URBAN AGRICULTURE STORMWATER MANAGEMENT IN CALIFORNIA CITIES

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ABSTRACT

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Rachel Cohen

Cities within California are beginning to incorporate urban agriculture into their land use designations. Prompted by residents and local organizations, cities are hoping to capture the benefits that urban agriculture provides. Research has shown that urban agriculture renews and beautifies neighborhoods, provides healthy food choices, increases public health, has the potential to help with stormwater runoff, creates jobs, and fosters community. In the last few years, several California cities have made headlines as they have adopted new zoning codes that include urban agriculture.

In reviewing these new zoning codes and exploring the topic of urban agriculture, it became evident that just because an urban farm was small, organic and provided certain benefits that it was not free from impacting its surroundings. As more urban agricultural ventures are established within cities, planners have to carefully consider their effect. One such impact could be stormwater pollution. There is insufficient research to determine whether there is a relationship between urban agriculture and stormwater, however, studies on conventional agriculture and urban landscaping (mainly urban lawns) show that each of these areas pollute the local water bodies with sediment, chemicals, and nutrients. Is urban agriculture different?

This thesis utilizes two case studies within California, the City of Oakland and the City of San Diego, to examine the similarities and differences between each city's urban agriculture ordinances and evaluate whether or not the cities have adjusted stormwater requirements in parallel with these ordinances. Interview responses and site visits in each city were analyzed and compared to expound upon the approaches each city engaged. Using the collected data and analysis as a base, a set of guidelines was created for managing stormwater runoff from urban agriculture.

Keywords: Urban Agriculture, Stormwater runoff, Best Management Practices, City of Oakland, City of San Diego.

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“We can be joyful while we’re trying to change the world. As long we we’re also aware that you can’t get away with things just by doing the easy stuff. You actually have to challenge certain things and put yourself in uncomfortable positions, often risking things in order to achieve real change.”

−Antonio Roman-Alcala, Farmer/Activist of Alemany Farm, San Francisco, CA

Urban agriculture has gained resurgence in popularity in communities throughout the United States. Urban agriculture is not an unfamiliar to many cities, with many of the first community gardens being formed in the 1890s and truly took hold as people created Victory Gardens during World War I (Lawson, 2005; Bentley, 1998). Since World War I, urban agriculture has continued to rise and fall in popularity with varying economic and health issues of the urban community. During the last 10 to 15 years, urban agriculture has gained heightened attention as residents have secured vacant lots and turned them into productive spaces within the city (Hodgson, Campbell & Bailkey. 2011). With more demand for garden and farm space within the city, planners have had to reassess how urban agriculture can be integrated into the city and consider the impacts it will have.

Urban agriculture provides multiple benefits for the city and its residents. Farms and gardens provide produce to the local community, beautify the city, improve stormwater management and air quality, moderate temperature, improve diets among lower income populations, and create greater community protection and control over troubled parts of the city (Flisram, Haller & Groc, 2009). Additionally, urban agriculture has the potential to improve the city by providing education, provides children and teens with alternative activities, creates jobs, encourages community building, increases property values, and diversifies land use (Flisram et al., 2009, Lawson, 2005, personal observation). In 1991, a USDA report estimated that 33 percent of the 2 million farms in the United States were located in metropolitan areas and made up 35 percent of the total produce and livestock sales nationwide (Brown & Jameton, 2000). What percentage of urban agriculture makes up today is unknown.

The benefits that recommend urban agriculture also leave room for concerns. Urban agriculture touts multiple benefits and, in much of the literature, is viewed as a use that will only make the city better, more resilient and sustainable. Yet there are some that challenge the notion that local food systems are inherently good. Just because an urban farm is small, local, and provides certain benefits does not mean that it will automatically be sustainable, just, or secure food for those that do not have it (Born & Purcell, 2006). Further planners have to consider impacts that urban agriculture has the potential to create such as vermin infestation, soil contamination from products and materials used by the farmers, air quality issues from exposed soil and a potential increase in dust particulate in the air, or impacts on local watersheds through the improper management of stormwater runoff.

The State of California, in particular, is concerned with protecting water sources from stormwater runoff pollution. In 2011, the EPA finalized the list of rivers, streams and lakes of California that exhibited toxicity and found an increase of 170 percent since 2006 (California Coastal Keeper Alliance, n.d.). The 2010 California Water Quality

Control Board listed 11 pollutant categories: hydromodification, metals/metalloids, miscellaneous, nutrients, other organics, pathogens, pesticides, salinity, sediment, toxicity, and trash (2013). Approximately 19 percent of the pollutants found in California's water bodies were attributed to agriculture; about 12 percent to urban runoff and 37 percent were classified as coming from an unknown or unspecified point source (California Water Quality Control Board, 2013). How urban agriculture fits into this picture is not clear, as there is very little literature or research on the topic. In theory, urban agriculture is a combination of agriculture and urban environment and faces the same stormwater runoff concerns that plague these respective areas.

Depending on how urban agriculture is implemented in the urban environment it could be used to minimize runoff and improve a city's overall urban stormwater management program or contribute contaminants into local receiving bodies. Unlike other projects, urban agriculture is not built and then left alone. The ground is turned, plants grow, die and then are replanted, and compost is made and applied to the ground, the process is continual and never stops changing. Whether organic or not, agriculture is in the business of growing plants and in order for plants to grow, they need food. Their food consists of nutrients high in nitrogen, potassium, and phosphorous as well as numerous other micronutrients. The raising of livestock within the city further adds to concentrated nutrient and pathogen sources. Thus the combination of loose soil, elevated nutrient levels, pathogens and a heavy rainstorm has the potential to be disastrous, allowing sediment, fertilizers, and pathogens to reach rivers, creeks and the ocean. By anticipating the problem before it happens, planners can create a set of best manage practices and regulations for urban agriculture that removes the possibility of negative impacts on the local watershed.

The objective of this thesis is to examine the similarities and differences between two California cities' urban agriculture ordinances and evaluate whether or not the cities have adjusted stormwater requirements in parallel with these ordinances. Based on the findings of this research, this paper will propose a set of guidelines for managing the stormwater runoff of urban agriculture.

II. Definitions

Agriculture is a broad title for the cultivation of plants, animals, fungi or other life forms for the survival and enhancement of human life. For the purposes of this thesis, agriculture is classified as one of two kinds: urban or conventional.

Urban Agriculture

Urban agriculture, as defined by the Community Food Security Coalition, "refers to the production, distribution, and marketing of food and other products within the cores of metropolitan areas (comprising community and school gardens; backyard and rooftop horticulture; and innovative food production methods that maximize production in a small area)" (as cited in Hodgson, Campbell, & Bailkey, 2011, p. 14). Urban agriculture projects can vary in their size, location and intensity of production, the manner in which it is carried out (hydroponics or row crops) and even vary in what they are raising (plants, animals, etc.). Those who run and manage urban agriculture include non-profit, for profit, or individuals with access to large or small-scale sites within a city. Large urban agriculture sites may seem large within the urban context, but are smaller than land farmed conventionally. Urban agriculture can be further categorized into three groups: noncommercial, commercial and hybrid. Noncommercial tends to be demonstration type urban agriculture, used mainly for education and awareness. Commercial urban agriculture is focused on selling and processing their products in order to make a profit. And the last group, hybrid, is a combination of both noncommercial and commercial.

Hybrid urban agriculture is more of a "social enterprise" that combines both marketing and educational activities into their projects (Hodgson et al., 2011). Due to access and availability, examples used in this paper are classified as hybrid urban agriculture.

Urban agriculture does not follow a set of general standards or practices that mandate any particular methods of farming, unless specifically regulated by a municipality. Typically urban farmers strive to farm sustainability, paying attention to water conservation, limited or no use of pesticides and the use of compost or other non-chemical fertilizers. Some sites are certified organic, whereas others choose to farm as close to organic as they can in order to provide chemical free produce for their customers (personal observation). Methods such as the use of mulch, raised beds, drip irrigation, and the making of compost are used in urban agriculture to meet this objective.

Conventional Agriculture

Conventional or industrial agriculture is defined by Knorr and Watkins as, "Capital-intensive, large-scale, highly mechanized agriculture with monocultures of crops and extensive use of artificial fertilizers, herbicides and pesticides, with intensive animal husbandry" (as cited in Beus & Dunlap, 1990, p. 594). What is considered conventional agriculture today arose during the industrial revolution with the invention and development of synthetic fertilizers, pesticides and herbicides (Harrington, 2012). Conventional farming is made up land that contains fields of wheat, acres of vineyards, pastures of cattle and row crops of vegetables managed by fieldworkers and machinery. This term is used very broadly in this paper and not intended to say all conventional agriculture is the same, but overall as a group it is considered to be different from urban agriculture.

III. History of Urban Agriculture

Agriculture has long been at the heart of modern civilization. Not too long ago, settlers of the United States created towns and villages based on where they were farming. As these areas grew and expanded, space for farming diminished. Land within the city became much more valuable as a space for new homes and places of work as the population grew. The advent of the industrial revolution also contributed to a shift in where agricultural production occurred. As it became easier to store and ship agricultural products, farms could exist further from urbanized areas. However, as time has passed, agriculture is finding a place back within the city.

Late 19th Century and Early 20th Century

The early rural life of the United States changed dramatically with the arrival of the Industrial Revolution in the late 19th century. Cities' population grew as immigrants and rural residents moved to the city to find work at many of the factories. To counter the filth and overcrowding, the City Beautiful movement introduced urban gardens into vacant lots and promoted home gardening (Lawson, 2005; Loukaitou-Sideris & Banerjee, 1998). Civic organizations facilitated activities around gardening, raised money through memberships and fundraisers to build and design gardens to improve the city surroundings and provide food and education for the poor (Lawson, 2005). Around this same time, Patrick Geddes' philosophy of regional planning intersected with city planning. This method focused on creating more sustainable living centers that acknowledged the importance of incorporating both urban and rustic elements, such as urban agriculture (Hall, 2002, p. 153). Unfortunately, the interest in these garden based cities never caught on (Lawson, 2005; Foglesong, 1986).

Periods of Depression

The focus on regional planning diminished as the United States moved through several periods of economic depression leading to severe poverty among a large percentage of the cities' populations. Cities around the country looked to urban farming as a way to help the poor help themselves. Pingree's Potato Patches of Detroit is one such example. Using his own money, Mayor Haze S. Pingree in 1894 started gardens in the Detroit's vacant lots to raise food for the residents of his City (Lawson, 2005). Along with providing food, programs like these provided hope, self respect, self reliance, exposure to the outside and exercise (Basset, 1981; "History of Urban Agriculture," 2008).

Urban farming during Great Depression of the 1930s mimicked the relief gardens of the early 20th century. These gardens once again provided food for individuals and families across the nation as people struggled find sufficient food to survive day to day. These urban gardens disappeared as the economy began to improve and the government shifted its resources towards New Deal Programs and vacant land (where most of the gardens were planted) became too valuable to donate to the poor (Lawson, 2005). The urban gardens had made a significant impact on the survival, nutrition, health and society of the city.

War

In 1914 World War I broke out and the United States became the main supplier of food for the allied forces, increasing food costs for Americans living in the United States. Unlike prior times of economic depression, the short supply of food affected the lives of everyone (Lawson, 2005). Propaganda was used to support urban agriculture. Campaigns promoted gardening as a means to a healthier lifestyle and way to support the war effort (Figure 1). People were excited to start gardening (Bentley, 1998) and turned any little space in the city into a garden. It was an opportunity to use land that was not otherwise being used in the city for a purpose that would benefit all (Lawson, 2005). The "war gardens," later named "Victory Gardens," (after the Allies had won the war (Bentley, 1998, p.117; Lawson, 2005, p.140)) were established all across the nation and provided food for 51 percent of the country's population (Lawson, 2005).

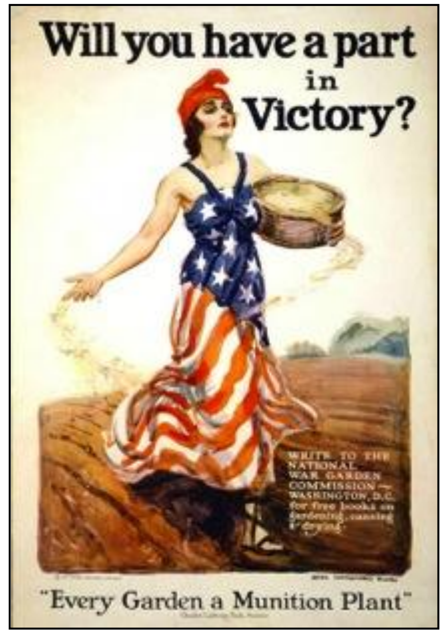

Figure 1: Propaganda from WWI

Source: ***http://www.ww1propaganda.com***

After the attack on Pearl Harbor and the start of the United States' involvement in World War II, the government began an intense campaign to start victory gardens once again. Urban farming "reached its peak in 1943, when three-fifths of the population produced more than 8 million tons of food, some 40 percent of the fresh produce consumed that year" (Bentley, 1998, p. 117).

By the 1930s and 40s, zoning began to impact victory gardens and the future of urban farming. "One Maryland farmer wrote FDR, complaining that he could not raise seedlings for victory gardens because of local zoning laws" (Bentley, 1998, p. 121). However, many cities continued to welcome urban gardens and encouraged them as a means to facilitate better and healthier communities (Lawson, 2005).

1940s-1990s

After the Second World War, the country headed into a time of rapid economic growth. During this time, the need and interest in urban farming dwindled. Although some cities like Washington D.C., New York and Boston found ways to integrate the victory gardens into existing parks and open space, most victory gardens disappeared. As soldiers returned from the war they bought homes outside the urban core. This departure contributed to a decline and deterioration within cities across the nation, increasing significantly the number of vacant lots and condemned buildings during the 1960s and 70s. The ugliness and destitution of the situation stimulated a civic desire to find ways to make these areas useful and beautiful (Lawson, 2005).

Renewal projects allowed for urban agriculture to flourish in the city once again. Cities began initiatives to clean up the vacant lots and tear down old buildings to make way for new buildings. While construction was delayed or halted, urban agriculture was encouraged to use the space (Flisram et al., 2009; Kaufman & Bailkey, 2000; Lawson, 2005). The desire to farm was further fueled, in the 1960's, by Rachel Carson's book *Silent Spring*. People throughout the country began to question the impact their lifestyle was having on the environment, especially in the use of pesticides and herbicides in agriculture (Lawson, 2005). Local activism formed to address these issues and inspired people to become more self-reliant (Lawson, 2005; Brown & Jameton, 2000) and "furnished motivation and rationale for local growth-control efforts" (Levy, 2005, p. 56).

Individuals and groups continued to develop more gardens in empty lots from the 1970's to the 1990s until concerns arose over high levels of contamination, safety, and property value. Lead paint chips, runoff from paved roads and air pollution were found to be contaminating the soil of many urban garden sites. Although many of these impacts could be mitigated, urban farmers began to question whether the city was the right place to grow food (Lawson, 2005). Theft and vandalism also diminished the desire to farm. Many sites installed fences and security, which changed the dynamics and intent of an open, community garden space (Lawson, 2005). In California, Proposition 13, which decreased property taxes and restricted annual increases of assessed value, further reduced urban agriculture's ability to find a home in the city. Land housing development furnished the city with more income than an urban farm (Bassett, 1981).

Current State of Urban Agriculture in California

Urban agriculture is making a comeback again, and unlike prior times of popularity, cities are making long-term changes that will maintain urban agriculture as a common fixture in the city. Most changes have come in the form of updated or modified zoning laws or ordinances that allow residents the ability to raise and sell produce and livestock within the city. Activists, residents, city officials and even some entrepreneurs, are the biggest promoters and supporters of these changes (Hagey, 2012, McClintock, 2012, Ogul, 2012, Romney, 2011).

Urban agriculture is fairly new to the state of California, where for centuries land within the State has been dedicated to conventional agriculture. Since the mid 1800s, California has been in the business of agriculture. The unique climate of the State supported different varieties of crops than those grown in the Midwest and “between 1859 and 1929, the number of farms increased about 700 percent” (Olmstead & Rhode, 2003).   Between 1988 and 2000 California saw 549,000 acres of farmland converted to urban uses. With this same rate of conversion and a steady increase in the population of California, some 4.2 million acres would be converted in the next 100 years (Sumner, Bervejillo, & Kuminoff, 2003). This change in land use is apparent, as observed in Southern California as citrus groves turned into housing tracts.

As California farmland converts to urban uses, small pieces of the urban landscape are being reverted back to agriculture. There are no records that indicate when urban agriculture started in California. Yet recently (within the last 5 years) urban agriculture has gained renewed interest in the state as concerns rise over fresh produce availability and accessibility, health issues (largely obesity) and climate change. In response to these concerns, some California cities and the state are re-envisioning how agricultural projects could fit into the urban environment and act as part of the solution to these problems. Change has mainly stemmed from community members who want the ability to grow local food for themselves and others close to home. “The urban farming movement is driven by people’s craving for a connection to their food source and for more affordable organic fare,” said San Francisco Urban Agriculture Alliance co-coordinator Eli Zigas, and it “is forcing cities to think about how to bring back activities that we pushed out of cities a long time ago”” (Romney, 2011, p. 1). At the state level, California Assemblyman Phil Ting has proposed the Urban Agriculture Incentive Zones Act (or AB 551). "Property owners who commit to leasing their land to agricultural enterprises for at least 10 years will be able to receive a re-valuation of their parcels that will lower their property tax bill" (Mark, J, 2013). The act would allow counties of California to opt in and apply the measures if they wanted to help urban farming in their county.

Throughout the last two centuries urban agriculture has played a role in the city landscape. Although its popularity and function have shifted and changed with the social and environmental issues of the time, urban agriculture persists. It seems logical from these historical observations, that cities and planners should be developing regulations that permit agriculture and related activities to exist and thrive in the city. How each city does this will depend on their community and urban agriculture's compatibility with other urban land uses.

IV. Case Studies

Urban agriculture is just getting on its feet in the state of California. Very few cities have had enough community support, funding, or incentives to pursue changes to their municipal code that would permit urban agriculture. Those cities that have decided to investigate and tackle the concept of urban agriculture, have had to balance the community's enthusiasm and support with how the use would best fit into the existing urban infrastructure.

This chapter presents a background on two case studies, the City of Oakland and the City of San Diego. The Cities of Oakland and San Diego within the last three years have adopted urban agricultural policies that allow more flexibility and use of urban land for farming. In both Oakland and San Diego, the combination of their respective histories, community needs, and the political atmosphere contributed to a change in the cities' policies. This section describes some of the reasons behind why each city adopted urban agriculture regulations and what those regulations allow.

Oakland

In 1852, with a population of 75, Oakland was incorporated into the state of California as a city (City of Oakland, 2002). The City grew quickly, often with intense disparity between the wealthy and the poor. This disparity formed along geographic as well as racial lines. Geographically, Oakland is divided between "the flatlands" and "the hills;" the more affluent residents residing in the hills. In the 1950s and 60s poverty increased in the flatlands in "the wake of deindustrialization and disinvestment" (McClintock, 2012, p. 2) and services, such as grocery stores, left the neighborhoods due to the diminished purchasing power of the residents. At the same time racial tensions grew as the flatlands became home to poorer, African American neighborhoods (McClintock, 2012). Such poverty and inequality led to the formation of many groups and organizations that sought and continue to seek the equal availability of resources for all those that live in the flatlands of Oakland.

Poverty within these neighborhoods was and is not only economic poverty, but also poverty of resources and, in the mid 2000s, many of these neighborhoods were deemed food deserts or lacked access to fresh produce. In 2006, the City of Oakland endorsed and supported the Mayor's Office of Sustainability to develop the Oakland Food Policy and Plan, which included a food assessment study of the City and the creation of the Oakland Food Policy Council (Oakland Food Policy Council, 2009; Hagey, 2012). The assessment was a turning point in the City's history to identify conditions in relation the food system in Oakland neighborhoods, but also put the city on track to meet its goal of becoming a more healthy and sustainable city.

Urban agriculture is a big part of meeting the goals of the Oakland Food Policy and Plan. One of the Mayor's objectives was reach a point where the City of Oakland sourced 30 percent of its food from within the city and immediate region (Hagey, 2012). Urban agriculture fulfills another goal by offering a means for lower income individuals and families to have more healthy choices of food closer to home when grocery stores are not located nearby. In order to support these goals, the City of Oakland was tasked to examine existing policies and present to City Council their recommended changes and modifications to the City's zoning regulations.

Oakland's Urban Agricultural Zoning Ordinance

On March 15, 2011, the City of Oakland adopted new residential and commercial zoning regulations, which allow the use of crop and animal raising agricultural activities with the approval of a conditional use permit. According to section 17.10.610 of the City of Oakland's Code of Ordinances, "Crop and Animal Raising Agricultural Activities include the raising of tree, vine, field, forage, and other plant crops, intended to provide food or fibers, as well as keeping, grazing, or feeding of animals for animal products, animal increase, or value increase. This classification also includes certain activities accessory to the above, as specified in Section 17.10.040" (2011, p.65). One such accessory activity is the ability to sell directly from the urban agriculture site, "Sale of goods on the same lot as a principal Civic Activity, but only if such goods are available only to persons participating in the principal activity" (City of Oakland, Section 17.10.040.E., p. 36). This means that only those growing the "goods," or produce, in the case of urban agriculture, are able to sell from the site.

Upon the approval of a conditional use permit the applicant must also meet the criteria of Section 17.134.050 of the Code of Ordinances (City of Oakland, 2011, p.85):

> 1. The proposal will not adversely affect the livability or appropriate development of abutting properties and the surrounding neighborhood in terms of noise, water and pesticide runoff, farming equipment operation, hours of operation, odor, security, and vehicular traffic;

2. Agricultural chemicals or pesticides will not impact abutting properties or the surrounding neighborhood; and

3. The soil used in growing does not contain any harmful contaminants and the activity will not create contaminated soil.

Additionally, the City Council approved an amendment to Chapter 17.112 of the Code of Ordinances to allow crop growing as a home occupation. The previous code only approved of home occupations that actually occurred inside the home. This precluded individuals who sought to grow crops as part of their home occupation. The new code states that non-mechanized farming is an allowable home occupation.

Currently, the City of Oakland is working on regulations regarding animal husbandry. Recommendations regarding animals will be made to City Council in the City's urban agricultural comprehensive update, which will implement policies and actions in the Open Space and Conservation Element of the General Plan and the Draft Energy and Climate Action Plan (City of Oakland, 2013). The city continues to get mixed public feedback on having livestock as part of urban agriculture. Generally, the community is supportive of having livestock, but there is an apprehension among some about raising livestock in the City for meat.

San Diego

San Diego was incorporated as a city in 1850, two years after the United States signed the Treaty of Guadalupe Hidalgo, which ended the U.S. war with Mexico (San Diego History Center, n.d.). By the end of the Vietnam War in 1975, San Diego had become home to thousands of Vietnamese and Cambodian refugees (Luna, n.d.). In the years that followed, San Diego received an estimated 90,000 to 150,000 refugees from different countries. According to the San Diego Refugee Forum, the City's "well-established refugee community may make it easier for newly resettled people to adapt to their new life in the United States" (Barraza, 2011, 10th paragraph).

In an effort to ease transition and offer support to refugees, the International Rescue Committee (IRC) developed several programs, one of which allows participants an opportunity to farm. The climate of San Diego provides the opportunity for many refugees to grow vegetables from their home countries and allows them the ability to sell their produce at a local farmer's markets for additional income.

> "New Roots Community Farm finally opened after years of delays, but only after organizers, led by the International Rescue Committee's San Diego office, paid some $40,000 in fees, filled out reams of paperwork and navigated a maze of regulations. Its success was marked by a 2010 visit from First Lady Michelle Obama and extensive media coverage that included a story in The New York Times. The co-op now has more than 80 growers, many of them from East Africa and Vietnam" (Ogul, 2012, p. 1).

The struggle IRC faced in establishing New Roots Community Farm spurred the community to entreat the City of San Diego to re-examine restrictions on urban agriculture.

San Diego's Urban Agricultural Ordinance

With the community seeking more flexibility in urban agriculture, the City of San Diego sought opportunities to make changes. The City applied for and was awarded a grant of $50,000 from SANDAG (San Diego Association of Governments), on behalf of the County of San Diego Health and Human Services Agency, to combat the rise of obesity in the San Diego region. Funding was given to support the planning of communities that sought to increase physical activity and access to healthy foods. The San Diego City Council requested that the City review the subject of urban agriculture and propose amendments to the Municipal Code that would support the goal of "increasing access to healthy, local and sustainable food by expanding the opportunities for community gardens." (City of San Diego, 2012, p.1).

On February 22, 2012 San Diego City Council adopted Ordinances number 0-20137, 0-20138, 0-20139, 0-20140, and 0-21041 to minimize restrictions on urban agriculture. The new ordinances divided urban agriculture into two categories: Community Gardens and Retail Farms. Community gardens "are premises that are used for crop cultivation by individuals or collectively, and may be divided into multiple plots" (City of San Diego, 2012, Chapter 14, Article1, Division 2, §141.0203). "Retail farms are establishments whose primary function is to produce and sell food and other related products on the same premises" (City of San Diego, 2012, Chapter 14, Article1, Division 5, Section §141.0505).

The new codes allow residents and businesses expanded opportunities to raise bees, rabbits, fowl, and goats within the City boundaries. Further, the Municipal Code has been amended to allow community gardens and retail farms in more locations. On-site sales of agricultural products are allowed in commercial and industrial zones, and may be permitted in residential zones one day a week with a use permit.

V. Water Quality

Managing water quality is a process that involves federal, state, and local involvement. At the state and local level agencies, strict stormwater standards keep receiving waters from incurring levels of pollutants that are toxic for the ecosystem and/or human uses such as recreation. Research has found that conventional agriculture and urban landscaping contribute sediment, nutrients, and metals into stormwater runoff, which have detrimental effects on aquatic species and has the potential to contaminate aquifers and wells (EPA, 2012; EPA, 2005; Cooper, 1993). Urban agriculture shares many similarities with conventional agriculture and urban landscaping. It is therefore assumed that it will contribute to stormwater pollution.

NPDES Permits and Stormwater Management

California established the State Water Resources Control Board (SWRCB) to manage water quality, use and protection in 1967. Regional Water Boards were created to work in different regions throughout the state and work with all the cities and counties that reside in their region. In 1972 the United States established the Clean Water Act with the goal to eliminate water pollution and in 1987 created the Water Quality Act to address the quality of drinking water sources. The U.S. Environmental Protection Agency (EPA) is responsible for implementing and enforcing both of these Acts.

The National Pollutant Discharge Elimination System (NPDES) was specifically developed by the EPA in 1972 to "control water pollution by regulating point sources that discharge pollutants into waters of the United States," such as from pipes or ditches (EPA, 2009, p.1). According to the EPA, urbanized areas must obtain a NPDES permit for their stormwater conveyance system (MS4). "Each regulated MS4 is required to develop and implement a stormwater management program (SWMP) to reduce the contamination of stormwater runoff and prohibit illicit discharges" (EPA, 2012, 3rd paragraph). The EPA recognized that managing urban stormwater directly impacted water quality and local aquatic ecosystems.

Each city in California must comply with the State Water Resources Control Board's NPDES Permit. Cities must rely on others in the community, such as those in industry, developers and residents, to meet their NPDES Permit requirements (EPA, 2012). This means that anyone who contributes anything besides plain water into the storm drains are putting the city at risk for non-compliance of their NPDES Permit. Because of this, industries that have the ability to add additional matter to stormwater runoff, like construction, are highly regulated to reduce their ability to pollute. Those businesses and industries that are regulated, can be fined heavily if found in violation of the law. As a result, best management practices (BMPs) have been developed to mitigate any impacts on stormwater runoff from certain businesses.

NPDES permit requirements set the framework and parameters for city planning and development in order to protect California's water. Planners play a large role in negotiating the balance between city growth and development with regulating water quality as they look at how land will be used and strategize ways to minimize the impacts on the local watershed. The main tool planners use to regulate city form and land use is through the general plan. The General Plan helps the city plan out how new projects will look and fit into the city while also making sure that these projects will meet the needs of the community. For example, a community may include a health element in their General Plan and list urban agriculture one of the ways to improve the health of the residents of a city. Zoning regulations are derived from goals set in the General Plan. Through zoning, planners are able to set guidelines that reduce risk and impact of different uses on one another. For example, a city could require that all development have a setback of 100 feet from any body of water, such as a creek or stream, to ensure that the water source remains protected from pollutants.

Impacts of Agriculture on Urban Runoff

Agriculture and urban landscaping both contribute to stormwater runoff and the associated pollutants. Agriculture is a means to cultivate plants and animals for consumption whereas landscaping is often used as a method to beautify an area or cover the bare ground. Chemical fertilizers and pesticides have provided a means to grow plants that are bigger, more vigorous, and can be protected from pests and diseases. These resources have made growing plants easier, but have also allowed agriculture sites and urban landscaping to contaminate local receiving waters, causing nonpoint source pollution. According to the EPA

> "nonpoint source pollution (NPS), unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even underground sources of drinking water" (EPA, 2012, highlighted box).

Pointing the finger at who exactly is contributing to NPS pollution is difficult;

however, extensive research has shown that both agriculture and urban landscaping, in particular home lawns, are significant contributors (EPA, 2005; Steinberg, 2006). Efforts to minimize agricultural nutrient pollution have come through a series of federal and state regulations. These include the Natural Resources Conservation Service (established by the USDA after the Dust Bowl), Clean air act (1970) and amendments (1977, 1990) and the CWA (1977, 1981, 1987) (Perez, 2010). There are yet any specific regulations for urban landscaping.

Agriculture, whether using conventional methods or intensive urban methods, has certain patterns and traits associated with its development and success that impact the local environment. As mentioned previously, plants and animals raised on a farm need certain conditions met in order for the farmer to gain a profitable harvest. One of the more necessary conditions is an availability of nutrients: nitrogen, phosphorus, potassium (NPK) and micronutrients. Animal manure or synthetic chemicals fertilizers are used to provide the necessary nutrients that plants need. Whether applying manure or synthetic fertilizer, over application can lead to environmental harm. Over application increases nitrate and phosphate levels that can contaminate receiving bodies of water and detrimentally impact numerous aquatic species. The use of manure has the potential to increase organic material in water sources and can contain veterinary/pharmaceutical compounds or pathogenic organisms. These contaminates are especially dangerous if found in drinking water (Delpla, Baurès, Jung, & Thomas, 2011; Chantigny, 2003; Sharlpley & Smith, 1995). The US EPA assessed various rivers throughout the US and determined that agriculture has impaired 48% of these water bodies by contributing to increased nutrients, siltation, metals and pathogens (EPA, 2003).

Urban landscaping, more recently, has been targeted as a contributor to degrading water quality in its use of fertilizers and pesticides. Lawns make up almost 50,000 acres in the United States (De Chant. 2011). Law, Band, & Grove determined that some of the highest rates of nitrate rich runoff were from properties in the process of establishing a new or redeveloping old lawns (2004). There has been concern in some cities that as the urban environment expands, so will the use of pesticides and fertilizers and many states and cities are exploring ways to mandate a decrease in their use (Lehman, Bell, & McDonald, 2009; Law et al, 2004). Often lawns are cited as a sink or a place that will absorb much of the water that flows over the impervious nature of the urban environment. However, some studies have shown that lawns may be too compacted or disturbed to rapidly absorb stormwater. With less absorption, fertilizers and pesticides are more likely to be flushed from the lawns and into stormwater collection drains (Kelling & Peterson, 1974).

Urban agriculture is a combination of agriculture and urban landscaping. Like conventional agriculture, urban agriculture relies heavily on nutrients to raise healthy, vigorous plants. Urban agriculture also faces the challenges of urban landscaping, mainly dealing with the impervious nature of the surrounding environment. Urban agriculture runoff is likely to be channeled directly to a city stormwater street drain or management system, taking nutrient and sediment rich water directly to local creeks, rivers, and the ocean.

Impact of Agricultural Pollution on Aquatic Ecosystems

Aquatic systems are composed of a diverse array of organisms that require specific environmental conditions, such as temperature, dissolved oxygen, light, nutrients levels, etc. in order to survive. When pollution enters these aquatic environs, it often causes a series of impacts that ripple through the complex relationships of the different species (like dominos). This disruption may be drastic enough, that organisms die, causing further disruption of the food chain. There are two primary threats that urban agriculture pose to aquatic ecosystems: sediment load and nutrients concentration. If left unchecked, these pollutants will cause harmful consequences within aquatic ecosystems.

Sediment pollution (by volume) is the largest pollutant in the US (Cooper, 1993) and can cause widespread damage to aquatic ecosystems. Sediment has the ability to gum up a fish's gills, smother fish larvae, or bury reproductive fish habitat, which leads to a reduced population in the next generation. Suspended sediment limits the amount of light that filters through the water. This limits algae productivity as well as the productivity of other aquatic plants and phytoplankton (EPA, 2005; Cooper, 1993). Research has shown that sedimentation also leads to the loss of a water body by substantially increasing the natural rate in which the body of water is filled in with sediment (Cooper, 1993).

Another pollutant threatening aquatic ecosystems is nutrients. As previously mentioned fertilizers and animal manure are sources of high levels of nutrients. In a rain event, these nutrients are picked up in runoff and eventually drain into local water bodies. These excess nutrients trigger different responses in different aquatic systems. For example, “large amounts of organic matter from animal wastes provide a greater BOD (biochemical oxygen demand) than an aquatic system can supply oxygen for, resulting in an "oxygen-sag" (Cooper, 1993, pg. 405). An increase of nutrients in an aquatic system can also lead to eutrophication. Eutrophication alters the environment in aquatic ecosystems, often adding certain toxins, and reduces the amount of dissolved oxygen in the water. Plants and aerobic decomposers increase their productivity with increased nutrients causing them to use more of the dissolved oxygen in the water, limiting the oxygen available for other organisms and themselves and thus create an anaerobic system (EPA, 2005; Cooper, 1993).

Pesticides and herbicides used in agriculture find their way into local aquatic ecosystems and impact water quality as well. Pesticides have allowed farmers around the world to increase food supply. The drawback of the resource is the lethal impacts it can play on the environment for multiple generations. One of the most well known cases is DDT (dichlorodiphenyltrichloroethane), which not only killed pests, but also moved within the food chain to impact other species. The biggest problem in using pesticides and herbicide is in their application. Only 0.1 percent of the applied pesticide reaches its target. The other 99 percent or so is left to pollute the air, water or soil (Cooper, 1993). During the wet season, pesticide and herbicide rates increase in surface waters from the increased runoff. Herbicides, being a plant killer, threaten aquatic plants and promote a change in the physical makeup of their ecosystems (Cooper, 1993). Regulations, like those within the Clean Water Act, the Water Quality Act and local laws are essential for protecting local aquatic ecosystems.

VI. Methods

The objective of this research is to see the extent to which cities have addressed the potential stormwater consequences of urban agriculture ordinances or zoning. One way this was determined was by evaluating whether or not cities have adjusted stormwater requirements in parallel with the urban agriculture measures.

Methodology

Research used several methods to construct case studies including an analysis of city urban agriculture regulations, interviews with multiple stakeholder groups, and observations of urban agriculture sites. The first task was to find at least two cities in California that had made modifications to city regulations to accommodate urban agriculture. The search was restricted to California to limit interstate variation in social issues and state-level policies. Once a city had been selected, their urban agriculture ordinance was reviewed to evaluate to what extent the regulations covered stormwater management. Next, stakeholders involved in urban agriculture were identified. Stakeholders were selected from agencies or organizations that were either involved in stormwater runoff, urban agriculture or both. Conversations with various individuals allowed for better understanding of the issues and processes involved in pursuing and incorporating agricultural land use within an urban setting. Additionally each case study included observation from visits to several urban agricultural sites within the city. Visual assessments of the sites informed the context and variability that existed between the two cases.

Case Study Data Collection

Case Selection and Background Research

Initial selection of the case studies began with a search of cities, within California, that had adopted urban agricultural policies within the last three years. The search resulted in three cities that met these parameters: San Francisco, Oakland and San Diego. Upon further research, it was discovered that the City of San Francisco manages a combined sewer and stormwater system. This meant that all water, runoff included, was treated before being released into different water bodies. The Cities of Oakland and San Diego, on the other hand contain stormwater drainage system that direct water straight from the street into local water source. Because of this direct connection, it was presumed that these two cities would have more interest in preventing potential sources of stormwater derived pollution.

Once the two case studies had been selected, general information was collected from numerous articles, government documents, books, and other similar research papers. This background research provided the history and context of the cities' recent zoning changes, why they implemented urban agriculture, the community's involvement and level of support, and the actual changes that the city implemented. This information formed the basis for the questions that were used during the open-ended interviews with the stakeholders.

Interviews

A majority of the research was conducted through interviews either in person or by telephone with various stakeholders in urban agriculture. Five groups of people were determined to be key stakeholders; the Regional Water Quality Control Board, Urban Farmers, the city's Stormwater Division, the city's Planning Department, and local non-profit organizations. Table 1 describes each group of stakeholders, their relationship to urban agriculture and the goals of each interview. Semi-structured and open-ended interviews were conducted over the two-month period of February and March 2013. Selected individuals from these groups were invited to participate in a 45-minute in-person or telephone interview.

As previously mentioned, interviews were semi-structured and open-ended. Based on a respondent's answers, follow up questions were asked. One set of questions could not apply equally for each of the six groups of stakeholders since each had their own specialty. A comprehensive list of the questions used for the interviews are provided in Appendix A. In total, the number of participants was 12.

Table 1: List of the five stakeholder groups interviewed

Interviewee	Relationship to the thesis objective	Informational Goals
Regional Water Quality Control Board (RWQCB)	A RWQCB manages the water resource of each regional area in California. The RWQCB protects and enforces the many uses of water, and most importantly is in charge of issuing National Pollutant Discharge Elimination System (NPDES) permits (which include Municipal Separate Storm Sewer Systems (MS4) permits) that regulate a municipality's stormwater runoff.	Determine: •how urban agriculture relates to a city's NPDES permit; •if the agencies are involved in public outreach/education on stormwater contamination.
Stormwater Managers	Each city has its own agency or division that manages and regulates stormwater in the city. Their goal is to reduce pollutants in urban runoff and stormwater to the maximum extent practicable as is directed by their MS4 permit.	Determine: •if there is communication and/or collaboration between stormwater managers and planners and, if so, how it works; •if stormwater managers are concerned with the development of urban agricultural projects; •if urban agriculture can be sited for code violations if it is not listed in any stormwater policy.
City Planners	The city planner is tasked to facilitate and guide the growth, health and viability of a city, in particular the designation of land use. More recently, city planners have played a significant role in incorporating the use of agriculture within the urban environment.	Determine: •the process the city went through in order to accept urban agriculture as an allowable use; •if other city departments were involved in the planning of the urban agriculture ordinance; •how the guidelines were designed for urban agriculture.
City Farmers	This group has the most intimate knowledge of what is happening on the ground as well the ability to minimize any adverse impacts that could result from stormwater runoff. With a wide range of experience found within the urban farming community, it is important to understand what the farmers know and do not know in regards to farming practices and their potential to pollute stormwater.	Determine: •if they have they been included in education about stormwater runoff; •if they are practicing stormwater management BMPs; •if they are using any agricultural practices that will have a higher impact on stormwater management.
Community Activists for Urban Farming	Many community groups spearheaded petitions and lent a voice to the lack of legal farming within cities. Although they are not necessarily farming, they were and are influential in helping create policy for urban agricultural development within the city.	Determine: • what benefits and concerns were considered in their support for the development of urban agriculture.

Mini Survey for farmers

Initial interview inquiries to urban farmers resulted in very few willing participants due to time limitations and job responsibilities. To accommodate the farmer's valuable time, a shortened, mini survey was developed that sought to unearth information that would aid in evaluating urban agriculture from the farmer's perspective. The survey contained five questions, developed to be answered with short responses. A copy of the mini survey can be found in Appendix B. A total of seven farmers returned the survey with their responses.

Site Visits

During the months of March and May, site visits were made to existing urban agricultural sites in both Oakland and San Diego. The goal was to obtain first hand observations of several examples of urban agriculture in the two cities. Overall a total of ten sites were visited, representing seven different organizations. The sites were evaluated on seven criteria:

1. What is on the site (basic observations)?
2. Are there indications that the site is valued? If so, what are they?
3. Are there any signs or indications water had run off the site?
4. Are there animals on the site? If so, what kind and where are they located on the site?
5. Is there compost on the site? If so, where is it located on the site?
6. What practices are being implemented that may to contribute to runoff pollution?

7. What practices are being implemented that appear to protect against runoff pollution?

Analysis

Data were compiled from the interviews, the site visits and the farmers' surveys and analyzed for common and repeated themes. Themes were developed by studying and comparing the findings from each information source and observing where they overlapped (see Appendix C). Four themes were found in the data: value and concern of urban agriculture, regulations and policies, existing conditions and practices, and potential solutions. Within each of these themes, the two case studies approaches were compared and analyzed to each other and evaluated.

Summaries of the cases and interview findings are included in the following chapter. The results of this research are helpful in determining the process of how cities have brought about changes in urban agricultural uses and how those uses relate to stormwater management and practices. The shortcomings of the documented practices were collected and analyzed in order to create a best management practices "toolkit" or "manual" for effective management of stormwater runoff from urban agricultural sites.

VII. Results and Discussion

Results were compiled from interviews, mini surveys and site visits. The following chapter discusses and analyzes these results by weaving a narrative from these sources. In order to tell the story, the gathered data were compared with each other for similarities (Appendix C). Excerpts from interviews and the mini surveys are included in the discussion along with observations made during the site visit. Table 2 is an abbreviated collection of data assembled from the site visits made to the Cities of Oakland and San Diego (the non-condensed version of the table can be found in Appendix D). Four major themes emerged about urban agriculture in the cities of Oakland and San Diego. These themes include 1) Value and Concerns, 2) Regulations and Policies, 3) Existing Conditions and Practices, and 4) Potential Solutions.

Overall, findings indicate that urban agriculture is highly valued, but should be responsible for managing stormwater runoff from its site. Unfortunately, due to urban agriculture's current small scale, no one is sure how to enforce runoff management, whether through regulations or guidelines, or how to best approach farmers with additional rules. Interesting, many of the site visits revealed the implementation of various techniques that keep stormwater runoff on site. These techniques, along with other potential solutions for stormwater runoff have the ability to minimize runoff, as well as benefit urban farms.

Table 2: Observations made during site visits to Oakland and San Diego

Site #	Location	Were there indications of water runoff on the site?	Are there animals on the site?	Is there compost on the site?	Is the site valued?	What practices are being implemented that may to contribute to runoff pollution?	What practices are being implemented that appear to protect against runoff pollution?
1	Oakland	No.	Yes. Bees.	Yes.	Yes.	Compost in close proximity to the street.	Mulching. Plant coverage. A mulched and vegetated buffer. A drainage field. Drip irrigation.
2	Oakland	No.	Yes. Chickens.	Did not see compost.*	Yes.	Chickens in close proximity to the street.	Crushed rock mulch. Vegetated and mulched buffer. Lower site. Drip irrigation.
3	Oakland	Yes.	Yes. Chickens.	Yes.	Yes.	The soil is higher on the site than the sidewalk.	Rain catchment system. Mulching.
4	Oakland	Yes.	No.	Did not see compost.*	Yes.	Soil is higher behind the fence than the sidewalk. Loose dirt and woodchips on concrete.	Mulch. Framed raised beds.
5	Oakland	No.	Yes. Chickens.	Did not see compost.*	Yes.	Non-framed raised beds. Water loss to street from hand watering.	Mulch. Thick vegetative buffer. Drip irrigation.
1	San Diego	No.	Yes. Tilapia and goldfish.	Yes.	Yes.	Loose dirt and woodchips on concrete and pavement.	Framed raised bed. Mulch.
2	San Diego	Yes.	No.	Yes.	Yes.	Soil higher within the site than outside. Water cut marks visible from overwatering.	Mulch. Significant plant coverage. Drip irrigation.
3	San Diego	Yes.	No.	Yes.	Yes.	Terracing without reinforcement.	Mulch. Terracing. Vegetated hillsides. Water retention system.
4	San Diego	Yes.	No.	Did not see compost.*	Yes.	Dirt, stepped pathways that are not reinforced. Exposed slopes.	Mulched paths. Drip irrigation. Diverse plantings.
5	San Diego	Yes.	No.	Did not see compost.*	Yes.	Exposed patches of dirt on the hillsides. Minimal terracing.	Mulch. Vegetation on slope. Drip irrigation.

* According to some of the mini surveys, some of these sites do have compost, but it was not observed during the site visit due to limited accessibility or was not noticeable.

Values and Concerns of Urban Agriculture

Urban agriculture, in both San Diego and Oakland, is highly valued but also presents a concern to several stakeholders, including planners, those of the Regional Water Quality Control Boards (RWQCB) of California, and community activists. One of the first things that became apparent from the interviews was the general value that interviewees saw in urban agriculture. Prior research indicated that in both San Diego and Oakland, community activists, local non-profits and city councils lent support to the inclusion of urban agriculture within the city. A source from the City of San Diego confirmed this in a recollection of a City Council meeting made up of council members, city staff, community activists and residents. At "the City Council meeting to approve the changes and adopt the ordinance that only one person voiced their disapproval. All the city council voted in favor and 200 some odd individuals contributed their support."

Interview subjects from the Regional Water Quality Control Boards (RWQCB) of San Diego and San Francisco Bay concurred in their statements that they saw value in urban agriculture. One source mentioned that in East Oakland urban agriculture benefits the city by utilizing under-utilized land. The source from the water board mentioned a Trust for Public Land Report that recounted that because people in the community valued urban agriculture, they would protect and care for it. The interviewee shared an observation that they had seen a reduction of trash in the City of Oakland. Empty lots that once

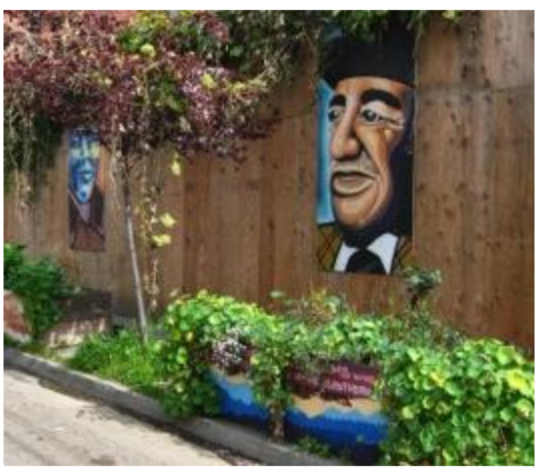

Figure 2: Paintings and painted plant boxes at a site in Oakland.

contained trash, now host agriculture and those caring for the project make an effort to keep the space trash free. Site visits affirmed this observation not only in Oakland, but also in San Diego. Sites were most often not only clean from trash, but also weeds. Site visits to both Oakland and San Diego illustrated the care, value and passion individuals had for their agricultural space by the installation of art (Figure 2), creativity, and even in the individualized plant signs. This kind of investment shows a level of care beyond a space for some plants and animals, but space that is valued.

No one specifically commented that urban agriculture was valued for reducing waste and promoting entrepreneurial businesses, however, actions spoke louder than words. A survey given to urban farmers from both cities found that seven out of the seven farms compost garden waste from their site. One farmer shared that they utilized compost from a local mushroom grower, using waste from that industry to benefit theirs. A non-profit organization in San Diego shared that they had started a composting program that collected vegetable scraps and organic material from local restaurants to use in their composting business. Although these farmers and non-profits gain for their sites by making compost they also are part of a process that reduces garbage that would typically go to the landfill.

Urban agriculture is also valued for its role in managing water in the urban environment by the water board and local activists. With the more impervious nature of the city, an activist in Oakland shared that urban agriculture had to potential to provide a means to increase water absorption. A source from the San Francisco Bay Water Board commented that urban agriculture “presents an opportunity to reduce the hydrograph and increase infiltration. Some of the sites or lots are small, but a collection of small sites taken together make up a difference." A source from Surfrider Foundation commented that urban agriculture could help manage stormwater. The "intent is to create a sponge out of the soil from the very beginning. By creating this sponge you can help manage water quality and flooding." Overall, urban agriculture would "provide a means of increasing green space in a City [Oakland] where people want to pave over everything. The more undeveloped green space, the better."

Although highly valued, many shared that they had concerns that urban agriculture could impact its surroundings in a negative way. Regional Water Quality Control Board (RWQCB) sources maintain a cautious opinion about urban agriculture. "Current farmers seem interested in helping the natural ecosystem, but if it gains mass appeal…then what? A lot of those people will not have a clue about the impacts of their actions and this could create some significant problems."

One of the things that the Oakland Planning Department heard from the beginning of their outreach process was how urban agriculture could cause various impacts such as noise, odor and water quality. This was especially poignant in the discussion around regulations for raising livestock. One source commented that they were concerned about improper disposal of animal manure. If not properly disposed or processed, manure could easily end up washing into the stormwater drains. In Oakland, the City recognized that having high-density livestock would detrimentally impact water quality. Oakland is in the midst of defining what parameters the City will set in regards to raising animals.

A source associated with a local non-profit organization in Oakland shared that many of concerns they heard had little to do with the urban agriculture's impact on the environment, but stemmed from racial tensions, safety (urban agricultural sites located in neighborhoods that even the people that lived there felt unsafe), tension between developers that wanted to develop certain parcels, and tensions (mainly personality conflicts) between organizations. Urban farming could become territorial and actually lead to division within the community.

Impacts not only include how urban farming affects others in the community and local ecosystems, but also how the city land itself could impact the creation/promotion of urban agriculture. One source mentioned that before they could really get the community (of Oakland) to buy into urban agriculture, they would need to tackle contamination. Additionally some were concerned that groundwater could become contaminated from using the site for agriculture.

Several stakeholders shared that although they felt that there were impacts and concerns they had in regards to urban agriculture that the benefits outweighed the costs. One source in Oakland commented that they felt that vegetable production would not have significant impacts on water quality. If there were impacts, such as stormwater runoff, it was seen as creating less harm than, for instance, not having healthy food options for lower-income neighborhoods.

Regulations & Policies

The management of stormwater and in particular stormwater runoff is a multi-agency process. Sources both in San Diego and in Oakland shared that in regards to urban agriculture there is little stated in federal, state or local regulations that speak to this use and its potential impact on water quality. This gap in the regulations has caused some agencies to maintain the status quo and rely solely on the basic regulations, whereas others have tried to establish stricter guidelines. Unfortunately those that have tried to set additional regulations have met with resistance, which has caused agencies to withdraw from making mandatory requirements and instead create guidelines.

Unlike construction and traditional agriculture, urban agriculture is often too small or unnoticeable to trigger water quality regulations. Agriculture is exempt from the Federal NPDES regulations, but California has more restrictions that allow the RWQCB to control issues of pollution related to agriculture. In most cases, agricultural activities (mainly rural or agricultural areas) within a regional water board area will receive a waiver of Waste Discharge Requirements (WDR). The San Diego RWQCB has a threshold of $1000 profit from the agricultural operation. A source commented that, "If you earn an income of $1000 from your farm you are required to get a WDR and meet the requirements of your permit, one of which might be controlling erosion or runoff." According to the interviewee this would include urban agriculture. This is a fairly new program (about 4 years) and the problem is that most people are unaware of this rule. "This is where there is a gap," admitted the source from the San Diego Water Board. The RWQCB does not have enough resources to monitor and notify everyone, and instead has to set up priorities to address those that are the biggest offenders.

The San Francisco Bay RWQCB does not specifically have a threshold that triggers a WDR. The Water Board does administer waivers for grazing, in the non-urban, northern part of the region and is working on waivers for vineyard agriculture. In terms of urban agriculture, the San Francisco Bay RWQCB would not "get that small." The source further shared that they would expect cities to oversee runoff discharged by urban agriculture under their Municipal Separate Storm Sewer Systems (MS4s) permit.

The Stormwater Division and the Planning Department from the City of San Diego and the City of Oakland revealed different approaches to how each city handles urban agriculture's potential impact on stormwater runoff. It is important to note that although both of these cities have implemented urban agriculture ordinances, that they are not the same and that Oakland is attempting to create an ordinance that will allow high density animal husbandry, whereas San Diego has restricted the type of livestock and their density significantly in their ordinance.

The City of San Diego has a fairly substantial stormwater program and campaign. One planner stated that the "stormwater regulations in San Diego are implemented separately for all projects in the City and include how stormwater must be managed on and off the site." Interestingly, not everyone in the Stormwater Division was aware of San Diego's new urban agricultural ordinance. Although caught unaware they shared that it was the role of their department to comply with the TMDL order from the Water Board and configure monitoring and enforcement along those standards. Thus, one of the ways they could regulate urban agriculture would be if it impacted the TMDL. At the moment, for example, City of San Diego has received a TMDL order from the Water Board to reduce bacteria levels, such as fecal coliform. Fecal coliform largely comes from feces or manure in the case of urban agriculture. If the San Diego Stormwater Division had evidence that urban agriculture was contributing to this problem, they then could take measures to regulate the sites. Otherwise, at this time, they do not have any other regulations. Overall the Stormwater Division has a pretty rigorous process for finding code and standards violators. The Division has several officers on staff that respond to complaints (there is a Hotline people can call) and complete regular inspections of industrial and commercial facilities. The source from San Diego's Stormwater Division shared it is unclear if urban agriculture would fall into this same category and need to be regularly inspected for compliance. They also inspect large events such as the City's Farmers Markets. The City pays staff overtime to visit farmers markets on Saturday to make sure they are maintaining compliance, as there have been occasions where they have violated the City's code.

In regards to urban agriculture the water divisions largest concern is nutrients and sedimentation. "Protecting water quality is important, but most important is that you minimize nutrients entering runoff as it only helps to promote and feed the exotics in the channels." San Diego has seen an increase of sediment and exotic plants in the flood channels. This increase reduces the channel's capacity to handle the quick heavy rains that San Diego receives and causes flooding in low lying areas.

The City of Oakland is divided in its view of regulating stormwater runoff from urban agricultural sites. On the one hand a source from Oakland's Public Works Department shared that the City felt that vegetable production would not have significant impacts on water quality and that the city's creek ordinance would protect creeks from farming or gardening with its setback provision of 100 feet. This sentiment stems from the city's desire to encourage vegetable gardening or landscaping. "Right now there is such a small amount of the population that is involved in urban agriculture that it is not large enough to have an impact yet." However, the Oakland Planning Department will not "jettison stormwater BMPs from the guidelines."

Livestock on the other hand would have different parameters than produce in Oakland. In investigating the community's desire to raise livestock in the city, Oakland realized that having high-density livestock would detrimentally impact water quality with manure being washed into the storm drains and eventually the creeks. "Scale," a source noted, "is very important in managing livestock. For instance, X number of animals is the threshold and once you have X number of animals then yes you will have to apply for a permit and you will need to create a management plan which requires stormwater plans. This is not so with produce or vegetables."

Another issue that Oakland has to contend with is the use of livestock on the hilly, wooded sections of the city. "Often animals are used to manage vegetation and help with fire suppression. Llamas and goats have been seen in these parts of the city and these animals, if not correctly managed could eat all the vegetation on the hillside which would lead to some very significant erosion and landslide issues. Here would be where a stormwater management plan would be very important. Again it is a balancing act trying to design regulations that oversee a wide range of land use."

The Oakland Planning Department researched and developed stormwater management practices in regards to livestock. Their goal was to establish requirements for those raising animals and set standard regulations and code to enforce those requirements, such as setbacks, and systems of water filtration plans. A list of approximately 30 regulations were developed and evaluated by the water division, building, animal services, state agencies that deal with animal health and veterinarians. All of these groups gave the thumbs up. However, in a conversation with the County Agricultural Commissioner, staff was informed that the county's regulations were not as stringent. The Planning Department then showed them to the urban famers and who responded, “No way.” They felt that the requirements would create numerous obstacles and cost too much. The planner shared, “Most people are pursuing farming in order to supplement their diets or to make a little money on the side. They do not have the resources to pay for extensive plans that meet certain regulations.”

The Oakland Planning Department pursued several options before they submitted their final recommendations. Ultimately the Planning Department decided convert their list of requirements into guidelines to prevent further obstacles to the development of urban agriculture. A source from the planning department shared that “hopefully we will not have any issues” with this method. The source continued to say “that if they had written it all out in the code as a requirement, then the City would have its hands tied and the farmers would have their hands tied. This does not mean that there will not be any requirements, just that we will have to pick and choose what impacts we want to manage at this time.”

Existing Conditions and Practices of Urban Agriculture

Each site within each city and between the cities of San Diego and Oakland face multiple challenges due to the existing conditions of their sites. These conditions impact the practices used on the site, as well as affect stormwater runoff. Overall farmers and non-profit organizations seek to apply practices that are sustainable. This is apparent even to outsiders as a source from the San Francisco Bay RWQCB commented, “Typically those involved with urban agriculture are invested in the community and take great care about what they are doing and how they are doing it.” Although there is no one way to design and manage an urban farm it is important to note site limitations and current practices being employed in order to better recommend solutions, especially for stormwater runoff.

Slopes

Observations from site visits indicated that most urban farms are limited in the sites they can use. This is due to a number of different things, but most farmers and non-profit organizations will work with what they can get. Due to this limited selection, land within the site is usually less than desirable and comes with various challenges. Table 3 is a condensed table composed of information gathered from the urban agriculture site visits in Oakland and San Diego. Each number correlates to a site as presented in Table 2 and Appendix D.

Table 3: Existing conditions of urban agriculture observed during site visits.

	Oakland Urban Agriculture Sites					San Diego Urban Agriculture Sites				
	1	2	3	4	5	1	2	3	4	5
Existing Conditions										
Slope										
Small site (~1/8-1/6 acre)										
Farming on concrete and soil										
Triangle land shape										
Drainage field										

A site that contains a hill or any slope over 3% is a challenge to farm anywhere, especially in an urban environment where space is tight. If not managed correctly, farming sloping terrain can lead to erosion and, potentially, issues with stormwater runoff. Observations from site visits showed that almost all the sites visited in Oakland were relatively flat. One site (Figure 3) had a slight slope and in order to make the site flatter, soil was filled in between the fence and the slope. The image shows how corrugated metal sheets were installed hold the soil. For the most part, the metal and the plants have kept most of the soil within the fenced area. However, after a rain event it was observed that water and some soil passed through the small gaps between the corrugated metal sheets and between the metal and the sidewalk. A better solution would be to construct a barrier that does not have any gaps or to have left a space between the fence and the sidewalk to plant a vegetated buffer to collect any soil that passed through the barrier.

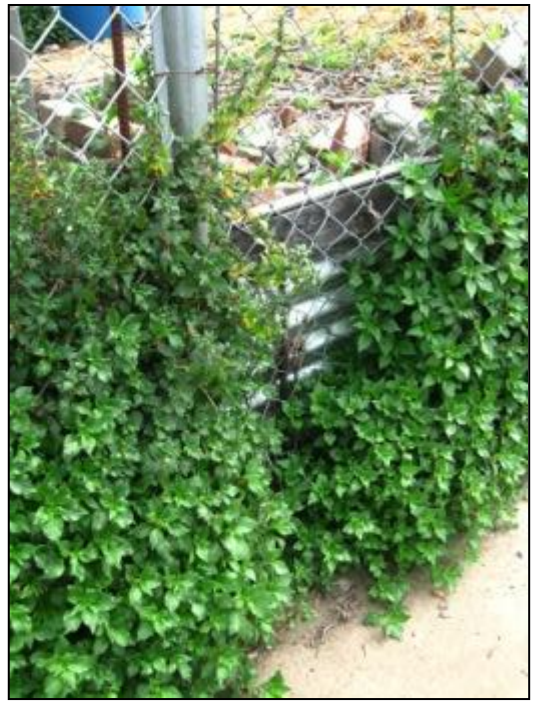

Figure 3: Corrugated metal sheets keep soil from falling through the fence.

In San Diego, three of the five sites contained some kind of slope. All three sites in San Diego have made efforts to minimize erosion by establishing terraces. Unfortunately, as shown in Figure 4, the terraces were not well established and there were signs of erosion and water runoff. Figure 5 shows how one site has attempted to terrace, mulch and vegetate their slope. However the choice of vegetation was less than ideal as annuals only live for a season and then die. A dead plant's root system disintegrates over time and will no longer be strong enough to hold the soil in place when placed against the pressure of water.

Figure 4: The hillside shows signs of erosion from water runoff

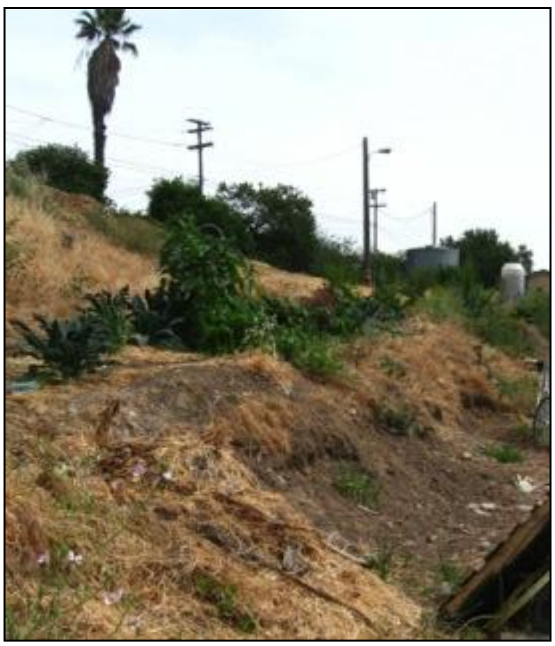

Figure 5: A terrace with insufficient vegetation

Small Sized Site

Another site limitation is size. Size matters in agriculture because the more space available, the more produce or livestock that can be raised. One farmer in Oakland shared that they were looking for another site to farm, because they wanted to expand beyond the space they had. Therefore urban farmers maximize the space they have, which means crops are often brought the edge of the site, where the soil touches the sidewalk. In many cases, both in Oakland and in San Diego, the only thing on the other side of the sidewalk is the street. Without anywhere else to go, runoff from the urban farm flows over the sidewalk, into the street and into a storm drain.

Figure 6: Soil that has escaped the site

In Oakland, four of the five sites visited were located on small parcels within the City. Two of the four sites used every bit of space they could for their farm. Figure 6 shows one site where the fence is right next to the sidewalk. Because of the close proximity of the site to the cement, soil from the site has swept under the fence. This, most likely, is from runoff or moving the soil during crop rotation. Without any kind of buffer or catchment system this soil could end up in the street and eventually in local creeks. Buffers, as seen at two other urban agriculture sites in Oakland (Figure 7), allow for more water to infiltrate the soil. Both of the buffers illustrated in Figure 6 are mulched and vegetated, reducing the velocity of water moving across the surface.

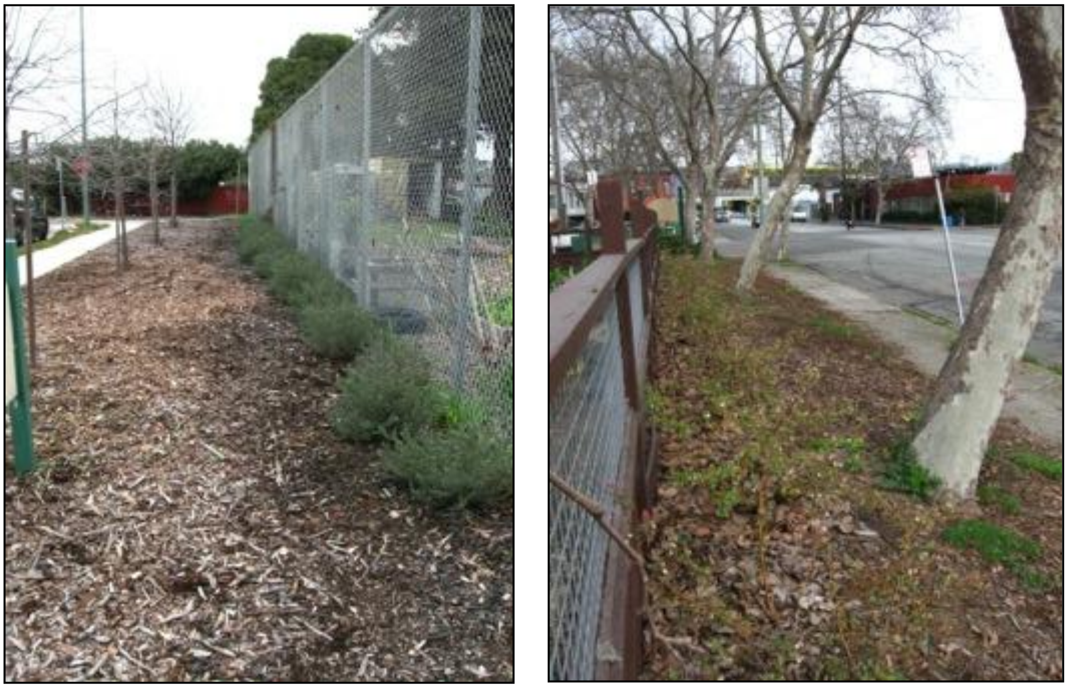

Figure 7: Mulched and vegetated buffers

Another site in Oakland, although not bound by size, has created a vegetated buffer within the fenced area. Instead of taking the crops to the furthest extent of the property, they left room for vegetation (Figure 8).

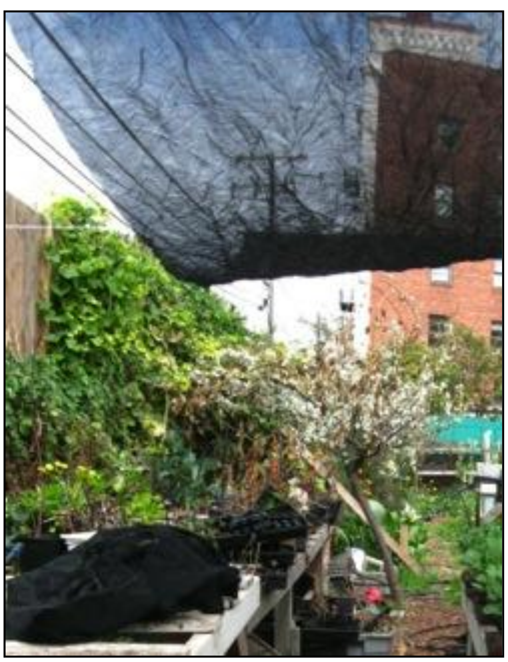

Figure 8: Buffer on the interior side of the fence

Urban agriculture sites in San Diego appear to be less constrained by site size than Oakland. Only two of the five sites visited exhibited limitations to site size. One site is nestled between two parking lots and the sidewalk. As with the sites in Oakland, this site in San Diego has the potential to direct sediment into the street because there is nothing to prohibit it from doing so. Another site in San

Diego is located on a slope above a sidewalk, next to a parking lot. At the base of the fence, soil and plant debris have collected since there is nothing on the hillside or at the base of the hill to filter and collect whatever runoff may be carrying. Other sites have established their agricultural activities several feet from the curb allowing a buffer. Buffers, once created, have to be maintained. Figure 9 visually shows how different techniques perform in keeping soil from entering the street. The image to the left is a buffer covered with woodchips and some vegetation. The middle image is a section of the buffer that is covered in grass. The image on the right illustrates a part of the buffer that has very little vegetated coverage. The lack of some sort of cover has allowed the soil to move away from the site. With a little bit of planning and regular maintenance, a site such as this one in San Diego could significantly reduce the possibility of polluting stormwater runoff.

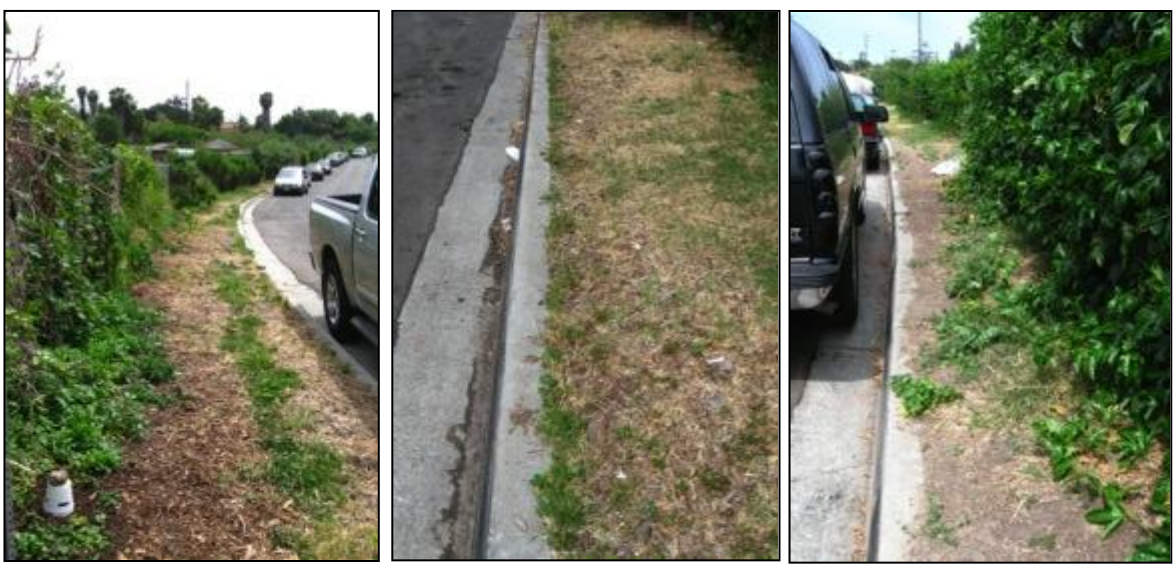

Figure 9: Comparison of mulch, vegetation and no coverage

Interestingly very little was said during interviews or from farmer surveys in regards to site size. This may be in part due to a lack of questions on the subject or farmers and non-profit organizations have made do with what they have. Mougeot in his research states, “given the constraints on access to, and on the size of, land plots available for UA [urban agriculture] at any location, production systems are very diverse in order to make the most and the best use of particular locations within the urban fabric” (2001, p. 16).

Nontraditional Farmland

Large parts of the urban environment are covered in impervious material such as cement or pavement, which are traditionally not seen as a place to raise crops and animals. With limited options, farmers and organizations often elect to use an abandoned or unused parcel for their agricultural venture. These sites often contain the remnant foundation of a building or even an abandoned parking lot. Sites in both Oakland and San Diego have devised ways to farm these spaces.

Figure 10: Raised beds on cement in Oakland

In Oakland two different sites have created raised beds on cement infrastructure Figure 10 illustrates where one of the sites has created raised beds with mulch around the bases. Traditionally, on soil, this would be a textbook technique. However, unlike soil, cement does not have the ability to allow water to pass through it. Instead it encourages water flow across it, gaining momentum as it moves. The mulch will help initially with a light rain, but with a shower or even someone overzealous with hand watering, the soil and the mulch could easily flush off the cement pad and into the street.

In San Diego, a portion of a parking lot was converted into an aquaponics and retail nursery site. The entire site is covered in mulch and it was unclear if the site was covered entirely in impervious material or if portions of the parcel were dirt. Three

Figure 11: Raised beds on cement in San Diego, before and after

sections of the site held wood framed raised beds. Figure 11, left image, shows a "bed" prior to planting and the cement underneath it. The right image shows similar raised beds on the site that are successfully growing various plants. The raised beds allow soil to stay in its place and benefit the plants.

Other Factors

Other existing site factors such as a drainage field or an odd shaped parcel contribute to the challenge of farming in the city. These conditions, in particular, were very site specific to urban agriculture in the City of Oakland. One site, for instance, is shaped like a triangle and is completely surrounded by streets on all three sides. If water runs-off, there is nowhere but the street to run into. In this case, the site has established a buffer of woodchips and trees to catch any runoff before it enters the street. Another unique challenge to another site was a drainage field (for the neighboring baseball field). A drainage field is very helpful in collecting water and keeping it from flowing into the street stormwater drain, unless it floods the site. Unfortunately, filling in the drainage field will only make matters worse and direct water to the street. There could be some creative solutions to this problem or it might be that the drain field should remain exactly as it is. Not every urban site will be farmable. Having guidelines and even requiring a stormwater plan would force farmers to assess if the site they want to farm is a viable option.

Practices

The agriculture sites in both Oakland and San Diego displayed both positive and negative practices that could benefit or threaten stormwater pollution. The most common positive practice was the use of mulch. Mulch protects the soil from the sun and the rain and slows the speed of runoff and aids in the permeation of water into the ground. Unfortunately on several occasions, the mulch was not contained and had fallen or been placed on an impervious surface. Putting mulch on cement does not change its ability to absorb water; instead water moves across the surface and lifts the lightweight mulch and carries it to the gutter. Compost is another practice that benefits stormwater runoff. In every survey received from the urban farmers, 100 percent of them said they make compost on site. The addition of compost to the soil not only provides nutrients for the plants, but the organic matter improves drainage and increases the amount of water the soil can hold (P. Berstler, personal communication, April 5, 2013). However, on several sites, the compost making area was located near a street or driveway. Location of compost next to a street does not allow a space for the collection or filtration of nutrients washed from the compost before it drains into the street.

How an agriculture site is irrigated can lead to runoff even during the dry season. Seven of the eight farmers interviewed shared that they use drip irrigation. Drip irrigation not only reduces the total amount of water used to irrigate, but it also reduces dry weather runoff (most of the time drip will not cause any runoff). One source from the Bay Area Water Board commented, “Typically those involved with urban agriculture are invested in the community and take great care about what they are doing and how they are doing it.” These cases show that urban agriculture in Oakland and San Diego have the potential to manage stormwater runoff, and many, have taken steps in that direction.

Potential Solutions

Solutions to managing stormwater runoff from urban agriculture sites are two fold: long-term investment in education and technical know how through best management practices (BMPs). Unfortunately education is limited and in most cases does not address urban agriculture. Of the seven farmers surveyed, only two had received some training in stormwater runoff. Due to this lack of education, new agricultural sites are being established without an understanding of their role in urban stormwater runoff. Further impacting the situation is the lack of definitive evidence or experience of what BMPs will work on an urban agriculture site. Many sources were able to pass along recommendations that they felt, from their experience in managing stormwater, would be successful. With the right education and tools, farmers could become an invaluable stormwater management resource for the city.

Education

Education in most cases happens at the local level as a requirement of a city's NPDES permit from the RWQCB. The Think Blue campaign of San Diego is such an example according to a source at the San Diego Water Board. A large part of the program centers on what homeowners, businesses and visitors can do to keep San Diego's biggest water source, the ocean, clean. "You hear PSA about stormwater even south of the border; they are everywhere. I mainly seem to see it in [areas of] tourism, or when I'm at the airport," shared a source from the San Diego Water Board. Oakland, as a member of Alameda County, is part of a regional education program, the Alameda Countywide Clean Water Program. A source from the San Francisco Bay Water Board commented that since the Bay Area is under a Municipal Regional Stormwater NPDES Permit, it makes sense that they would work collaboratively on education. The Clean Water Program is very similar to the Think Blue campaign, but crafted for the Alameda County region. Neither have education specifically for urban agriculture.

In most instances the Regional Water Quality Control Board does not have funding for outreach and educational programs. Instead, the RWQCB educates on an as needed basis and as situations call for it and require cities within MS4 programs to provide public education and outreach as well as participation and involvement (EPA, 2013). In San Diego, the Water Board will review a city's reports and offer to help them in any area that they need better training or understanding. The RWQCB will also step in and educate when they determine a particular site is in non-compliance.

Under the MS4, a city is responsible for managing the pollutants that the Water Board has deemed a priority. In one particular example, a source from the City of San Diego's Stormwater Division shared that they had determined that restaurants were causing an issue with water quality. The Division tailored an education program, that even included commercials, to educate and make the industry aware of how their actions were impacting local water and how they could be better the situation.

Additional education is supplemented and driven by local nongovernmental agencies that are concerned about the health of the local environment. A member of a non-profit organization in San Diego commented that stormwater education should be more than just BMPs, but also an opportunity to educate city staff. Although the organization does not deal directly with urban agriculture, they are involved in educating people about ocean friendly gardening, which deals with stormwater runoff. The source recommended that education be two fold, "You can have the classroom part, but hands-on is key for people to fully understand the material. It also builds confidence, and better communication between staff (at the city), residents, and community members. It also gives those who may not use the information directly the ability to know what they are looking for when they need to hire someone to actually work within this particular topic."

Managing Stormwater Runoff

Numerous sources recommended BMPs and other strategies that could aid in managing stormwater on urban agriculture sites. A source from the San Francisco Bay RWQCB mentioned that they were "underwhelmed" by the resources available to the public about how to manage stormwater. Thankfully, many of those interviewed had other experiences to draw upon to make suggestions of what urban farmers could try.

These recommendations can be broken down into two broad categories: production practices and structural practices. Production practices include the methods used to till, control pests, and manage nutrients and water. Structural practices include strategies that manage stormwater runoff through development or improvements of the site.

Production Practices

A source with a non-profit organization in San Diego shared that the "intent is to create a sponge out of the soil from the very beginning. By creating this sponge you can help manage water quality and flooding." The source continued, "that the first key steps to any "rain" water management are permeability and retention. Once people understand this concept, then you can move on to the plants and irrigation methods. To create such an environment, you have to implement the 3S's: Slow it, Spread it, and Sink it."

Some of the more simple measures that can be taken by the farmer to minimize their site's impact on water quality are already being applied on sites in Oakland and San Diego. One source stated, "the most important thing would be to make sure that the farms used organic methods and not pesticides, especially if they were along a creek." All of the farmers interviewed and the sites visited described themselves as sustainable, organic or both. In addition to not using pesticides and chemical fertilizers, almost all the sites utilized mulch. The NCRS in a report about two sites in San Diego listed mulch as one of the practices farmers could use to slow water movement and aid in infiltration.

Structural Practices

Implementing practices that slow, sink, spread and otherwise reduce storm runoff can also be managed through various improvements. Sources from the Stormwater

Division and the Public Works Department described several programs that the cities of San Diego and Oakland are implementing to reduce the overall amount of stormwater runoff within the city. Both San Diego and Oakland have implemented a rain barrel program to help slow peak flow. The City of San Diego is providing rebates to residents in order to encourage more people to participate in this program. One source commented the rain barrels could be a potential BMP on urban agricultural sites. Although rain barrels will help in some ways, most sites are not big enough to hold a tank of all the water that is collected on site. Also, most sites have limited structures to actually catch the water with.

Low impact development (LID) is another method being used to reduce stormwater runoff, especially in new development and redevelopment sites. Similar strategies used in LID could be applied to urban agriculture. Examples include bioswales, rain gardens, detention basins or re-establishing native vegetative cover that reduce storm runoff flow rates (volume, velocity, and duration). Another source supported having some sort of filtration or remediation system at a low end of the site. And vegetated berms and bioswales are also methods that could be used by farmers to minimize stormwater runoff and also as a means to increase biodiversity and pollinators for the farm. Establish roof top garden may be another strategy. One source shared that "green roofs were an excellent way to manage water, save energy and potentially be an excellent place for urban agriculture."

VIII. Conclusion

This thesis has engaged in a conversation about the impacts urban agriculture and stormwater runoff in two cities, Oakland and San Diego. Intriguingly these two cities entered into urban agriculture for different reasons, using different methods, but have ended with similar outcomes in regards to stormwater runoff. The reasons behind the shift to urban agriculture in each city, although different, inspired community members in both Oakland and San Diego to push their respective cities to reexamine their zoning regulations and update codes to allow residents the ability to farm. Oakland has allowed urban agriculture with a use permit, whereas due to existing policies and fee structures, San Diego has allowed urban agriculture outright in designated zones. The cities differ the most in one area: animals. San Diego with their most recent changes has limited the kinds of animals allowed in the city. Oakland on the other hand, continues to dialog with the community about what kind of livestock should be allowed and at what scale. For Oakland, it is when they talk about livestock that stormwater runoff becomes more important. Both Oakland and San Diego at this point want to promote the benefits of urban agriculture and are not currently concerned with its impact on runoff just yet.

The literature asserts that urban agriculture poses a risk and ultimately cities are responsible for creating policy and/or guidelines that reduce or stop pollutants from entering the local waterways. Overall the majority of those interviewed from both Oakland and San Diego acknowledged that urban agriculture had the potential to pollute stormwater runoff. The problem is that unless cities are willing to add provisions to their urban agricultural ordinances about runoff, there is no other set of regulations that controls urban agricultural activities. However adding additional rules on top of more rules disincentivizes individuals from engaging in urban agriculture as was seen in the case of Oakland. Instead cities should encourage programs that educate, collaborate on alternative solutions with farmers, and create guidelines and Best Management Strategies (BMPs) specifically designed for urban agriculture. Additionally, more research is needed to better understand the real impact urban agriculture will have on communities, in particular in the Cities of Oakland and San Diego.

Education is one of best ways to encourage changed practices without instituting more regulations. Both the City of Oakland and the City of San Diego have programs geared towards educating the public about its role in protecting the receiving bodies in their communities. However both lack any education geared toward urban agriculture runoff. On the other side, many urban farmers are very conscientious about the relationship the farm has with its surrounding and most engage in organic and/or sustainable farming techniques. In the gap between these two sides, cities should adopt a program that utilizes the resources of each side and promotes better stormwater management. This would provide cities with an opportunity to improve their stormwater runoff program, reduce pollutants from urban agriculture, and release farmers from having to meet a set standard of regulations that may not always apply to their sites.

Collaboration will be needed for theses regulations to take shape. Urban farmers are not engineers (usually) and city engineers are not farmers. Alternatives would need to be developed that meet city standards for water quality as well as be within the means of the farmers and their organizations. Many techniques are being implemented in conventional agriculture that could be applied to urban agriculture sites. There are also new urban measures, largely from low impact development (LID), that may be adapted to work on an urban farm. By working together on solutions, the farmer will not feel put upon and the city will maintain some control in how stormwater runoff is managed.

The best management practices derived from the combined efforts of the city, farmers and other stakeholders could then be developed into a guidebook or manual. This resource would provide education as well as solutions to common issues that urban agriculture sites face. A sample BMP manual has been created as a part of this thesis and is presented in Chapter 9. This manual can be modified and adapted to each city's specific conditions.

Scale is a significant area of concern and needed research. Several of those interviewed shared that urban agriculture was too small to have an impact on stormwater pollution at this point in time. Yet there must be a point in which urban agriculture outgrows mere guidelines and needs standard regulations like construction. One source, however, from the San Diego Water Board was quoted earlier in this paper as saying, "Current farmers seem interested in helping the natural ecosystem, but if it gains mass appeal…then what? A lot of those people will not have a clue about the impacts of their actions and this could create some significant problems." If urban agriculture continues to gain momentum, at what point does the city consider urban agriculture as a problem? At what point does the city shift from guidelines to requiring that sites comply with certain regulations? Is there enough information on urban agriculture to determine its tipping point?

Because of questions like these, cities and communities should continue to monitor and observe the urban agriculture phenomenon. In particular, more research is needed to provide evidence that shows the actual impacts urban agriculture has on stormwater runoff. Although studies have shown that lawns, landscapes, and conventional agriculture all contribute to stormwater pollution, no study has examined and proven that urban agriculture performs in the same way. In addition, research is needed to evaluate how much rainwater an urban agriculture site can effectively manage. Many cities claim that urban agriculture provides a sink for runoff, but there is little research supports this assertion.

The gap between stormwater management and urban agriculture exists. This thesis has sought to explore this gap, understand why it exists and explore ways the gap could be bridged by looking at two case studies. These cities, as well as others have a unique opportunity to plan for urban agriculture sites that minimize runoff and improve a city's overall urban stormwater management program.

IX. Guidelines to Managing Stormwater Runoff for Urban Agriculture

Whether you have been urban farming for years or are just setting out on your first urban agricultural adventure, take a moment to examine your site through the lens of stormwater runoff. Where does it go? Have your ever noticed it before? Urban agriculture has the potential to either protect water quality or contribute to its degradation. The following guidelines walk you through: 1) how to evaluate your site for stormwater runoff and 2) provide best management practices (BMPs) to reduce urban agriculture's impact on water quality. These BMPs will also work to conserve the soil and water on your site, which will reduce your water use (irrigation) and preserve the rich soil you have developed. Since each urban agriculture site is unique and faces different challenges, these guidelines will enable you to adopt stormwater management strategies that best suit your site and that are cost effective, relatively simple to do, and will integrate well into your project. Local agencies, such as the Regional Water Board or the City's Stormwater Department may also be able to provide additional information on managing stormwater runoff in your area.

Evaluate Your Site[1]

The first step is to identify where runoff is occurring on your site during a rain event. An evaluation can be made prior to the design of an urban agriculture site or after, however it is highly recommended that you make an assessment of stormwater runoff as early in the design and layout process as possible in order to minimize any issues with runoff from the site. In order to accurately know where water is going, the site will need to be evaluated while it is raining. During the evaluation you will be looking to see how runoff is currently on the site, where runoff is going, and where you may be able to apply best management practices (BMPs).

Step 1. Make a sketch of the site.

This can be drawn ahead of time, so when it starts raining you can quickly gather your sketch, a pencil (pens often bleed on wet paper), and an umbrella and head outside. On the sketch include where your beds, livestock, any structures, compost or other established components of the site are located. Also draw the area immediately around the site including streets, trees or other vegetation, where the street drains are located, the location of creeks or streams or other existing infrastructure. Also make note on your drawing where there are areas of cement or pavement on your site as well.

[1] Taken and modified from *Slow it. Spread it. Sink it! A Homeowner's Guide to Greening Stormwater Runoff*. By the Resource Conservation District of Santa Cruz County. 2009. Capitola, CA.

Step 2. Note on the drawing where the water is going.

The most accurate time to complete your evaluation is after a couple of good rain events (1/2 inch or so of rain). Once you have had some rain, watch for water flowing on the site; this is your signal to head outside and make your evaluations. On your drawing, use arrows to indicate where runoff is occurring and the direction of the flow. Note also where the water accumulates on your site. It may be helpful to take photos of the things you are recording on you sketch so that you have images to remind you later what you saw. These photos can also be helpful if you find that you need guidance from an outside source on what BMPs to apply to your site.

Step 3. Know the rainfall rates and soil types of your area.

Knowing how much rain your site might receive or what the trend of the past year's rain events were, can be helpful in knowing what BMPs could work best for your site. Some areas receive lots of rain from multiple rain events over the course of four or five months. Other areas receive infrequent, but intense and heavy amounts of water in a similar time frame. NOAA (National Oceanic and Atmospheric Administration, http://www.noaa.gov/) is a great source for finding information on rainfall for your area.

Knowing the type of soil you have can also be helpful in determining which BMPs to implement. Local agencies such as the Regional Conservation District (RCD in California) or National Conservation Resource Service (NCRS) have soil maps available. NCRS provides an internet resource called Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm), that allows you to search any address in the United States for soil data. Once you know what kind of soil type you have, you can research its properties and how they may impact stormwater runoff on your site.

Step 4. Assess your results.

Once you have collected all your data it is now time to consider what BMPs to employ to manage the runoff on your site. The following sections provide numerous recommendations and practices for you to try. There is no perfect solution for managing urban agriculture stormwater runoff as each site and situation is unique.

Best Management Practices

Now that you have evaluated your site, it is time to determine which BMPs to apply to minimize the stormwater runoff from your site. BMPs for stormwater management fall into two categories: Production Practices and Structural Practices. **Production Practices** are techniques and strategies that focus on *how* you farm as a means to slow and allow runoff to infiltrate into your site. **Structural practices** include strategies that manage stormwater runoff through development or improvements of the site. These strategies are designed to slow runoff, filter out sediment and/or nutrients and allow the runoff to permeate into the soil. Depending on your situation, you may use practices from one or both categories.

Production Practices

Compost

Adding compost to your soil not only benefits the health and growth of your plants, but also improves the soil's ability to manage high intensity (~ 4 inches/hour) rain events. Using compost will:

- Reduce pollution and clogging of the storm sewer.
- Reduce soil erosion and water runoff.
- Improve water absorption in soil and plants.
- With the addition of compost, sandy soils hold water better and clay soils drain faster. (Glanville, Richard, & Persyn, 2003, Mid-America Regional Council, 2013)

As you turn over a bed from one crop to another, add compost. Over time you will see your soil improve and an increase in water absorption

Because compost is such a great resource and has such great benefits, you are fairly likely to be creating you own on site. Although an invaluable resource, a pile of composting material has a high concentration of nutrients and loose soil, which in the event of heavy rain could move from the site to the street and contribute to stormwater runoff pollution (Ministry of Agriculture and Food, 1996). It is important to identify locations on your site where compost is least likely impact stormwater runoff. The best locations are:

- Away from the street,
- Higher ground (not sitting in a depression that collects water),
- And out of the path of runoff.

Refer to your sketch and runoff notes to choose the best location for your site. Compost can be maintained on impervious surfaces as well, however, it will be essential to manage any runoff that comes from those surfaces. Berms or vegetated buffers (or strips) can be implemented to slow and filter any water leaving the compost area before it reaches the street (*see Structural Practices Below*).

Livestock & Manure

Many urban agriculture sites raise animals for the benefit of eggs, milk, or meat. They have an integral tie to farming and the crops on the site can benefit from their manure. However, raising animals on your site could impact stormwater runoff pollution (EPA, 2005) and it is necessary to select a location that will minimize this impact. Again you will want to refer to your sketch to identify which locations seem the most appropriate, as you did for compost. Additionally, you will want to regularly remove manure from the animal pen to reduce a build up of the nutrient rich material. This can be added to your compost or perhaps shared with another local urban farmer. As with compost, you can reduce the amount of runoff around coops and other animal pens by installing vegetated buffers or berms.

Mulch

Mulch is one of the easiest and cost effective ways to improve stormwater runoff. As an added bonus, it will minimize weeds and weed growth, increase soil moisture, reduce soil erosion, improve the soil and protect your crops (University of Florida, IFAS Extension & Florida Department of Environmental Protection, 2009). There are many types of mulch you can choose from. Some options include woodchips, fallen leaves, hay, grass clippings, or even gravel or pebbles. Each type has benefits and drawbacks, but all will aid in slowing and filtering runoff. As you apply mulch to your site, be sure to consider what you are mulching. Allowing mulch onto sidewalks or other impervious surfaces will provide an opportunity for flowing water to pick up the mulch and carry it away since most mulches float. You do not have to forgo using mulch on or near impervious surfaces, but rather create a way to contain it. An example of this is creating a raised bed. This approach will allow you to reap all the benefits of the mulch and help stormwater stay cleaner.

For more information on the benefits of different types of mulch and tips on how to apply it, check out The Florida Yards and Neighborhoods Handbook (http://fyn.ifas.ufl.edu/materials/FYN-Handbook-v1-2012.pdf).

Pesticides and Fertilizers

Protecting and helping plants thrive is one of the main objectives of many urban agriculture sites. Pesticides and fertilizers provide several ways of meeting this objective. However too often these can be misused and find their way into stormwater runoff.

Fertilizer

When applying fertilizer, evaluate what your plants need and choose a fertilizer accordingly. To prevent fertilizer pollution:

- Select slow release fertilizers,
- If you spill it, clean it up quickly and thoroughly as to not leave anything behind, especially on a impervious surfaces,
- And don’t fertilizer before a heavy rain event (University of Florida, IFAS Extension & Florida Department of Environmental Protection, 2009).

If you are using compost, then you may not need to add other fertilizers, except to correct for nutrient deficiencies. Remember that organic fertilizers are just as rich in nutrients as many chemical fertilizers and you should follow these same guidelines in order to prevent runoff pollution.

Pesticides

Managing pests on your urban agriculture is a never-ending task. Integrated pest management (IPM) is “an approach to the management of pests in which all available control options, including physical, chemical and biological controls, are evaluated and integrated into a unified program” (Hoffmann, M.P. & Frodsham, A.C., 1993, p. 51). The idea is to combine multiple tactics to eliminate pests, instead just one.

- To prevent pests try the following:
- Keep your plants healthy,
- Regularly check plants for pests,
- Learn to identify beneficial insects (University of Florida, IFAS Extension & Florida Department of Environmental Protection, 2009).

A great resource for learning more about beneficial insects is the book *Natural Enemies of Vegetable Insect Pests* by Michael P. Hoffmann and Anne C. Frodsham (1993). The book includes numerous colorful illustrations and descriptions of the most common beneficial insects. Also, the Florida Yards and Neighborhoods Handbook has a section that discusses IPM, as well as beneficials and how to identify them (http://fyn.ifas.ufl.edu/materials/FYN-Handbook-v1-2012.pdf).

When you do find pests, how do you treat them?

- Pick them off by hand and kill them,

- Remove infected portions of the plant,
- Check for beneficial insects (if you find them they are probably taking care of the problem),
- Don't treat all pests the same and use a broad-spectrum insecticide (it will kill both the good and the bad insects),
- And always try low impact solutions first (University of Florida, IFAS Extension & Florida Department of Environmental Protection, 2009).

When applying any insecticide, be sure to read and follow the manufacturer's instructions to avoid poisoning people, pets, or the environment.

Structural Practices

Land Preparation

In order to farm, you need land. In the City, land can come in many different shapes, sizes, heights, and textures. Because of these unpredictable circumstances, you have to be flexible and creative, in order to build a successful urban agriculture site. Sloping terrain and sites with impervious surfaces pose particular challenges when it comes to managing stormwater runoff.

Slopes

Terracing

Creating a site for agriculture on a slope is a difficult and challenging endeavor. One of the most effective techniques of hillside agriculture is terracing. The Minnesota Department of Agriculture lists five reasons to terrace:

- Reduces soil erosion by breaking long slopes into a series of shorter ones
- Protects water quality by intercepting agricultural runoff
- Helps prevent gully formation by directing runoff to stable outlets
- Makes it easier to farm steep slopes
- Improves soil quality and productivity by improving moisture retention and reducing soil erosion (Minnesota Department of Agriculture, 2013).

Depending on the slope of your site, there are several different techniques that can be applied. The Food and Agriculture Organization of the United Nations has created a document called *Conservation Agriculture for farmers and extension workers in Africa* that describes various methods of conserving soil on a slope, http://www.fao.org/ag/ca/AfricaTrainingManualCD/PDF%20Files/08WATER.PDF (FAO, ACT & IIRR, 2005). Although the text is geared for Africa, it provides descriptions and illustrations of various types of terracing practices and how they work. According to Wheaton, R.Z. & Monke, E.J of Purdue University, it is possible to install your own terraces, but they recommend hiring an engineer, "Regardless of who installs it, a terrace system must be well designed. Terraces must be spaced correctly, have adequate ridge height and channel cuts to provide the necessary water storage, and have properly-sized outlets. Considerable field surveying work may be needed to design and stake out a system. Usually this will require the services of an engineer or someone specially trained in terrace design" (2001).

Contour Swales

Contour swales are another strategy you can use to manage runoff on sloping land. Contour swales are designed with a combination of a berm and a ditch that in combination slow and capture runoff, allowing it to infiltrate into the ground. These swales are built along the contour of a slope perpendicular to the direction of the runoff. Additionally, this technique could also be applied to sites that have a slight slope at the edge of a site towards the street. The best instructions on how to develop contour swales can be found at WikiHow, *How to Dig Swales*: http://www.wikihow.com/Dig-Swales.

Farming on Concrete

Large swaths of the urban environment are covered with impervious surfaces. An impervious surface is made of material that does not allow water to pass through it, like cement and pavement. Due to this characteristic, water collects and moves; gaining momentum as more water is added. This moving water can easily wash loose soil, if it is not bounded, from an impervious surface. To farm on concrete, the key is to think containers and rooftops. Containers allow you to pile soil on concrete within the confines of a container. A container can be a pot, a bathtub, or even a bottomless wood frame box (the bottom is the concrete). The container restricts the soil from being washed away with stormwater runoff. Farming on concrete also allows you to farm without soil. Many rooftop sites utilize hydroponics as a means of growing their produce. You can find more information and techniques on how to farm on cement at ECHO: http://www.echonet.org/content/urbanGardening/697. Note, you will have some slight runoff if you use containers, because your plants will need to be able to drain. Any water that is shed from the concrete should be directed to a rain garden or passed through a vegetative buffer strip to allow the runoff a chance to infiltrate or be filtered before it enters the street. More information on these techniques is detailed below.

Rain Gardens/Bioretention Basins

Rain gardens or bioretention basins are a type of vegetated water retention basin. The purpose of a retention basin is to collect runoff (instead of letting it go to the street) in order to allow it to infiltrate back into the ground. By slowing the velocity of the runoff, the water has the opportunity to permeate into the soil. The size, shape, and depth of the basin depends on the amount water you need to collect for your site. Check online for a rain garden calculator to help you determine what size basin to create.

A good place for a bioretention basin is in an area that water naturally accumulates on your site. Since water already flows to this area, it will minimize the some of the work involved in figuring out how to get water to move to a designated area. Other places you may want to consider a rain garden/bioretention basin is near compost, especially if the compost is on an impermeable surface.

Although it is highly recommended to plant rain gardens and bioretention basins with native plants that can handle periods of standing water, you may want to consider integrating plants that will be beneficial for your site. Space is valuable in an urban agricultural site and adding plants that do not have an edible component or market value may not be a realistic option. Consider selecting native species that flower, such as salvias, and will attract pollinators to the site. Another option might be adding perennial herbs, many of which, such as rosemary, lavender, and sage, are drought hardy and could be planted on the upper portion of the rain garden or bioretention basin. Herbs are a wonderful addition to an urban agriculture site that can be sold or added to value added products. Additionally, several types of perennial or annual flowers could be added as well and be used as cut flowers for sale. For more ideas on potential plants, check out: http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-67996/6.4.8%20BMP%20Vegetated%20Swale.pdf

There are multiple websites where you can find more information about rain gardens and bioretention basins and how to create your own: http://buildgreen.ufl.edu/Fact_sheet_Bioretention_Basins_Rain_Gardens.pdf, http://raingardenalliance.org/, http://www.lakesuperiorstreams.org/stormwater/toolkit/bioretention.html, http://www.msa.saccounty.net/sactostormwater/RFL/raingardens/raingardens.asp#started. Depending on your site, it could be easy or fairly technical to install a rain garden/bioretention basin. Many local engineers, landscape architects, and consultants are familiar with this BMP.

Vegetative Filter Strips

Research has shown that vegetative buffer strips (VFS) can remove sediment and nutrients from stormwater runoff (Grismer, O'Geen, & Lewis, 2006). According to Dilliah et al. "A VFS is an area that is planted intentionally to help remove sediment and other pollutants from runoff water" (as cited in Grismer, O'Geen, & Lewis, 2006). Most VFS are planted with grasses as they have been found to most effectively filter runoff (Field, O'Shea, & Chin, 1993).

Creating a VFS between your site and the street will improve water quality by filtering sediment, capturing nutrients, and removing pathogens from runoff (Grismer, O'Geen, & Lewis, 2006) before it enters the storm drain. Because space may be limited on your site, consider placing the VFS outside the fenced area of your site. The University of California, Davis has published an excellent article that describes further how VFS work and how to design and install your own on your site (http://ucanr.org/freepubs/docs/8195.pdf).

Berms

Berms are another technique that can be used to either filter sediment from stormwater runoff or form a bank that keeps water from flowing beyond a specific point. A **filter berm** "is a dike of compost or a compost product that is placed perpendicular to sheet flow runoff to control erosion in disturbed areas and retain sediment" (EPA, 2010). This BMP would work especially well on an urban agriculture site that has areas of where large amounts of water pass through. Filter berms can also be used in connection with a retention basin, by slowing runoff and reducing the amount of sediment that ultimately reaches the basin. The EPA's website describes how to construct a filter berm and includes information on what size would be appropriate based on precipitation rates (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=119). The drawback of the filter berm is that is does not filter out all nutrients or chemicals. It is not recommended that a filter berm be your only line of defense against stormwater runoff pollution.

An **earthen berm** is composed of soil and functions "as a dam to temporarily hold back water (floodwater storage) or they can be used to deflect or collect water"

(Stone & Hilborn, 1999). The intent of this berm is to stop runoff from leaving the urban agriculture site and guide it to an area where it can infiltrate the soil. Unlike a filter berm, an earthen berm is more likely to keep nutrients and chemicals from leaving your site and entering into stormwater runoff. An earthen berm fact sheet, produced by the Ministry of Agriculture in Ontario, Canada describes how to construct an earthen berm and maintain it (http://www.omafra.gov.on.ca/english/engineer/facts/99-047.pdf). Be careful not to construct your berm so close to a street curb that if any erosion occurs, the soil falls in the street. Both the earthen berm and the filter berm can be used for plantings. Consider using the berm to grow perennial plants that will attract pollinators to your site or perennial herbs, cut flowers, or grasses.

Vegetative Swales

Similar in function to contour swales, vegetative swales are "broad, shallow channels designed to slow runoff, promote infiltration, and filter pollutants and sediments in the process of conveying runoff" (Department of Environmental Protection, Bureau of Watershed Management, 2006). Vegetated swales act as a gutter and curb system would along a street, but with the ability to slow the flow and allow runoff to permeate and not be flushed directly into a local water body. Because of these characteristics, the best location for these swales is along the street frontage of your site. Like the retention basin or rain garden, you can vegetate the swale with a variety of plants, some which can tolerate standing water as well as those that are drought hardy. The Central Coast Water Board and the UC Davis LID Initiative have created a document that helps you select the right plants for your swales, rain gardens and retention basins:

http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-67996/6.4.8%20BMP%20Vegetated%20Swale.pdf

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APPENDICES

A. Interview Questions

B. Urban Farmer Mini Survey

C. Themes and Findings

D. Site Visit Observations

APPENDIX A

Interview Questions

Semi-structured and open-ended interviews were conducted with individuals from different agencies and roles in order to better understand and analyze the relationship between urban agriculture and stormwater. Five groups have been identified as having either a direct or indirect role in stormwater management and urban agriculture. Selected individuals from these groups were invited to participate in a 45-minute in-person or telephone interview. Each interviews was scheduled in advance and each participant asked to complete an Informed Consent Form.

The interviews were semi-structured and open-ended. Based on a respondent's answers, follow up questions were asked. One set of questions could apply equally for each of the groups, therefore a reference is provided below indicating the questions asked of that group. The comprehensive list of questions follows.

Interview Groups

1. Regional Water Quality Control Board
   Questions: 1, 2, 4, 11, 12, 13, 14, 15

2. Clean Water Program
   Questions: 1, 2, 10, 11, 13, 14, 15

3. Stormwater Managers (Public Works Agency, Public Utilities Commission, and Storm Water Division)
   Questions: 1, 2, 3, 4, 5, 11, 13, 14, 15, 16

4. City Planners (City Planning Departments)
   Questions: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 16, 17, 18, 19, 20, 21

5. Community Activists for Urban Farming
   Questions: 1, 2, 3, 4, 5, 13, 14

Interview Questions

1. How is your organization/department involved in the development of urban agriculture?

2. Did your organization/department collaborate in the development of [the city's] urban agricultural programs? If so, in what way?

3. What benefits do you see with the implementation of urban agriculture with [the city]?

4. What concerns do you have with more urban agriculture in [the city]?

5. To what extent should urban agriculture be regulated? What are some regulations you would want to see?

6. Are there currently any permits cities or individuals must obtain in order to construct or create an urban agricultural project?

7. What was the process that [the city] went through in order to accept urban agriculture as an allowable use?

8. Were there examples of other urban agricultural programs that [the city] used as models?

9. Who participated and is participating in the development an urban agricultural ordinance?

10. Urban agriculture is a more intense procedure of crop or animal production than most home gardening. Do you have programs specifically targeted at urban farmers or those interested in urban farming?

11. Do you provide public outreach or education that includes information about minimizing the impacts of urban farming (sediment, nutrients, pathogens, pesticides, metals and salts) on stormwater contamination?

12. Within the urban setting, clean water is maintained through the National Pollutant Discharge Elimination System (NPDES) permit program. Do urban agricultural activities fall under this program?

13. Do you think urban agriculture will have an impact on local water quality? Have others raised concerns about how urban agriculture may impact water quality?

14. Do you think urban agriculture will have an impact on stormwater management?

15. How much education is provided on stormwater runoff in [the city]?

16. Do urban agricultural projects in [the city] implement stormwater Best Management Practices (BMPs)?

17. Are urban agricultural projects of [the city] creating their own compost on site?

18. Are urban agricultural projects of [the city] raising livestock?

19. Are urban agricultural projects of [the city] using pesticides/herbicides?

20. Are urban agricultural projects of [the city] using other irrigation methods other than drip?

21. Do urban agricultural projects of [the city] contain large sections of bare soil?

22. Have you received education or training in managing stormwater in an urban environment?

APPENDIX B

Urban Farmer Mini Survey

The Urban Farmer Mini Survey was designed to gather a snapshot of information. The brief survey was sent to eight farmers, six responded to the survey. Below is a sample of the e-mail and survey that was sent.

My name is Rachel Cohen and I am a Masters Graduate Student in City & Regional Planning at Cal Poly University, San Luis Obispo. I am writing to you because I believe you may be able to assist me with my thesis research. I am looking at how urban agriculture can play a role in minimizing runoff and improving a city's overall urban stormwater management program.

In an effort to better understand what the farms are like in [the City] I am asking different organizations to share with me about their farms. Since I know you are very busy, I have created a very short questionnaire (below). It should take no more than 5 minutes. I really appreciate your help. All information will remain secure and kept confidential.

Short "yes" or "no" type responses are encouraged, but feel free to elaborate if you desire.

1. Approximately how big is your urban farm?
2. How many sites do you farm in Oakland?

3. Do you raise livestock? If so, what kind?

4. Do you make compost on your site?

5. What irrigation methods do you use?

6. Have you received education about stormwater or urban runoff?

APPENDIX C

Themes and Findings

Interviews with stakeholders, the farmer survey, and observations gathered from site visits were gathered and compared for similarities. Below are topics and/or themes that overlapped. The "X" indicates the topic and which groups contributed to that particular topic. For the most part, only topic/themes that received two or more Xs were considered to be significant and included in the results.

Findings	Stakeholders	Farmer Survey	Site Visit
Values and Concerns			
Urban agriculture is valued. The motivation may be different for each group, but the goal is to increase opportunities for urban agriculture within the City.	X	X	X
There are concerns about urban agriculture and its relationship with the urban environment. Especially the inclusion of livestock.	X		X
Existing Conditions and Practices			
Urban agriculture should be/is practicing sustainable and organic farming techniques (i.e. composting, water conservation, no pesticide/herbicide use, etc.).	X	X	X
Sustainable/Organic practices have resulted in farms applying BMPs that also manage stormwater runoff.		X	X
Sites showed evidence of water runoff and sediment loss.			X
Every site is unique in form, design, terrain, climate and management.		X	X
Regulations & Policies			
No regulations or policies are triggered for Urban Agricultural development.	X	X	X
No enforcement of stormwater runoff	X		

Findings	Stakeholders	Farmer Survey	Site Visit
Regulating stormwater runoff creates obstacles or discourages farmers from investing in urban agriculture; balancing act	X		
Potential Solutions			
Education is not available/non-existent/rare on urban agriculture stormwater runoff	X	X	
Numerous strategies exist for urban agricultural sites to keep water from leaving their site. Not only is this beneficial for protecting water sources, it is also beneficial for the farm.	X		X

APPENDIX D

Site Visit Observations

During the months of March and May 2012, site visits were made to existing urban agricultural sites in both Oakland and San Diego. Observations were made based on seven questions or criteria. Below is a table that includes all the information that was collected during visits to each of the sites. A total of 10 sites were visited and observed.

Site #	Location	Are there indications of water run off the site?	Are there animals on the site? If so, what kind and where are they located on the site?	Is there compost on the site? If so, where is it located on the site?	What practices are being implemented that may to contribute to runoff pollution?	What practices are being implemented that appear to protect against runoff pollution?	Are there indications that the site is valued? If so, what are they?	What is on the site (basic observations)?
1	Oakland	No.	Yes. Bees. The hive is at the edge of the site.	Yes. Compost is located on the edge of the site, near the fence and next to the tool shed.	The close proximity of the compost to the street.	Mulching. Plant coverage. A wide buffer between the site and the street that is mulched or vegetated. A drainage field. Drip irrigation.	Very engaged director and volunteers working at the site, clean and well-maintained site (no trash or weeds), shared community dinner made from the garden.	The site has several raised beds made of wood framing. There is a 12-foot fence around the site. The site contains a drainage field for the baseball field next to the site and there are portions of the site that stay wet continuously.
2	Oakland	No.	Yes. Chickens. They are situated along the fence.	Did not see compost.	The proximity of the chickens to the street.	Crushed rock mulch. Large buffer between the street and the site that is vegetated and mulched. The site actually sits slightly lower than the ground outside the fence. Drip irrigation.	Clean and well maintained site (no trash or weeds), actively selling produce from the site.	The site is a triangle piece of property that is between three streets. The crops are grown in raised beds made of corrugated metal and wood. The site is fenced. They have a tool shed on site that is made from ½ a storage container. The other ½ is used for a chicken coop.
3	Oakland	Yes.	Yes. Chickens. The coop is situated in the inner corner of the site against the fence closest to the neighbor's property.	Yes. One plastic compost bin, placed against the fence closest to the neighbor.	The soil is higher on the site than the sidewalk.	Rain catchment system. Mulching.	Clean (no trash).	The site is fenced and locked. At the time of the observation, the site contained no vegetable beds, fruit trees, picnic tables, a chicken coop and a rain catchment system. Observations were made from outside the fence.
4	Oakland	Yes.	No.	Did not see compost.	Fencing has a gap at the bottom and the soil is higher behind the fence than the sidewalk. Beds next to the street are built higher than the sidewalk and are overflowing.	Mulch. Raised beds with borders.	Artwork on the fence, clean (no trash).	The majority of the site is within a chain link fence with privacy slats. Additional plantings are within the space between the sidewalk and the street. This area was mulched, but the mulch was strewn everywhere and dirt was on the sidewalk and in the street. The portion of the site within the fence is made of a mix of cement and dirt surfaces.
5	Oakland	No.	Chickens. The coop is placed in the inner corner away from the street.	Did not see any compost.	New beds on a cement slab without any framing, only mulch surrounding the new beds. Water was on the street after hand watering the planter boxes.	Mulching. Thick vegetative buffer on the inside of the wood wall. Drip irrigation.	Paintings integrated into the garden, clean and well-maintained site (no trash and minimal weeds), high interaction with the community selling food and seedlings, engaged volunteers and staff working on the site.	The site is comprised of two parts. A wood fence/wood wall about 15 feet high surrounds the older part. Behind the wall are raised wood framed beds, a greenhouse, nursery tables and a chicken coop. The newer portion of the site is across the street and is surrounded by a chain link fence. The newer part of the site is made of a large cement slab and dirt. Outside the fencing of the two parts, the site also contained several wood planter boxes placed along the sidewalk.

Site #	Location	Are there indications of water run off the site?	Are there animals on the site? If so, what kind and where are they located on the site?	Is there compost on the site? If so, where is it located on the site?	What practices are being implemented that may to contribute to runoff pollution?	What practices are being implemented that appear to protect against runoff pollution?	Are there indications that the site is valued? If so, what are they?	What is on the site (basic observations)?
1	San Diego	No.	Yes. Tilapia and goldfish. Most of the fish are contained in the greenhouse in the middle f the site. A small tank is located at the middle edge of the site.	Yes. Along the back of the site, next to a port-o-potty, in front of a fence that borders an alleyway.	Loose dirt and woodchips over cement and pavement that is not contained.	Beds framed to contain soil. Use of woodchips.	Relatively clean, engaged staff working on the site, attractive display of nursery plants, interactive display of aquaponics system.	The site is developed to raise fish, produce and ornamental nursery plants. The site is fenced and contains a greenhouse for the aquaponics system, a potting area for the nursery, a small retail nursery area, several beds (some filled with cuttings and plants, others empty), an outdoor aquaponics system, a shade area, an area to store potted plants and a composting system.
2	San Diego	Yes.	No.	Yes. Compost is collected in the middle of the site.	Three foot buffer from the edge of the garden to the street. Soil higher within the site than outside. Water cut marks visible from overwatering.	Mulch. Diverse plant coverage (both perennials and annuals). Drip irrigation.	Artwork in the fence and the communal area of the site, clean and well maintained site (no trash and minimal weeds).	The entire site is fenced and locked. Wherever there is soil, there is either something growing or a walkway. There is sort of a haphazard approach to the layout/design of the site. The site contains several small structures, such as a greenhouse or shade structure. There is a central area that hosts a palm thatched gazebo and bulletin board, a large enclosed shed, a structure that holds pots, and a composting area. Observations were made from outside the fence.
3	San Diego	Yes.	No.	Yes. On the edge of the site, close to a downhill slope. Next to the compost are remnants of a pile of horse manure.	Terracing without proper reinforcement. Compost/manure at the top edge of a downhill incline.	Mulching. Terracing with cement block supports in the orchard. Vegetated hillsides. Water detention system.	Clean and well maintained site (no trash or weeds), employs creative gardening techniques and garden art.	The site is made of many long beds of vegetables and herbs and a small orchard. Additionally, the site contains a stormwater run-off detention system from a near by parking lot. The site is not fenced.
4	San Diego	Yes.	No.	Did not see compost.	Dirt, stepped pathways that are not reinforced. Exposed slopes (no vegetation or cover of any kind.	Mulched paths. Drip irrigation. Diverse plantings.	Clean and well maintained site (no trash or weeds), engaged staff and students.	The site is fully planted with vegetables, flowers and fruit trees. Vegetables are planted in beds and interplanted on the terraced side of the site with fruit trees. The site is fenced and locked.
5	San Diego	Yes.	No.	Did not see compost.	Exposed dirt on the hillsides. Minimal terracing.	Mulch. Vegetation coverage under the orchard on the slope. Drip irrigation.	Clean and well maintained site (no trash and minimal weeds).	About 1/3 to ½ the site is planted; fruit trees on the slopes and vegetables planted in beds along the flat portions of the site (the top and bottom of the slope). The site was fenced and locked. Observations were made from outside the fence.