, carton and all into the curbside bin.

Many cities have offered kitchen containers automatically to residents, with varying levels of population coverage depending on available resources. Costa Mesa was one of these cities, but required that residents interested in receiving a free kitchen pail come collect it during a two-day event or in their offices. However, the limited office hours of the Sanitary District and limited access to transportation of some community members limited access to the kitchen pails. Even among some of those who received the pail, dissatisfaction with functional or aesthetic elements, or the difficulty in cleaning some elements of the pail, led to the rejection of the pail. Cities with limited resources should query actual demand and reduce barriers to receipt of such devices should they chose to supply them to residents.

**Education Campaigns.** This research indicates that successful OCPs can be implemented with pre-OCP education campaigns, continued opportunities for dialogue between community members and the city, as well as communicating the new norms of community separation. To the first point, Costa Mesa engaged with the public through several media in town

hall meetings, radio and TV announcements, and hosting booths at local events (e.g. high school football games). Each of these venues provided the opportunity for the Sanitary District not only to communicate what the program meant for householders and how it would impact finances and the environment, but also the broader motivations of the district. These efforts had some effect on policy support as the data indicate that residents who were aware of the OCP before receiving the carts were more likely to support the program.

Other cities considering implementing an OCP may learn from some of the shortcomings herein. Specifically, presenting information graphically can reach a broader and multi-lingual audience. Using flyers and graphics with too many words can turn off even native speakers, in addition to preventing communication with non-English speakers. Providing graphically instructive materials in the form of magnets will also encourage householders to display the relevant information in the venue in which separation behavior takes place. This helps spread awareness to other family members and friends or relatives visiting the home.

Education campaigns should not only consider how they present information, but what information the householder needs in order to maintain long-term participation rates. For instance, it may be obvious that providing information on which materials are allowed and which are prohibited in the organics cart will encourage participation. But, especially when dealing with the messiness of organics, proper maintenance of household separation systems is crucial to reduce instances of confronting the "ick-factor". Several participants indicated frustration with their household separation system on account of odors, flies, and general "ickiness". Providing graphical instructions for proper maintenance can prolong the positive experiences residents have with food waste separation--or at least reduce negative ones.

Instructions should be specific. Rather than merely stating "frequent" removal of food waste from the kitchen and placement of the bin for collection will reduce nuisances such as odors and fruit flies, specify the appropriate frequency (e.g. "daily" or "every-other-day", or "weekly" in the case of the curbside bin). This level of frequency is important as food waste begins to putrefy and become odorous inside the kitchen container or can become solidified at the bottom of the curbside bin within this time frame. Similarly, stating that "regular" rinsing of the both the container used in the kitchen and the curbside cart can prevent build-up of residues that attract nuisances is helpful. But specifying the appropriate frequency will yield better results. Each time the kitchen container is emptied, it should become a matter of habit to give it a rinse before beginning to use it again. Using soap and water may only be necessary every-other-empty or once a week. Furthermore, using images of people doing the desired behavior in media may be instructive in a way that words are not. Show people actually using a liner such as a compostable plastic bag, paper bag, or newspaper inside the in-kitchen collection container to reduce the occurrence of nuisances.

**Ongoing Dialogue.** Providing opportunities for community members to ask questions, learn from each other, and provide feedback on programmatic elements can improve not only participation rates, but program support. Several respondents used the open-ended questions in the surveys to ask often basic questions about how to participate correctly or to express frustrations or satisfaction with program elements. Cities should offer a medium through which residents can communicate with city staff regarding the program, whether that be through a survey offered at particular intervals or through a constant portal on a website or hotline. Especially being able to address simple "how to" questions may reduce residents' negative interactions with the program early on that would discourage their future participation. If



ongoing access is not financially viable, then providing a temporary hotline during the months leading up to and following the implementation of the program may be sufficient. Several questions could be answered using an automated system to reduce demand on staff.

Alternatively, providing an outlet through which community members can share ideas and strategies with each other may reduce the burden on city staff as well as normalize community participation.

**Norm Communication.** The intervention experiment indicated that communicating the new norms of food waste significantly increased participation and reduced drop-out. Cities considering implementing OCPs will benefit from using this low-cost tool to promote program success. Of course, different contexts will offer different opportunities and constraints for communicating norms. Cities in which residents receive monthly or bi-monthly bills for waste have a ready vehicle through which to communicate normative behavior. O-Power has done this using regular electricity bills with some success. Similar messaging could be communicated to those who have requested paperless statements.

The challenges are greater where the frequency of communication is lower. In the Costa Mesa case, for instance, residents pay for their waste and waste-water services only once per year on their property taxes. This meant that the Sanitary District only officially communicated with residents once per year and occasionally by including an insert in the paper mailings sent by the water district. In cities with limited outlets for communication with their residents, innovative approaches must be sought to communicate norms. Cities should also look to incorporating frequently updated normative messaging into their websites, apps, newsletters and other media apart from bills. Some cities may have the capacity to include new mobile applications that residents can use to report their own food waste generation and separation as well as receive

norm communication and reminders from the city. For the less tech-savvy residents, using magnets to communicate norms proved effective in the current study. There is currently insufficient data, however, to determine whether and how often updating this information leads to significantly greater gains than a static normative message in which the percentage of participating residents does not change. If future research indicates that the frequency of normative message updating is a strong predictor of its normative effect, this could prove cost-prohibitive for cities hoping to rely heavily on magnet communication. However, there may be some middle ground in which cities can target under-performing neighborhoods with normative messaging rather than city-wide messaging campaigns.

These tools and considerations discussed above will help cities in implementing successful OCPs. The findings of the current research highlight the importance of providing appropriate and supportive infrastructure, using specific and graphical instructions, establishing opportunities for dialogue with and between community members, and communicating the new norms of separation. Implementation of OCPs will likely need to take on different manifestations depending on contextual factors discussed above, including climate, financial capacity, population density, and existing infrastructure. Additional research in this regard will continue to inform our understanding of successful OCP development and implementation.

### **Future Research**

This research contributed new understanding to several domains including social psychology, social marketing and organic waste policy. The experiments indicated that intention to separate food waste will be enabled to lead to actual performance with the provision of supportive infrastructure (i.e. curbside carts, collection and processing services), but that additional participation gains can be made by pairing social innovations with technological ones.

Specifically, communicating the new norms of community food waste separation will significantly increase participation in curbside OCPs. Based on the findings, I outline a future research program to address the limitations and new questions that have arisen in the course of this research.

**Addressing Limitations.** Future research should strive to address the limitations of this study and continue to move forward our understanding of household behavior as it interacts with the systems of provision designed to transition to circular urban food metabolisms. Several limitations can be addressed with alternative study designs, new technologies, and even further analysis of the existing data. New research questions have also emerged from that will advance our understanding of household metabolic processes.

**Improving Internal Validity.** In terms of addressing the internal validity limitations, different methodological approaches could be undertaken or new technologies used. For instance, a nascent field of ethnographic household food studies has proven indispensable in revealing complex social aspects of food purchasing, storage, preparation, and disposing (Evans, 2014). This approach has been further explored in terms of the everyday practices around other household items (Gregson, Metcalfe, & Crewe, 2007; Gregson, 2007; Bulkeley & Askins, 2009; Southerton, McMeekin, & Evans, 2011). Future research can contribute to this area of scholarship by leveraging ethnographic field research to more deeply investigate the social aspects of adoption, resistance, and other ways of responding to curbside OCPs. This sort of in-depth field research will provide needed understanding of the everyday practices that disrupt or support circular urban food metabolisms.

New technologies are on the rise and in practice in some corners of the world that will overcome the limitations of self-report by doing for household food waste what metering has

done for water and energy. Disaggregated household-level data on household food waste would not only improve measurement of food waste flows and the leverage of norm communication, it would also enable the latter to be used city-wide. A new household waste metering program has been piloted in parts of Seoul, South Korea where residents use a radio frequency ID card to unlock a common disposal bin or chute, the bin records the household and the weight of the matter placed inside for billing purposes. Moreover, the bin has a screen that reports the weight and cost back to the resident. If real-time community norms of waste disposal and food waste separation were presented on the screen, this may be a cost effective way to use more accurate, real-time disposal data for an entire city. This technology offers new opportunities for understanding but as yet little to no research exists on the effects of the smart-bin in this context, much less the opportunities for norm communication.

Another approach to using technology has yet to be developed, but would be a better fit for existing infrastructure in curbside programs and provide similarly disaggregated data. In many parts of the U.S., millions of curbside carts are already being collected with an automated arm from a waste truck that lifts and empties the bin into the truck. Waves of other cities are following suit. These arms could be equipped with a device that records the household (e.g. using a barcode on the bin) and the weight of the bins as the arm lifts it for disposal. While this approach would provide disaggregated household-level disposal data, it would not provide the real-time feedback as in Seoul's smart bins, nor would it capture food waste prevention strategies used by residents. Nevertheless, the micro-data provided could be used to design new waste rating systems, or coupled with monthly billing cycles to communicate community norms.

***Improving External Validity.*** Developing methods for automated household waste data collection also overcomes several threats to external validity. For instance, complete enrollment

of the community eliminates the selection effect of participating in a mail-in survey program or placing magnets on one's fridge. Mechanized measurement also eliminates the social desirability bias that threatens self-report survey measures. This approach to measurement also overcomes language barriers in survey data collection. Challenges would remain, however, for communicating norms in the appropriate language for the household member responsible for different stages of the household food metabolism (i.e. planning, purchasing, preparing, storing and sorting). Alternatively, cities may develop graphics that transcend language to communicate the norms as San Francisco and others have done for communicating appropriate bin contents. These approaches would improve the generalizability of results, and possibly the widespread effectiveness of norm communication.

Furthermore, new research is needed from cities with diverse baseline waste systems. As discussed in the Limitations section, CMSD had been promoting backyard composting for years prior to the implementation of the curbside program. The extent to which this led to greater overall awareness of food waste as an environmental problem, it may have served as a confounding variable. Replicating this study in cities that have yet to be exposed to food waste as an issue will advance our understanding of the true effect of communicating the norms of food waste separation.

**New Research Questions.** Based on the findings of this research, new questions have been identified. These questions pertain to the role of supportive infrastructure and social aspects of organic waste programs, the further refinement of normative effects, the household food metabolism model, spillover behaviors, and the socio-ecological relationship of householders to natural systems. The research program described below will advance social and behavioral theories as well as municipal efforts to close the loop on urban food metabolisms.

***Supportive Infrastructure and Intention.*** The findings indicate that providing supportive infrastructure (i.e. curbside carts, collection and processing services) significantly increased food waste separation behavior. Once the infrastructure was in place, the role of behavioral intention in the Theory of Planned Behavior model significantly increased. One explanation here is that the barriers to separation behavior without supportive infrastructure were too great to overcome by intention alone. This finding may inform other pro-environmental behavioral domains. Future research should examine whether and to what extent this relationship persists in predicting use of sustainable public transportation. For instance, does incorporating behavioral intention improve models predicting use of a proposed rapid bus lane? Conversely, does incorporating a measure for the constraints in the built environment improve TPB models in other research where behavioral intention underperformed? Given that the TPB is a model for predicting volitional behavior, the omission of these variables obfuscates structural constraints and attributes an excess of power to the individual.

***Household Dynamics: Age and Cohort, Responsibility and Power.*** Age was found to be positively correlated with separation behavior, both before the supportive infrastructure was in place and after. It also remained significant with the addition of the TPB model variables. As discussed in the previous chapter, the data are insufficient to parse out whether this is an effect of age, whereby people will separate more on average as they get older, or an effect of cohort, whereby people of that particular generation share experiences that make them more likely to separate.

With proper research design, future research may be able to add to the body of work already examining this relationship as it pertains to other pro-environmental behavior. For instance, future research should examine whether non-linear models better explain the

relationships between age and pro-environmental behavior. If there is a quadratic or cubic relationship, this would support a life-cycle model in which as one moves through the different life stages (i.e. young adult, young professional, young family, middle-aged family, retirement) they are more likely to separate food waste. We could expect to see that while there may be positive relationships as a young adult and as a retiree, life-stages with intensive demands on the time of the household (e.g. new demanding job or young children) may see a drop in participation. This would define a cubic relationship and support the life-cycle model in which age effects separation.

Future examinations of the household dynamics of behavior change should regularly incorporate data not only on household size and presence of children, but on actual time spent in the home and materials management responsibilities by different household members. Data on full and part time income-earners, stay-home spouses, and retirees, for example, could account for some of the differences in age seen in this study by virtue of actual time spent in the home. If one spends more time in the home they may be able to dedicate more time to separation tasks. This may also explain why even before the curbside program was in place, backyard composting was correlated with older ages. Spending more time in the home, of course, is not necessarily correlated with older age, but in this case it may be a more important factor than age.

To detect whether the difference lies in the cohorts, a different approach will be needed. In-depth interviews and ethnographic methods may be necessary to unpack issues of cohort without a decades-long panel study. Understanding the perspectives, motivations, and life-course events that shape household behaviors could inform whether distinctive characteristics define cohorts and explain the differences in behaviors.

Additionally responsibilities for different tasks, decision-making models, and the power-dynamics within a household will define who is actually impacted by changes in policy. Some households shared responsibilities related to food purchasing, food preparation, and waste disposal tasks and others were solely responsible for different (or all) tasks. The model of household decision-making in the delegation of tasks may play a significant role in whether households participate in curbside programs. Several components of this will be ripe for future examination; the effect of the decision-making model (i.e. collective, unitary) on whether shared or individually responsible roles emerge, and are there significant differences in the participation rates of these different approaches? We might expect that household members using collective decision-making to share responsibilities feel more responsibility to perform the pro-environmental behavior than unitary and/or sole duty households based on their relative power in the decision-making process. But perhaps we would expect greater lapses in participation in a model in which household members are rotate their responsibilities. Several respondents in the current research expressed concerns about cooperation by other household members. These respondents were significantly more likely to be women. How do minority voices garner support from household members and how are traditional gender roles (re)produced in the on-going negotiation of household participation?

***Refining Normative Effects.*** First, related to unpacking the normative effects, cities may improve their norm communication programs by refining the message further. New experiments should be designed to test whether particular reference groups will be more effective than "the community" at large or "your neighbors" (Latané, 1981; Hooper & McCarl Nielsen, 1991). The current study was not designed to detect these differences, but greater understanding it may result in greater efficacy of norm communication tools. Furthermore, new research should test



the effect and duration of injunctive norms that communicate what the reference group thinks is the right thing to do, rather than what is actually done (i.e. descriptive norms that were used in this study) (Cialdini, Reno, & Kallgren, 1990). Previous research in other household domains has found the former to have more lasting effects (Schultz P. W., 1998). Finally, informative influence (as opposed to normative influence) (Deutsch & Gerard, 1955) may still prove useful despite the fact that CMSD in this case had implemented an extensive information campaign to prepare residents for the new curbside OCP. Given that frequent disposal and proper maintenance of the kitchen pail and the curbside cart are so critical to preventing the nuisances that turn-off residents to participation, informative influence that communicates the right way to do a behavior (i.e. leverages people's desire to be right) may still be necessary.

***Household Metabolism Model.*** This dissertation began to articulate a household metabolism model in order to identify predictive factors of and points of leverage for changing household food waste. Future research should endeavor to quantitatively measure the flow of food materials into, through, and out of the home. This model provides a compelling framework for testing the relationship between these flows and the most effective interventions (i.e. behavioral, structural, or both) at these different stages. For instance, researchers may develop quantitative models to determine how the type, quantity, or variety of household food inputs, shapes household food outputs. Such a model may refine our understandings of the relationship between purchasing fresh produce over frozen produce leads to more compostable materials or food packaging waste in the waste stream, for example. This information could shape packaging regulation or improve planning for waste flows by municipalities (or their private haulers).

Additionally, the household metabolism model through the urban political ecological lens lends itself to new research questions. The UPE metabolism framework focuses our attention on

the socio-ecological relationship between householders and the material flows of the home. Source separation schemes demand new labor of householders and thereby alters the household metabolic processes. The separation of food waste materials from other waste streams demands that householders transform their engagement with organic materials, and even orient their disposal schedule around natural (and immediate) processes of decomposition. Future research should examine whether and how this more intimate and focused management of household organic material flows effects householders' experience of the urban as a natural system. Put another way, do householders who newly engage in food scrap separation develop new awareness of natural systems or of the urban system as part of natural systems? Are curbside programs sufficient to activate this new awareness and any subsequent change in behaviors or preferences, or is the more intimate practice of backyard composting necessary to see such effects?

*Systems Thinking & Spillover Behaviors.* These questions are also linked with another set of new research questions spurred by this research. From a systems-thinking approach, we would expect that changes in one component of a system will result in changes in other components of the same system. The current research identified a multi-scalar network at which changes are occurring related to organics policy; that of the household, municipality, and international trends in problem framing.

At the household level, future research should investigate whether participation in curbside OCPs leads to changes in other behaviors or attitudes. Both the social psychological literature and the practice literature understand household behaviors as connected, albeit via different processes. Spillover behaviors are those that develop as a result of engaging in some new behavior (Truelove, Yeoung, Carrico, Gillis, & Raimi, 2016). If the target behavior of an

intervention is food scrap separation for curbside composting, and residents who begin participating also engage in food waste prevention behaviors or water conservation behaviors, then spillover has occurred. If cities can expect significant uptake of spillover behaviors by implementing curbside OCPs, understanding this process and quantifying its effects will provide a more complete picture of the environmental impact of OCPs and related interventions. For instance, as residents begin separating their food waste, are they likely to generate more or less waste? Will guilt about wasting food be heightened by visualizing the sheer magnitude of household food waste each day as the kitchen food waste bin fills up? Or will that guilt be assuaged by the thought that 'at least its going to good use'? This future research would also advance our understanding of the processes through which spillover occurs.<sup>65</sup>

Furthermore, additional research is needed on the 27% of households who continue not to participate. Perhaps barriers remain for these households that were not addressed by supportive infrastructure or by communicating normative behaviors of food waste separation. Are these barriers an artifact of some other constraining element of the built environment or physical capacity, or perhaps additional psychological or ideological factors not captured by the survey measures.

At the level of the municipality, future research can build on the findings of this research. The current research found that OCPs in the U.S. are responding to municipal or state-level mandates rather than national ones, in contrast to other, smaller developed countries with comparable organic waste policies (i.e. The Netherlands, South Korea). Indeed, save a few small states (i.e. Vermont and Connecticut), U.S. cities are leading the charge ahead of state-level mandates as in San Francisco, Portland, New York City, Boulder, and Seattle. A systematic

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<sup>65</sup> I am currently completing a collaborative project that takes up this question using the data from the experiments herein.

examination is needed to understand the factors that drive a city to adopt, reject, or ignore organics diversion programs. The current research found that statewide grant and loan programs were working to expand processing capacity needed as cities work to achieve statewide mandates--in the states that have them. Better understanding is needed to determine what effect these grant programs are having on reproducing the consolidation of waste management by large corporations in locations far afield from the cities generating the waste. Are cities experimenting with alternative scales of management and organizational approaches and can their models be replicated elsewhere? Are these alternative models able to contribute to other urban challenges (i.e. quality soil in urban agriculture, fresh produce in poor neighborhoods) that large-scale organics processing facilities cannot achieve?

Cities also need to adopt a systems-thinking approach in the pursuit of OCP implementation. The Costa Mesa Sanitary District had prepared impact analyses for their town hall meetings introducing the program to the public. There was a particular focus on the impact of trucks on the road, and this seemed of great concern to residents in attendance. Organics cannot be collected in the same trucks as garbage or recycling, at least not in the same trip. Other communities that already have source separation are visited by three different trucks on trash day for garbage, recycling, and yard waste (or the respective trash days). This added truck traffic can put significant wear and tear on the road, put pedestrians and children at increased risk, and emits more pollutants. Some cities, like Portland, have taken to collecting regular garbage only every other week while collecting food waste every week. This model encourages use of the food waste carts as households can eject the putrescence more frequently, but it also reduces the number of trucks on the road each week compared to a weekly pick-up of all materials. They are

currently evaluating the impact of a monthly-only service for regular garbage, significantly reducing the impact of truck traffic.

The OCP in Costa Mesa is able to use trucks powered on the methane produced from the anaerobic digestion of the food waste. This eliminates diesel particulate matter that significantly impacts the air quality and health of communities, especially children and asthmatics. It also nearly eliminates the climate-change contributing greenhouse gases emitted from carbon-based fuels. Future research will need to examine whether, in practice, the reductions in air pollution and GHGs are a good trade off for the impacts of additional truck traffic (e.g. accidents, injuries, congestion, added road repair).

Of course, these impacts are not only local when the organics processing facility is 60 miles away from the source of food waste and is regionally coordinated. The impacts of additional trucks on local roads reflect the additional routes between communities and the material recovery facility (MRF). It does not capture the effects of the routes between the MRF and the actual processing facility, nor the transport of the transformed product (i.e. biogas or compost) to the next user. In the case of Costa Mesa, the MRF is located 15 miles away in the city of Stanton where the organics are further sorted and prepared for shipment to the anaerobic digester (AD) in Perris, CA. The additional truck traffic between the MRF and the AD facility is in the form of long-haul semis that currently lack the green upgrades of the local collection fleet.

Evaluating the impact of OCPs and their processing from a systems-thinking approach also demands an understanding of the historical context for communities at the site of the new processing facilities. Were communities already developed at or near the site, if so what role did they play in site selection? What processes are in place and what efforts were undertaken to ensure that implementing "green" policy for one community does not shift additional negative

externalities onto other communities? What criteria are considered or ignored in the decision to choose one processing method over another (e.g. compost, anaerobic digestion, or incineration), or one scale over another (e.g. community, municipal, or regional)? How do these decisions (re)produce particular industrial practices and obstruct others?

For instance, does anaerobic digestion necessarily lead to more sustainable industrial practices, or does the incorporation of biogas result in more incremental changes in industries that would otherwise face major transformations under new environmental regulations? Does the decision to support compost processing lead to more sustainable agricultural practices in the region by displacing synthetic fertilizers compared to AD? In beginning to answer some of these questions, future research can help cities decide what course of action can reduce the social and environmental impact of the urban by taking a systems-level understanding.

There is currently growing interest in understanding the nexus of food, energy, and water systems at the NSF and elsewhere. From a systems-thinking approach this is a necessary next step in understanding the impacts of changes made to one system (e.g. food) on elements of other parts of the same system and even on other systems (e.g. energy and water). Some trans-boundary impacts have been detected and discussed in the current research. The processing facility used by Costa Mesa provides a key example of the intersection of these sectors. The AD facility generates biogas, some of which is being used to power water treatment plants. This approach simultaneously reduces methane from organics in landfills, displaces carbon-based fuel for collection fleets and water treatment plants, and reduces the demands on conventional stocks for clean drinking water. Additional research can illuminate new pathways for cities to achieve this trans-sector synergy by examining what contextual factors (e.g. regional climate, population density, existing infrastructure) shape optimal solutions for different regions.

At the international level, this research examined how the framing of the problem of organic waste has shaped the policy response. In the U.S., organics have been understood as a *risk* due to a context in which widespread open dumping led to leachate contaminating groundwater or methane entering the atmosphere. The response was characterized by high-tech sanitary landfills with tightened restrictions on landfill seals and methane capture. Future research should undertake a broader systematic review of countries that have adopted organics policy to improve our understanding of the relationship between problem-framing, policy response. This approach could potentially detect additional factors that influence policy responses such as stage in development, baseline environmental policy profile, and political and social culture.

### **Conclusion: Socio-Ecological Approaches to Environmental Problems**

The current research should not be misconstrued as claiming that OCPs are the only solution necessary to shift toward closed loop urban food metabolisms, nor should it be mistaken for identifying the individual as the source of environmental problems--or solutions. To the former point, emphasizing the clean capture of waste products so it can be re-circulated does not address the need to reduce consumption and waste in the first place. To the latter, the experiment herein attempts to engage both the supportive infrastructure and the social aspects of waste separation to transition to circular urban food metabolisms; this is in contrast to individualist approaches that assume deficits of knowledge or financial incentives or material .

**Reducing Consumption.** Recirculation alone will not address the environmental problems before us. Closed-loop urban food metabolisms must also prioritize reduced consumption and waste prevention as well as the recirculation of organic materials. "Per-capita growth in consumption is, for many resources, expanding eight to twelve times faster than population growth" (Princen, Maniates, & Conca, 2002, p. 4). This is true for a range of

materials including animal products, fibers, and water. Neither reuse nor recirculation, can absolve policy makers and industry of the responsibility to curb consumption. Yet resistance to these efforts is steep.

"governments, particularly those espousing a free-market orientation, have shown themselves to be quite reluctant to take any policy measures aimed at curbing consumption and thus industrial activity (Cohen, 2001). ... many governments quite genuinely believe in the importance of economic growth." (Schaefer & Crane, 2005, p. 88).

Indeed metrics of healthy national economies are tied explicitly to a 3% annual growth rate despite the fact that this standard is based on an exceptional period of economic growth in the post-war U.S. boom. Perpetual growth in a finite world has been deemed untenable by a litany of scholarship (Piketty, 2014; Princen, Maniates, & Conca, 2002; Mill, 1848). However, the concept of a steady-state economy (Mill, 1848) has yet to take hold in the global political-economy where the costs of extraction and production are kept artificially low<sup>66</sup>, the transnational commodity chains are increasingly out of reach of regulators, and new markets seem ever on the horizon.

This dissertation contributes to a body of literature that seeks to illuminate the social context of consumption (Princen, Maniates, & Conca, 2002; Schaefer & Crane, 2005) and disposal (Evans, 2014; Gregson, 2007; Hooper & McCarl Nielsen, 1991). The intervention experiment in Phase B brought otherwise private household practices of food waste management into the social domain by directly communicating the norms governing that behavior. Individual approaches, by contrast, construe the problem as one of insufficient knowledge or incentive.

"Consumer's choices are not isolated acts of rational decision-making...far from being autonomous exercises of power by sovereign consumers, such choices in modern political economies are heavily influenced by contextual social forces and subject to structural features that often make it convenient, rewarding, even necessary to increase consumption" (Princen, Maniates, & Conca, 2002)

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<sup>66</sup> by neglecting what would be a full-cost accounting to incorporate social and ecological costs of current practices.



Extending this understanding of structural forces to the phenomena of disposal, we see that individuals are navigating social contexts of disposal as much as consumption. Some scholars argue that the ease of disposal has encouraged consumption (Rogers, 2005). Indeed, the availability and ease of recycling has been shown to increase consumption of recyclable goods (Catlin & Wang, 2013).<sup>67</sup> The first municipal waste collection schemes are thought by some to have hastened the cultural shift away from values that reflected a "stewardship of objects" toward consumption patterns that value convenience, speed, and homogenization (Strasser, 1999). Rather than a natural evolution of consumer values, however, significant evidence suggests that industry provided kindling and regularly stoked the flames of the modern consumer (Rogers, 2005; Strasser, 1999; Conca, 2001; Schaefer & Crane, 2005; Dauvergne, 2008).

It seems that trash collection and recycling infrastructures may risk the encouragement of guilt-free disposal and even increased consumption. If curbside OCPs result in greater quantities of food waste, even into the appropriate bin, then the larger project of closing the loop on food systems for a healthy circulation of organic materials to nourish human bodies and fertile soil has failed. Recognizing the social context of consumption and disposal must accompany efforts to reduce consumption and redirect disposal.

**Engaging with Social Aspects of Waste Disposal.** The environmental movement, and so much environmental policy suffers from the logic of neoliberal economics that casts the most important role of the individual as a consumer, marginalizing their potential impact as a citizen (Redclift, 2012; Maniates, 2002). This is echoed by Maniates who is concerned with the individualization of responsibility for global climate change. Maniates conceptualizes the individualization of responsibility as:

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<sup>67</sup> Providing paper recycling infrastructure increased use of paper in the experiment (Catlin & Wang, 2013).

"[The] largely American response to the contemporary environmental crisis...[that] understands environmental degradation as the product of individual shortcomings... best countered by action that is staunchly individual and typically consumer based...It embraces the notion that knotty issues of consumption, consumerism, power, and responsibility can be resolved neatly and cleanly through enlightened, uncoordinated consumer choice." (Maniates, 2002, p. 45)

That sustainable systems, or sustainable development, could be achieved through "sustainable consumption" is the subject of intense criticism (Conca, 2001; Princen, 2002; Dauvergne, 2010; Redclift, 2012; Layzer, 2010) and is a position that serves the free-market ideology in two ways. First, individuals feel that they are meaningfully contributing to the environmental crisis by bringing their reusable bags to the grocery or recycling their plastic bottles. This perception pacifies; it reduces the perceived need for collective political action (Redclift, 2012; Conca, 2001). Meanwhile, the logic and the machine of endless economic growth that characterizes the global capitalist economy can continue unabated, with new green market niches greasing the rails. Now, a staggering amount of companies are ready to sell you the solution to the environmental problems we collectively face, and they will obligingly profit off the problem.

"Rather than necessitating expensive and comprehensive restructuring in new systems of provision, or even reduced volumes of production and consumption, [the] neoclassical view was that sustainability could be delivered through *increased* consumption of particular kinds of products, simultaneously" (Redclift, 2012, p. 167)

The second way that the misplaced goal of 'sustainable consumption' serves the narrative of the neoliberal economic paradigm is through the promotion of the "freedom of choice" ideal.

"The solution was to introduce more choice of products and services, new "Greener" technologies and market opportunities which could maximize utility while placing more responsibility on the individual" (Redclift, 2012, p. 169)

This narrative of the individual responsibility is reified by the "freedom of choice" and is thusly driven deeper into the social imagination (Redclift, 2012; Maniates, 2002). We cannot consume our way out of the environmental crisis before us. Yet environmental problems in general, and

waste problems in particular, have been increasingly characterized as technological problems. The solutions have followed suit. Indeed, Redclift (2012) argues that the role of political collective action to make change has been diminished by this technological emphasis.

"The challenges of reducing material throughput and reducing carbon emissions, converted environmental policy into a technical question, while the agency of social movements and their pursuit of alternative social and cultural objectives was effectively sidelined." (Redclift, 2012, p. 169)

This tech-emphasis cast the role of the individual as a consumer and reduced or even eliminated the role of the individual as part of a social force through collective action.

Dauvergne (2010) contends that in terms of the environmental degradation wrought by the global capitalist economy, the causal forces are not only imperceptible to most consumers, but "beyond the control of consumers". At the same time, Conca (2001) and others argue that the regulations to protect environmental and social systems are increasingly difficult to establish and enforce. This is in part because of global trends of trans-national commodity chains and capital fluidity (Conca, 2001). The latter enables the quick shifting of capital to new short-term contract locations (i.e. the Post-Fordism model), resulting in economic instability and relative political impotence over these practices in the manufacturing regions of the world (Conca, 2001). These trends:

"create new configurations of power and authority within global production systems---thus changing what is required to rein in the forces behind pollution and ecosystem degradation" (Conca, 2001, p. 62).

But others are optimistic. Vogel (1997) for example, suggests that there is reason to expect that the "California effect" is the ultimate outcome of this process. That is, when producers enter global markets, they raise their own human and environmental standards (especially where their entry is contingent upon it) and thus push for similar ascensions of other producers in their region.

Dauvergne (2010), Daigger (2009), and others argue that what is needed is a full-cost accounting where the cost of consumption reflects the socio-environmental impact of commodity life-cycles (and Swyngedouw would argue, of urban production). Dauvergne and others also point to the need to reduce economic inequities at local, national, and global scales; evoking the imbalances of power that distribute socio-environmental benefits and burdens at these same scales (Dauvergne, 2010; Dauvergne & Farias, 2012; Swyngedouw, 2006; Princen, 2002; Conca, 2001).

Taken together, this dissertation supports the literature of skepticism regarding the ability of "sustainable consumption" alone to bring about resilient, closed-loop urban food metabolisms, especially if pursued within a neoliberal framework of perpetual growth. The increasingly long and deep shadows of consumption impinge on the ability of nation-states to wield their historical economic and political power to reign in polluters and industrial-scale over-consumers. Solutions must come from a diversity of scales, sectors, and methods. Together, they must be oriented toward curbing rising per-capita consumption levels and work to transform the social aspects of consumption and disposal practices alongside infrastructural improvements in order to shift toward closed loop systems. The myth of consuming our way out of environmental problems must be understood as antithetical to the true nature of these problems and rejected as undermining the real power of individuals through collective action.

**Urban Household Metabolism.** In Chapter 4, I outlined a household metabolism model and in this chapter I discussed new research questions that this model illuminates. This model also demands we address more conceptual questions. When we are talking about household metabolism, who are the metabolizers and what are they doing that is metabolizing? Metabolizing is transforming; at the household level it is processing, transporting, moving, it is

chopping, blanching, burning, it is sharing, sorting, disposing. Labor, even unpaid and under-appreciated labor that occurs in the household is part of metabolic processes that transform nature and human effort into more than the sum of its parts (and in the case of capitalist economies, commodities).

The form and function of this labor emerges through particular socio-ecological relationships, but the motivation for this labor originates outside direct market forces. The householder is not driven by market forces to eat a meal, to prepare it. The householder has no "natural" incentive to separate food waste from recyclables. Certainly the realities of the market and the householder's relative status therein support and constrain the "choice situations" (Vlek & Steg, 2007) before the householder. While market forces may shape the content and the form of the food being prepared, eaten, and discarded, it is not the impetus for it. Householders pursue the daily rituals of transforming food into bodily energy and matter as a matter of survival. Before class-based conspicuous consumption, before social engagements, before cultural traditions, food is a matter of life and death; but we cannot ignore the social context in which food passes into, through, and out of households.

This dissertation, in part, answers the call of urban political ecologists to consider that society and nature are inter-constitutive. Previous urban metabolism scholarship "fails to theorize the process of urbanization as a social process of transforming and reconfiguring nature" (Swyngedouw, 2006, p. 33). The current project demands that households be conceptualized as engaged in this process of (re)producing the urban. Households are the site of transformation of food material into nourishment (i.e. bodily energy and matter) and human waste, garbage, or feedstock for compost and biogas. Through their adoption, resistance, or innovation in municipal

programs that link the household with larger municipal material flows, householders actively take part in urban metabolism, and so the (re-)making of the urban.

Households must be conceptualized as active metabolizers in urban systems despite having received scant attention in the urban metabolism literature as a collective unit of analysis. Much of the literature on urban metabolism instead focuses on macro-level metabolism. Urban metabolism frameworks from political ecology, engineering, and planning focuses on macro-level processes. F & F use an industrial ecological framework to examine urban metabolism. Here they engage ecological systems and industrial economies. Political ecologists have been found to adopt multiple, nested scales in their analysis of "how humans organize themselves to interact with nature" (Pincetl, Bunje, & Holmes, 2012). While these approaches deal with critical local, regional, and global political-economic influences, they ignore sub-governance levels of analysis. Those very actors whom local, regional, and global environmental policy has been identifying as "individually responsible" (Maniates, 2002; Ferrao & Fernandez, 2013) as "sustainable consumers" have yet to earn the spotlight of urban metabolic analysis.

The household is a relevant unit of urban metabolism as millions of households engage in food inputs, transformations, and outputs. These sites of metabolism are akin to industrial processes that were the focus of early urban metabolic thought. Household metabolisms link to larger systems of metabolism; the processes, infrastructures, and social arrangements of the micro-level have cascading effects to the macro and vice versa. The members of households are "doing", "placing", and transforming the energy and materials that enter, pass through, and exit a household through conduits that link to larger urban systems. In terms of inputs, householders link to larger food provision systems through national grocery chains or farmer's markets. In terms of outputs, performances of resistance to supportive urban infrastructure for closed loop

food systems (e.g. curbside OCPs) create blockage that reduces circulation of nutrients by sending food waste to landfills. Across the country there are hundreds of millions of nodes in the household metabolic network. Together, they are critical sites of metabolism within urban systems, and householders are critical metabolizers, yet there remains no place for them at the table of urban metabolic thought.

I have endeavored to make clear to the reader that the crucial circulation as discussed in this dissertation pertains to a human-scale circulation. When I argue for circular urban food systems, I recognize that given enough time, all human-made landfills and the materials therein will decompose and even if they radically alter ecosystems as we know them today, they will be doing so in a system that is circular on a geological scale. The earth at the most macro-level is a circular system (save the input of energy from the sun). The replenishment and regeneration of material inputs and the absorption and recovery of material outputs must occur within a time frame that is manageable within the ecosystems that support human life.

Cities can change the flow of urban food without changing the hearts and minds of the entire population. This is promising for significant, potentially immediate gains to be made in reducing the environmental impact of urban food systems by providing supportive infrastructure for those who already see a benefit to food waste separation, and using norm communication to encourage others who are not yet sold on the environmental crisis. These are changes that can and indeed need to be made, even if as a stop-gap measure (Dietz, Gardner, Gilligan, Stern, & Vandenberg, 2009). But these changes alone will not be enough to create circular food systems that support the ecosystems giving rise to human flourishing. To achieve this may demand a more fundamental shift in socio-ecological relationships, one that eschews market-based priorities over those that are life-supporting.

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## Appendix A: Constructs and Scale Items.

The table below presents Questionnaire items used for each construct, including the mean, standard deviation, and item-total covariance (rpbis) for all. Cronbach's  $\alpha$ , mean and standard deviation is also reported for each construct at Time 1-3. All items were assessed on a 5-point Likert scale; where necessary, items were reverse coded such that higher values correspond with stronger agreement with the statement. (n=363)

Items per construct	Time 1			Time 2			Time 3		
	M	SD	rpbis	M	SD	rpbis	M	SD	rpbis
<i>Environmental Concern (N =6) Cronbach's <math>\alpha_1=.66</math>; <math>\alpha_2=.69</math>; <math>\alpha_3=.67</math></i>	3.84	0.73	na	3.94	0.75	na	3.93	0.72	na
Modifying the environment for human use seldom causes serious problems.†	3.92	1.24	0.32	3.94	1.25	0.37	3.92	1.25	0.37
The balance of nature is delicate and easily upset.	4.00	1.07	0.31	4.02	1.16	0.36	3.96	1.16	0.34
Plants and animals exist primarily to be used by humans.†	3.71	1.24	0.31	3.77	1.24	0.37	3.68	1.24	0.35
There are limits to economic growth even for developed countries like ours.	3.73	1.23	0.34	3.69	1.20	0.42	3.81	1.20	0.37
Despite our special abilities, humans are still subject to the laws of nature.	4.50	0.73	0.40	4.45	0.85	0.47	4.46	0.85	0.40
The so-called 'ecological crisis' facing human kind has been greatly exaggerated.†	3.69	1.28	0.26	3.79	1.28	0.32	3.73	1.28	0.26
<i>Perceived Control (N =3) Cronbach's <math>\alpha_1=.60</math>; <math>\alpha_2=.53</math>; <math>\alpha_3=.72</math></i>	3.84	0.88	na	3.96	0.88	na	4.09	0.96	na
For me, to separate food waste at home would be an easy task.	3.74	1.21	0.31	3.80	1.27	0.26	3.84	1.27	0.60
If I wanted to, I could separate food waste at home.	4.23	0.94	0.31	4.27	1.04	0.22	4.38	1.04	0.51
The decision to separate food waste from the regular trash is completely up to me.	3.55	1.38	0.73	3.81	1.37	0.75	4.09	1.37	0.78
<i>Subjective Norms<sup>a</sup> (N =4) Cronbach's <math>\alpha_1=.87</math>; <math>\alpha_2=.88</math>; <math>\alpha_3=.87</math></i>	3.37	0.80	na	3.03	0.82	na	3.11	0.82	na
I believe that most of my FRIENDS will separate organic waste	3.42	0.94	0.55	2.92	1.00	0.57	3.03	0.99	0.59
I believe that most of my NEIGHBORS will separate organic waste	3.20	0.94	0.56	3.03	1.02	0.59	3.13	1.02	0.58
My FRIENDS would think that I should separate organic waste	3.49	0.95	0.56	3.06	0.88	0.60	3.11	0.90	0.59
My NEIGHBORS would think that I should separate organic waste	3.38	0.92	0.55	3.11	0.93	0.61	3.16	0.95	0.60
<i>Attitude toward Separation (N =4) Cronbach's <math>\alpha_1=.71</math>; <math>\alpha_2=.74</math>; <math>\alpha_3=.88</math></i>	3.89	0.97	na	4.03	0.94	na	4.22	0.92	na
Separating organic waste will have NO effect on the environment. <sup>b</sup> †	3.82	1.22	0.99	3.92	1.18	1.07	4.06	1.08	0.71
I support the curbside organic waste program in Costa Mesa. <sup>c</sup>	na	na	na	na	na	na	4.31	1.06	0.99
Curbside organic waste programs should be promoted to other cities.	3.83	1.24	0.56	4.03	1.17	0.42	4.25	1.07	0.65
I believe that separating organic waste at home, including food scraps, is the right thing to do.	4.02	1.17	0.45	4.15	1.14	0.49	4.28	1.08	0.66

† Item was reverse coded.

<sup>a</sup> Original question text ended with: "including food scraps into the new green curbside bin."

<sup>b</sup> Original question text specified "Separating organic waste into the new curbside organics bins..."

<sup>c</sup> Question was only available in Time 3 Survey.

## Appendix B: Socio-Economic Characteristics.

The table below presents descriptive statistics for the Final Sample, Attrition, and Costa Mesa populations. Final Sample includes only those who completed all three surveys. Attrition population includes those missing surveys or responses to questions used in the analysis.

	Final Sample (n=363)	Attrition Population <sup>1</sup> (n=721)	Costa Mesa <sup>2</sup> (n=86,278)
Female	67.3	65.8	49.1
<i>Age</i>			
18-24 years	1.6	2.7	14.9
25-29 years	1.6	2.3	13.0
30-34 years	7.9	6.6	11.4
35-39 years	7.7	9.6	10.3
40-44 years	6.0	7.3	9.6
45-49 years	7.1	8.3	9.1
50-54 years	7.9	10.5	8.2
55-59 years	13.7	13.4	6.6
60-64 years	16.9	9.8	5.1
65+ years	29.5	29.5	11.7
<i>Race and Ethnicity</i> <sup>3</sup>			
Hispanic or Latino	5.7	3.2	35.8
White	66.7	75.0	16.7
Black	0.0	0.0	0.3
American Indian	0.0	0.0	0.4
Asian	0.0	0.0	0.2
Pacific Islander	0.0	0.0	0.0
Other or >1 races	22.2	25.0	18.3
Not Hispanic or Latino	89.7	86.3	64.2
White	86.3	86.9	51.8
Black	0.3	0.0	1.2
American Indian	0.6	0.0	0.2
Asian	7.0	7.5	7.7
Pacific Islander	0.0	0.0	0.4
Other or >1 races	2.4	4.7	2.7
<i>Education</i>			
< High school	0.0	0.8	14.7
High school	4.7	0.8	19.8
Some college	20.2	20.5	23.3
Associate's	14.9	12.3	11.7
Bachelor's	36.5	36.1	21.6
> Bachelor's	23.8	29.5	8.9
Household size (mean)	2.6	2.7	2.7
Children Present	25.5	26.2	30.8

<sup>1</sup> Non-response varied by demographic survey item. Percentages for "Attrition population" reflect percent of respondents who answered the question. Population sizes for "Attrition population" are as follows. Female= 691; Age= 696; Race and Ethnicity= 124; Education= 122; Household & Children= 126. A significant portion of the baseline sample did not answer the Race and Ethnicity questions or the subsequent Education question. Household size and Children Present questions were only asked in the Post-Program (2nd) survey, so if participants did not complete the second survey, they could not answer this question.

<sup>2</sup> Residents of Costa Mesa, CA aged 18 and over based on 2010 US Census data. Education and household size characteristics are based on the 2006-2010 American Community Survey estimates. Race and ethnicity data are based on n= 109,960 residents in 2010 Census, no age-based race and ethnicity data could be located. Household size and Children Present data are based on n=39,946 households in 2010 Census.

<sup>3</sup> Actual questionnaire response options coincide with U.S. Census categories: White, Black or African American, American Indian and Alaskan Native, Asian, Native Hawaiian and Other Pacific Islanders, Some other race, and Two or more races.