DOES THE BAY AREA HAVE A SOCIAL CENTER?

Delimiting the Postmodern Urban Center of the San Francisco Bay Area

by

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DEDICATION

I dedicate this document to my wife, Breehan, and parents, Jeff and Marlene, for their constant support throughout this process. Without Bree's support, both emotional and editorial, there is no way this thesis would have been completed.

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LIST OF ABBREVIATIONS

ABAG   Association of Bay Area Governments

AWS   Alternative Work Schedule

CBD   Central Business District

CSA   Combined Statistical Area

CTD   Central Technology District

DMM   Directory of Major Malls

E/R   Employee to Resident Ratio

GIS   Geographic Information Science

GLA   Gross Leasable Area

ICSC   International Council of Shopping Centers

LC   Location Coefficient

LISA   Local Indicators of Spatial Association

MAUP   Modifiable Areal Unit Problem

MSA   Metropolitan Statistical Area

MTC   Metropolitan Transportation Commission

NAICS   North American Industry Classification System

PI   Proximity Index

UCI   Urban Centrality Index

V   Venerables Index

ABSTRACT

An analysis of urban morphology was conducted in the San Francisco Bay Area using Local Indicators of Spatial Association ("LISA") to quantify clusters of different types of Urban Amenities (Anselin 1995). Concentrations of different types of Urban Amenities were given a centrality score, which was then used to delimit the Social Center or Centers of the Bay Area.

This thesis project used Samuel Krueger's (2012) methodology, employing multiple regular hexagonal arrays of different size to aggregate indicator amenity points. The aggregated clusters of amenities were calculated, assigned cluster scores, and ultimately ranked by centrality and finally shared as a cartographic visualization.

Previous methods for delimiting urban structure focused on employment centers, commuting patterns, and the Central Business District ("CBD"). This research seeks to expand on Samuel Krueger's method measuring clusters of Urban Amenities that describe the experience of place to delimit an ambiguously bounded but internally consistent central place known as the postmodern urban center (Krueger 2012; Dear & Flusty 1998). The objective was to determine whether San Francisco represents the center of the San Francisco Bay Area, or if the nickname the "Bay Area" better fits the region today.

This study reveals both polycentrism and strong centers with two dominant urban centers: San Francisco and Oakland-Berkeley; and an unexpected suburban center focused on the Silicon Valley, capturing Santa Clara and Sunnyvale, but mostly excluding San Jose.

CHAPTER 1: INTRODUCTION

Urban sociologist Ray Oldenburg discusses the importance of "third places"—informal public places where people meet and relax, such as coffee shops, taverns and bookstores. After home and work (the first and second places, respectively), third places are where people gather informally to participate in public life (Oldenburg 1999). Third places capture one of the primary functions of modern cities: socializing.

This thesis advances Oldenburg's theory of third places and delimits the spaces where people spend time (the "Social Center") as a new way to look at cities separate from residential and employment statistics. I will describe a method for identifying urban Social Centers using intersecting clusters of specific third places: (1) restaurants, (2) entertainment, (3) high culture, (4) trendy hangouts, and (5) hotels (each an "Urban Amenity" and collectively "Urban Amenities") to identify postmodern urban Social Centers, adapting the concepts of Samuel Krueger's research, and applying Krueger's method to the San Francisco Bay Area (Krueger 2012). These Urban Amenity clusters are analyzed and calculated using a Geographic Information Science ("GIS") analysis method known as Local Indicators of Spatial Association ("LISA") (Anselin 1995). LISA analysis identifies clusters of high or low values among a spatial dataset, as well as spatial outliers. In this study, clusters of Urban Amenities are summed to identify areas with Urban Amenity density. These core locations will delimit the Social Center or Centers of the San Francisco Bay Area.

1.1   Background

The majority of urban centrality research uses employment-focused methods such as employee density (Giuliano & Small 1991), employee to resident ("E/R") ratios (Greene 2008), and commuting networks (Cladera, Duarte & Moix 2009; Cervero & Wu 1998), applies thresholds

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for centrality to delimit a Central Business District ("CBD") using the "Central Business Height Index" (Murphy & Vance 1954), or uses office and retail space thresholds (Garreau 1992) to delineate urban centers. These methods all focus in one way or another on employment or housing.

Past studies of centrality in the San Francisco Bay Area assert and/or accept the conventional wisdom that the Bay Area is a polycentric region (Wu 1997; Cervero & Wu 1997; Cowell 2010). Polycentric regions:

1. Consist of a number of historically distinct cities that are located in close proximity;

2. Lack a clear leading city which dominates political, economic, cultural and other aspects and consist of a small number of larger cities that do not differ significantly in size or overall importance and a greater number of smaller cities; and

3. Consist of member cities are not only spatially distinct, but also constitute independent political entities (Cowell 2010, 947).

This study will identify weaknesses in employment-based studies and show why anecdotal evidence that San Francisco is the center of the Bay Area—the point around which the remainder of the Bay Area organizes and reorganizes itself—is true.

1.1.1   *Weaknesses in Applying Employment to Urban Centrality*

The workplace has transformed. As heavy industry gave way to a knowledge-based economy, warehouses became offices, offices became cubicles, and cubicles are now being reimagined and replaced with smaller individual work spaces, shared work areas, increased business travel, and working wherever the cloud or Wi-Fi is available. In this period of sustainability awareness, continuous access to work materials, the ability to work from anywhere, and Alternative Work Schedules ("AWS"), the amount of office space that companies *need* is an exceedingly

scrutinized expense. Offices that were once full 40 hours per week and the best place to accomplish work are now occupied for much fewer hours because of the cloud, Wi-Fi, cell phones, tablets, laptops and the decreasing cost of business travel (Hannum 2014). Telecommuters who work from home on set days or on tasks that require individual focus instead of teamwork are an increasing segment of the workforce (Hannum 2014). Laptops, now powerful enough to handle most business functions and inexpensive enough to justify the expense, have made the office unnecessary for a growing percentage of work functions (Jones 2013).

Two key trends that reduce office space are hoteling and hot-desking (Nelson 2013; Gladys 2014; Davis, Leach, & Clegg 2011). Hoteling is a reservation-based method for supporting unassigned seating in an office environment. Employees reserve workspace for a period of time and are able to plug in their own devices or login to company devices with their user ID and password. Hot-desking refers to multiple workers sharing one workstation either during one shift or often over multiple shifts (Davis, Leach, & Clegg 2011). These employment trends are diminishing the power of commuting and employment for understanding city structure (Hannum 2014).

1.1.2   *Urban Amenities Drive Urban Growth*

Richard Florida's *The Economic Geography of Talent* introduced the "Creative Class": educated knowledge workers drawn to work and live in urban environments for technology, talent and tolerance. The Creative Class is drawn to diverse environments that have a high "cool index." The "cool index" is measured by the concentration of amenities such as bars, nightclubs, museums, and galleries (Florida 2002). In this research, the "cool index" criteria are referred to as Urban Amenities.

The "24-Hour City"—epitomized by New York City, London, and Tokyo—where people can get anything they want any time of day, has become the goal of urban planners seeking to revitalize old cities with new life, and stands in stark opposition to "Nine to Five Cities" where shops close early and which become dark and quiet in the evening. According to Wolfe (2011), there are five critical qualities for a 24-Hour City to exist: (1) safety, which creates the conditions for the remaining four to exist; (2) mobility; (3) proximity; (4) commerce; and (5) interaction. San Francisco's spatial structure and pre-automobile design makes for a pedestrian friendly city, which fosters the development and existence of a Social Center that thrives with activity well past the core "Nine to Five" period. Mixed-use office, retail and housing is a current trend, but has been the common use type in San Francisco for more than a century.

1.1.3   Regionalization

Human population has transitioned from an agrarian society settled in the countryside, to an industrial society with suburbs spreading like spokes from major cities, to the present post-industrial knowledge-economy where North America is approaching 85% urbanization and cities are giving way to regions (United Nations, Department of Economic and Social Affairs, Population Division 2014). Today rural and suburban populations are infilling cities, millennials and baby boomers are opting for smaller spaces, shorter commutes, and walkable living (Thompson and Weismann 2012). Understanding how these regions sort themselves and function is of great interest to the residents that make up these new geographies and the policy makers tasked with operating them.

The Bay Area is a great case study of the challenges these regions face. Unlike Los Angeles, Phoenix, or Houston where the majority of the metropolitan population is encompassed in a single county, the Bay Area is made up of at least nine counties, making regional

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collaboration difficult to plan and execute. San Francisco itself is both a city and a county, while the balance of the Bay Area is comprised of 100 cities in eight different counties, which have competing agendas and limited instruments to act in concert. The Association of Bay Area Governments ("ABAG") is a regional planning agency that deals with land use, housing, environmental, and economic matters. The Metropolitan Transportation Commission ("MTC") and various other regional agencies advance sustainable development ideas. However, ABAG and MTC are advisory organizations and carry limited authority.

1.2   Purpose of the Current Study

This study will show in the following chapters that the Bay Area retains a central place, and the central place is the city of San Francisco. Adapting the postmodern urban method for delimiting urban Social Centers, arrays of cells will be used to find intersecting clusters of Urban Amenities, and by summing those clusters, Social Centers will be identified and demarcated (Krueger 2012). Previous studies of centrality show that the San Francisco Bay Area is polycentric; this study will show, using different criteria, that the Bay Area is actually still dominated by the San Francisco-Oakland historic core. While San Jose has a greater population than San Francisco and Silicon Valley has replaced San Francisco as the economic engine of the Bay Area, San Francisco remains the Social Center of the Bay Area.

1.2.1   Research Objective

The objective of this study is to determine whether the San Francisco Bay Area has a dominant center or multiple centers using pertinent methodology. The research questions are: (1) Does the San Francisco Bay Area have an urban center?; and (2) How does the San Francisco Bay Area's urban center compare to the Los Angeles urban center, the geographic region to which this methodology was first applied? Urban centrality has predominately been studied through various

spatial analysis techniques applied to the concentration of jobs or residential population (Giuliano & Small 1991; Cervero & Wu 1997). Employment only accounts for 40 out of 168 hours per week. The Urban Amenity methodology will measure where people spend their time during their non-working hours and how the San Francisco Bay Area is experienced by both residents and visitors.

1.2.2 Description of Study Area

This study is situated in northern California and focuses on the San Francisco Bay Area Megalopolis. There are many ways to define the San Francisco Bay Area. For some people the Bay Area means the City and County of San Francisco, for many the Bay Area is comprised of the nine counties that share the San Francisco Bay shoreline. For this study the Bay Area will include both the traditionally understood 9-county region, plus the additional 8 counties that make up the 17-county northern California megaregion defined by America 2050 (Regional Plan Association 2007). This area includes all of the counties that border San Francisco Bay plus the Greater Sacramento Metropolitan Region (Yolo and Sacramento counties), the increasingly connected northern San Joaquin Valley (San Joaquin and Stanislaus counties) and the counties that have recently fallen into the Silicon Valley's sphere of influence (San Benito, Merced, Monterey, and Santa Cruz) (Figure 1).

The strange case of the Bay Area nicely summarizes the current urban form of the Bay Area drawing on the literature and using a brief history lesson to explain the 150-year evolution of the region into the megaregion it has become (Walker & Schafran 2015). Because the Bay Area is made up of 9 counties and 101 cities, the political landscape is one of competing agendas and priorities. The Bay Area is the only U.S. metropolitan area with three central cities: San Francisco, Oakland, and San Jose. The Bay Area is home to 7 million people, and San Francisco

and San Jose each have a population of approximately 1 million. Oakland is approximately half

the size of San Francisco and San Jose. However, when the Bay Area is divided into three main

parts, Oakland's East Bay is slightly larger (2.5 million residents) than San Jose's South Bay

(1.75 million residents) and San Francisco's Peninsula (1.75 million residents). While the North

Bay does not contain a large city, Santa Rosa, San Rafael, the surrounding cities that make up the

affluent San Francisco suburb of Marin, and the well-known wine counties, Napa and Sonoma,

add approximately 1 million more people to the group who call the Bay Area home.

Figure 1 Thesis Study Area

The three major cities are known for their industrial concentrations. San Francisco is the

historic core of the Bay Area and remains a financial and business service employment center.

Oakland and the East Bay house the port and are the center of manufacturing and heavy industry in the region. San Jose and the South Bay, better known as Silicon Valley, are the global center of the information technology industry.

A larger definition of the Bay Area was used to reflect the increased distances people commute for employment, and the growing virtual and telecommuting population that information technology and knowledge work permits (Figure 2). This larger definition was chosen to avoid unnecessary omissions, leaving open the possibility of discovering surprises, and with the belief that the less populous counties have minimal effect on the overall results of delimiting the Social Center.
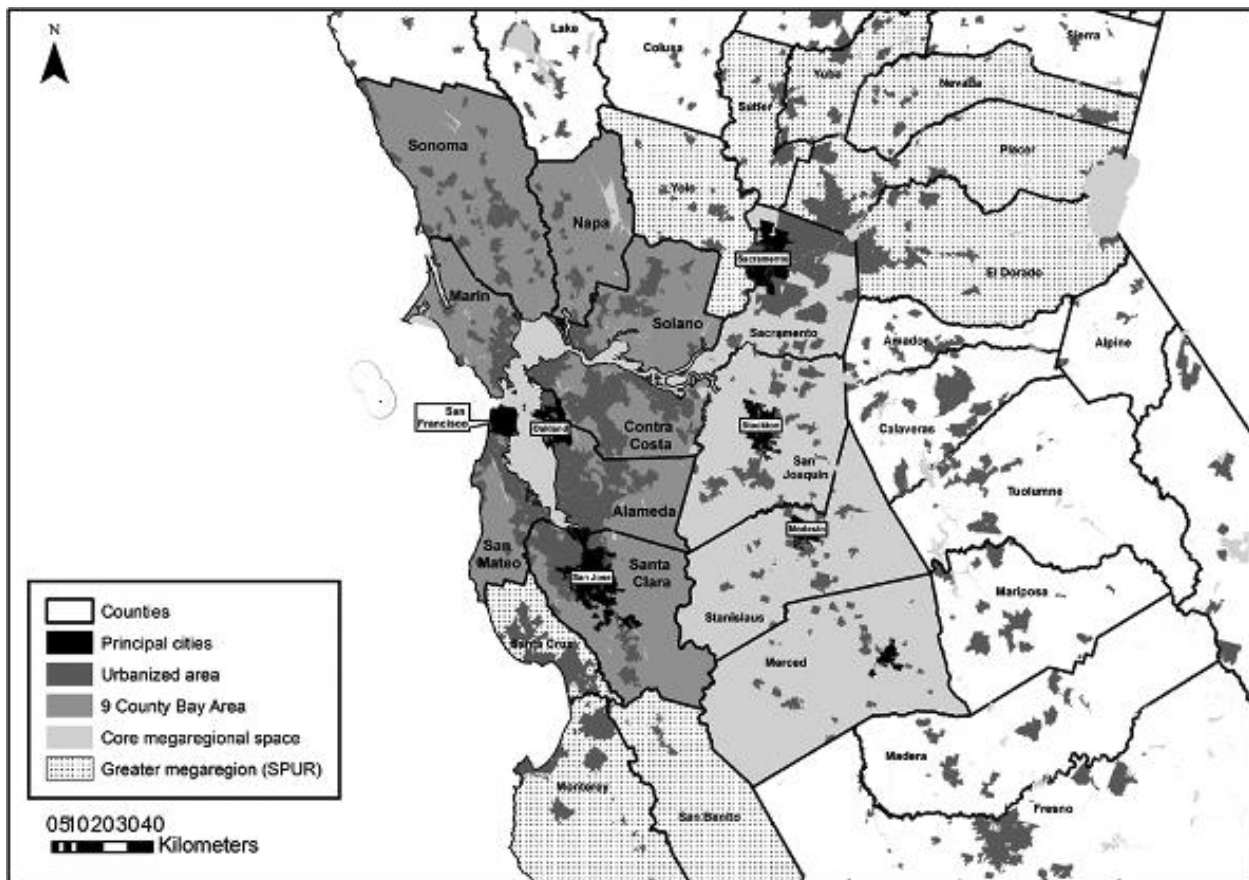
Figure 2 The Many Bay Areas
Source: US Cen sus Bureau, https://www.census.gov/geo/maps-data/data/tiger.html;
Metcalf & Terplan (2007); map by authors.

1.3   Thesis Structure

This thesis will show in the following chapters that the Bay Area is a polycentric megaregion with San Francisco as the strong center despite Silicon Valley's emergence as the origin and global center of the Information Technology industry. Chapter 2 reviews the relevant literature, Chapter 3 presents the data and methodology applied to execute the research, Chapter 4 presents the results, and displays and interprets them cartographically, and Chapter 5 offers some conclusions and suggestions for future work in this field.

CHAPTER 2: RELATED WORK

Three key questions need to be answered to establish a framework for this analysis:

1. What are the methods for delimiting city centers?

2. Are the existing methods for delimiting city centers still applicable in 2015?

3. What is known about the center of the San Francisco Bay Area?

2.1   Delimiting City Centers

Urban centrality has mainly been addressed by analyzing spatial patterns of employees and employment commuting patterns, quantifying the power of networks, and, more recently, measuring high amenity zones to delimit postmodern urban centers. These methods primarily focus in one way or another on employment or housing. Power and networking delimit the postmodern urban center by identifying concentrations of clusters of Urban Amenities.

2.1.1   Employment-Based Methods

Previous attempts to delimit city centers have focused on employment metrics or commuting for the purpose of employment. Other studies focus on industrial agglomerations or on the density of knowledge workers. Many Bay Area studies look for ways to examine, define and reinforce the widely held belief that the San Francisco Bay Area is uniquely and classically a polycentric region, accepting and advancing the edge city theory that suburban sprawl is equivalent to decentralization and a diminished central city (Garreau 1992; Cervero & Wu 1997; Greene 2008; Cladera, Duarte & Moix 2009). The primary focus of these economic and population methods is to determine the presence or absence of economic activity as depicted in Figure 3.

2.1.1.1 Employment Density Thresholds

Employment-based methods include employment density thresholds for delimiting urban centers, employee to resident ("E/R") ratios, and commuting networks for employment. A common

employment density threshold method is the '10-10' or '20-20' threshold cutoff advanced by Giuliano & Small (1991). The method requires finding all spatial units in a study area having minimum employment thresholds; '10-10' or '20-20' refers to the minimum thresholds of employees per acre and a total employment of 10 or 20 employees per acre and at least 10,000 or 20,000 employees total (Giuliano & Small 1991). Areas meeting these minimum criteria are defined as "subcenters." This study revealed a high degree of subcentering and concluded that the San Francisco Bay Area is losing its influence as a primary center. Figure 3 depicts subcentering in the Bay Area (Cervero and Wu 1998).

Figure 3 Bay Area Subcenters - Employment Centers Growing, Declining and Static
Source: Cervero, Komada & Kruger (2010)

The E/R ratio compares total employment to the number of resident workers in each spatial unit (Greene 2008). Any E/R ratio greater than one indicates a spatial unit is attracting more workers from other spatial units than it is sending to other spatial units (Greene 2008). Agglomerations of spatial units with greater employment than residents define employment subcenters. The E/R method is another way to confirm what zoning maps say: high rises and office parks have more employees than residential neighborhoods.

2.1.1.2 Commuting Networks

Commuting networks for employment reveal a multi-nodal urban structure (e.g. Figure 4). This method uses similar measures to the previous employment-based models, calculating a resident/R ratio. These methods reveal urban landscapes with subcenters everywhere, raising the question: What is learned from measuring employment?
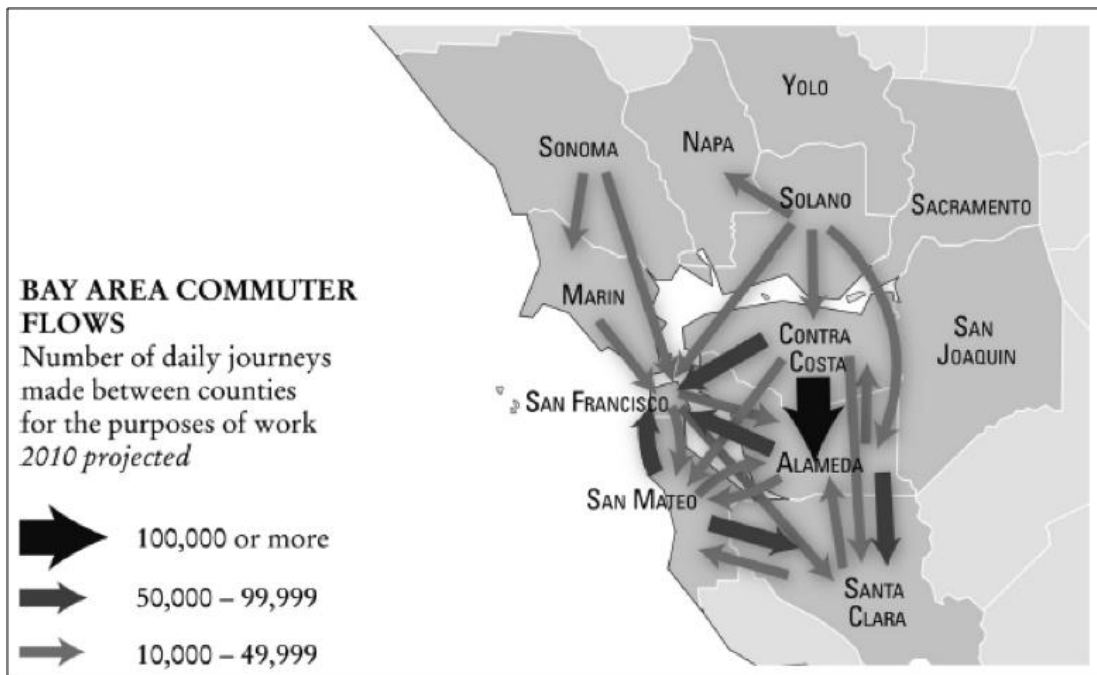
Figure 4 Bay Area Commuter Flows, 2010
Source: Data from Assocation of Bay Area Governments; cartography Isabelle Lewis; reproduced from Walker & Lodha (2013)

Cervero & Wu (1997) discussed the polycentric metropolitan form of the Bay Area from a traffic and commuting perspective. McMillen & Smith (2003), on the other hand, discussed the population threshold or thresholds that lead to the formation of subcenters. Studies have measured the impact of industrial agglomeration (Scott 1983), zoning and land use policy, housing affordability, and commuting on the growth and development of the Bay Area as a region, but have not delimited the urban core (Cladera, Duarte & Moix 2009).

Commuting shows the interconnectedness of the Bay Area region, but the rise of reverse commuting from San Francisco to Silicon Valley's corporate campuses via shuttle buses, CalTrain, and personal vehicles shows that Silicon Valley has become a central employment node and San Francisco its suburb (Figure 5) (Walker & Schafran 2015). High Tech, however, is making its way to San Francisco in the form of an emerging cluster of high rises centered on the ongoing TransBay Transit Center south of Market Street (Cutler 2014). Google, Twitter, Splunk Inc., Zynga, Dolby Laboratories, OpenTable, Yelp, Salesforce.com Inc., Square, Uber, UStream, GitHub, Pinterest, Airbnb, LinkedIn, Dropbox, and Planet LabsSega are all currently located or have signed agreements to occupy space in the South of Market ("SOMA") San Francisco neighborhood.
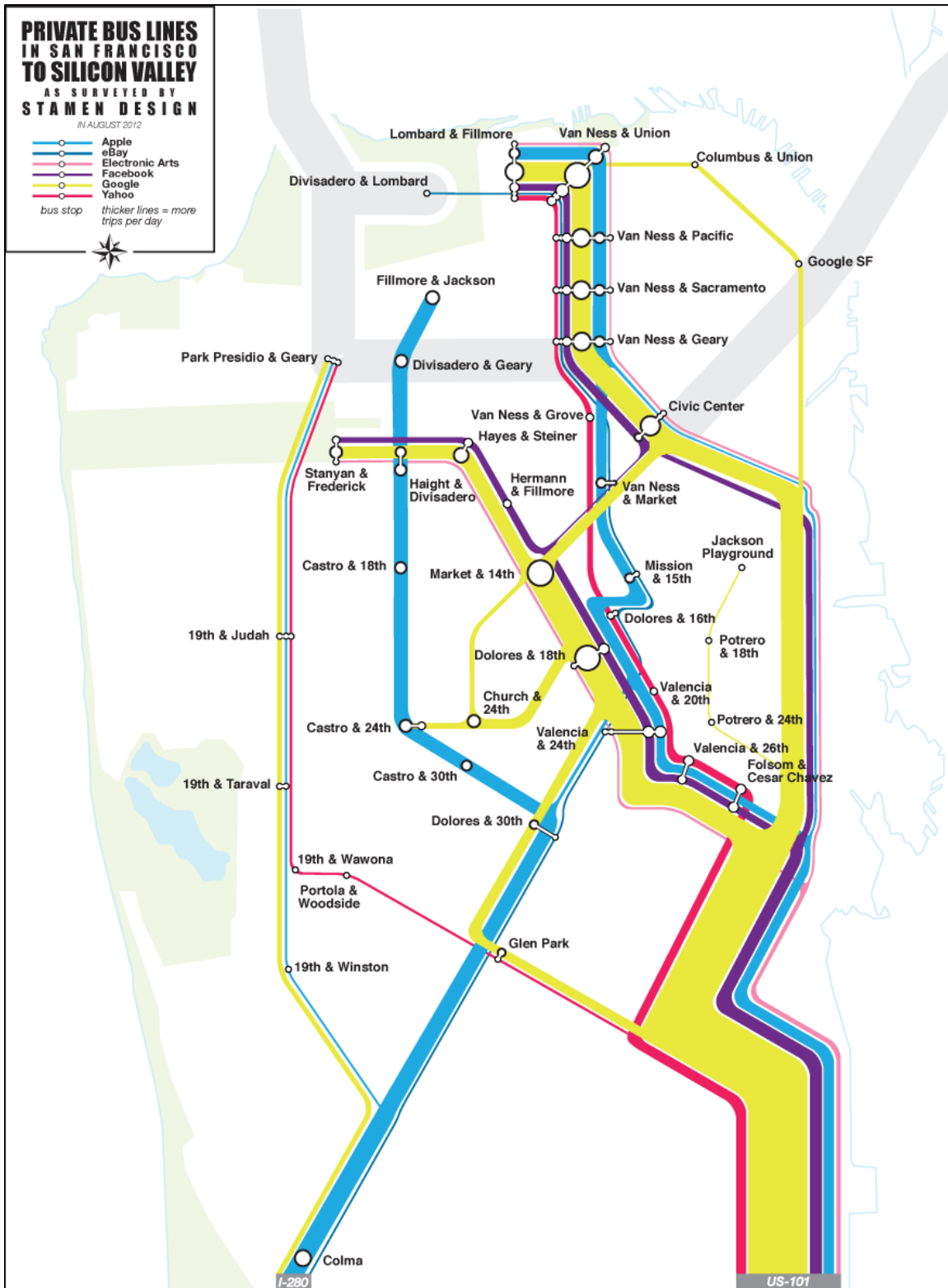
Figure 5 Corporate Shuttles From San Francisco to Silicon Valley
Source: Stamen Design (2012), http://www.stamen.com/zero1/

2.1.1.3 Urban Centrality Index

The Urban Centrality Index ("UCI") creates a single index to define and measure urban centrality in urban agglomerations. UCI identifies distinct urban structures from different spatial patterns of employment activities on a continuum from high monocentricity to high polycentricity, instead of defining an area as either monocentric or polycentric (Pereira et al. 2013). UCI employs the location coefficient ("LC") introduced by Florence & Baldamus (1948) to measure the unequal distribution of jobs within an urban area. The second component of the UCI, the Veneables Index ("V"), is based on the spatial separation index proposed by Midelfart-Knarvik and colleagues (Midelfart-Knarvik et al. 2000; Midelfart-Knarvik, Helene, & Overman 2002), which evaluates changes in the spatial distribution of economic activity across European regions, where V equals zero when employment is completely concentrated in one spatial unit (de Sousa 2002). As V has no maximum value, this led to the creation of the proximity index ("PI") to normalize V. PI is the opposite of V with a range of zero to one (0–1). The proposed UCI is the product of LC and PI (LC x PI). UCI identifies potential sub-centers. Then the subsequent sub-centers are included in the estimation equation and the estimated density functions where potential sub-centers having high coefficients are considered sub-centers (Pereira et al. 2013).

2.1.1.4 Central Business Uses

Central business methods were developed to delimit the CBD. These methods identify blocks and buildings that serve for-profit business use, employ a CBD Height Index, or set square footage thresholds for office and retail space to delimit the CBD by building type and use. These central business definitions narrowly define the center as the center of commerce (Murphy & Vance 1954).

2.1.1.5 Industrial Agglomeration

Scott (1983) described industrial agglomeration as business decisions to locate industrial plants in locations that best suit inter-plant linkages, reduce costs, and offer access to the relevant subcontracting community. According to Scott, uncertainty in some industries leads to significant subcontracting to distribute risk, and this leads to small- and medium-sized plants locating in a manner that links the larger plants. Shipping, rail and trucking all form large agglomerations near sea- and inland-ports.

Hall's (2003) *The End of the City? "The Report of My Death was an Exaggeration"* looks at industrial agglomeration from the perspective of advanced services instead of heavy and light industries. Four key groups of information-based activities dominate major global cities in this framing:

1. Finance and Business Services: banking and insurance, law, accountancy, advertising and public relations.

2. Power and Influence: national government, supra-national organizations, and headquarters of transnational corporations.

3. Creative and Cultural Industries: live performing arts, museums, galleries, print and electronic media.

4. Tourism: business and leisure tourism including hotels, bars, restaurants, entertainment and transportation services.

These industries principally involve the creation and exchange of information and contain significant overlap. The falling cost of transportation and communication has led to businesses that operate profitably in suburbs and small cities, knowledge work operations relocating to subcenters, and call centers relocating to remote locations for labor and operating cost savings,

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and friendly accents (Hall 2003).

This view of the city as a fusion of central business uses, Urban Amenities, and a cultural center, embraces the concept of the whole range of the city's uses. Hall describes today's archetypal urban form as a traditional business core, usually around a node; a secondary business core with headquarters and entertainment activities; a tertiary business core outside of the primary two zones with large concentrations of new offices; an outer edge city, usually near the major airports; the outermost edge cities, made up of planned towns or expansions; and specialized concentrations of activity that require large amounts of space such as stadiums, arenas, and convention centers, which are often located in edge cities (Hall 2003).

2.1.1.6 Office and Retail Space Thresholds

Garreau's *Edge Cities* (1992) dedicates an entire chapter to the structure of the Bay Area and defines several edge cities and emerging edge cities applying a minimum of 5 million square feet of leasable office space, and 600,000 square feet of leasable retail space, to advance the theory of polycentrism. Figure 6 depicts the polycentric Bay Area, showing seven edge cities, including San Jose, located around the San Francisco downtown area.

2.2   Power Centrality

Hall (2003) references the Global Analysis of World Cities urban hierarchy of global cities containing at least 5 million people serving very large global territories, and sub-global cities typically containing 1 to 5 million people and performing specialized functions at the regional or national level. San Francisco ranks high in this list, behind only New York City, Chicago, and Los Angeles in the U.S. and ranked 28th in the world. I would argue that the San Francisco Bay Area's boundaries are arbitrarily drawn and are the result of being founded before the car. "San Francisco" consists of the docks on Oakland's shores and Stanford University, the university that

fostered the Silicon Valley. Viewed this way, San Francisco is in fact a global city region.
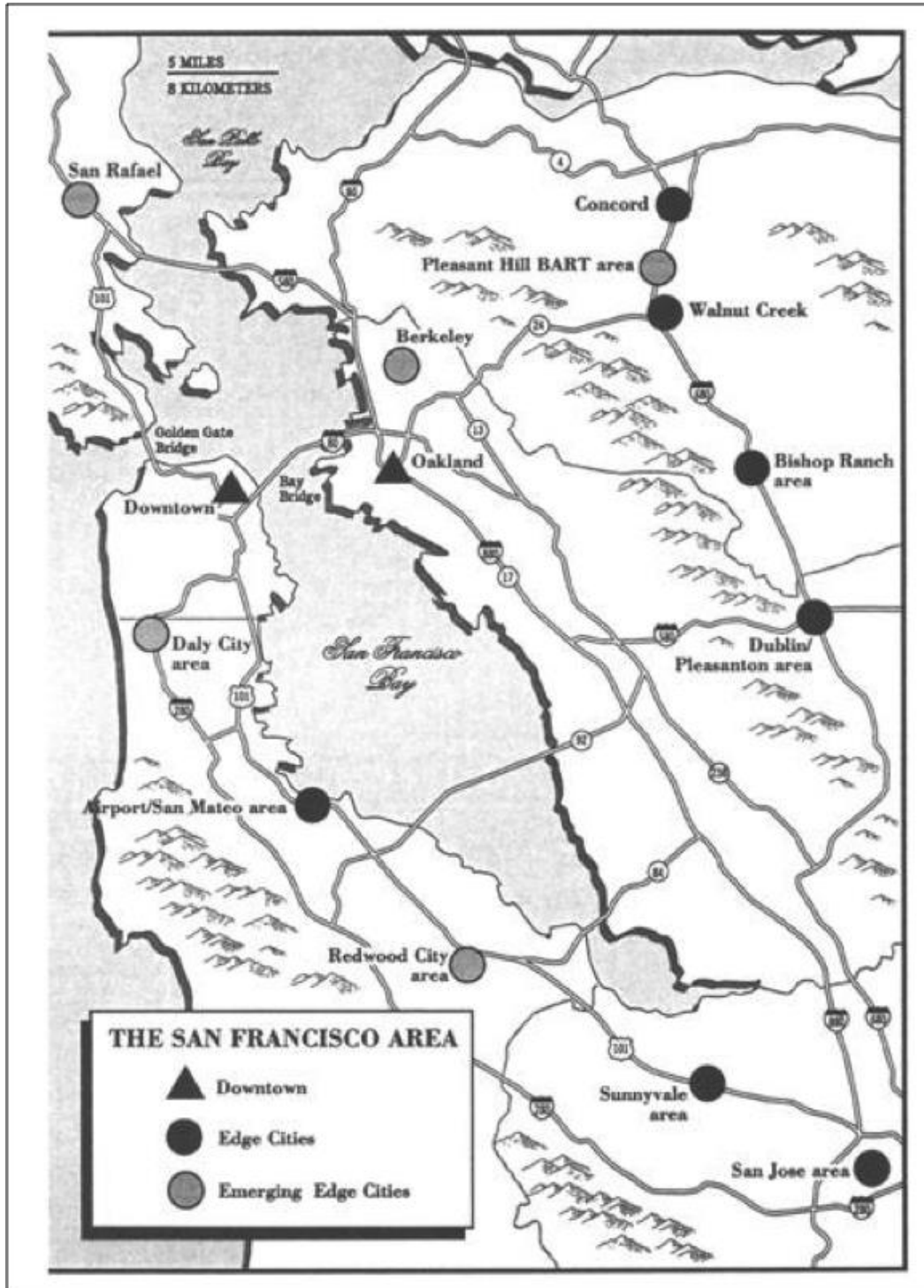
Figure 6 Edge Cities
Source: Garreau (1992)

Splintering Urbanism Theory, an offshoot of Power Centrality, defines the contemporary city as a fragmented agglomeration of isolated pieces that are highly connected without being contiguous (Graham & Marvin 2001).

2.3   Sustainable Workplaces

Sustainability, in this context, means that society and employees are holding businesses to higher environmental standards, which is leading to smaller, more efficient offices:

> "The contemporary green building movement arose out of the need and desire for more energy efficient and environmentally friendly building practices. The oil price increases of the 1970s spurred significant research and activity to improve energy efficiency and find renewable energy sources. This, combined with the environmental movement of the 1960s and 1970s, led to the earliest experiments with contemporary green building" (U.S. Environmental Protection Agency 2015).

Green building today is seen as an opportunity to reduce operating costs and to make a branding/public relations statement about a company. I would argue that green buildings and green thinking have decreased how much space a business requires. The shrinking of cube spaces, reduction of offices, and removal of walls to let in more natural light also let in more noise and distractions, which cause people to work from home where they can better focus on tasks that do not require collaboration. Green buildings increase telecommuting.

2.3.1 Reverse Commuting

Technology shuttle buses, the current symbol of San Francisco's gentrification paranoia, represent the manifestation of reverse commuting, and illustrate the impact urbanization is having on how suburban sprawl is being reversed in the Bay Area (Figure 5). Facebook, eBay, Genetech, Yahoo!, and Google all have private buses that shuttle workers from their homes in San Francisco to their jobs in Silicon Valley. These private shuttles are a response to the difficulty of navigating multiple modes of transportation and to the productivity lost when

employees spend up to four hours a day commuting to and from work. The shift in employment base from a population living and working in the South Bay suburbs to a younger generation of engineers living in San Francisco, Oakland and the East Bay and commuting south has caused a boom in high-rise development and a migration of many of the large technology companies into the city of San Francisco (Stamen Design 2015).

Sixty percent of SOMA's office space is now dedicated to Tech (Cutler 2014). San Francisco's desire to retain space for non-profits and the arts is driving commercial space rents up to dotcom era prices. Long commutes and knowledge work following knowledge workers is causing Silicon Valley companies to locate their newest offices near mass transit stops in San Francisco. The new TransBay Transit Center is being surrounded by new development, highlighted by the new Salesforce building, which will add more than 1 million square feet of office space. Redevelopment around the TransBay Transit Center includes housing, including affordable housing, and permits to exceed the previous building height restrictions. The new San Francisco skyline is being driven by High Tech. The market is now offering both corporate campuses and high rises to accommodate Tech's knowledge workers and the CBD of San Francisco is growing a Central Technology District (CTD) around mass transit in the heart of the city.

2.3.2 Telecommuting

"The typical telecommuter is a 49-year-old college graduate—man or woman—who earns about $58,000 a year and belongs to a company with more than 100 employees, according to numbers culled from the U.S. Census Bureau's American Community Survey" (Tugend 2014).

There is considerable debate over who qualifies as a telecommuter. The most common definition of a telecommuter is a full-time employee who is not self-employed, and works at

home at least half the time. When the definition is expanded to include trade workers (e.g. plumbers, electricians), the self-employed, and people who work from home as little as one day a week, the percentage of telecommuters jumps from 3.2% to 30% of the workforce.

When previous urban centrality measures were developed and published, most employees needed to be in the office to be productive. The office was the only place to access a company's phone lines and records. The office was where the typewriters, computers, fax machines, printers, filing cabinets, and office supplies were located. Today laptops, the cloud, Wi-Fi, and cell phones have replaced those essential constraints of the traditional office. While the office still exists, it can be replicated anywhere employees have Wi-Fi and electrical outlets to charge their devices.

2.4   Postmodern urbanism

Kruger's (2012) method delimiting postmodern urban centers views the city as an entertainment hub and does not bind its view to core employment hours, but rather looks at the entire 24-hour cycle of use. I will apply his methodology to the San Francisco Bay Area.

Krueger implemented an alternative method for delimiting urban centers by demarcating dense overlapping clusters of Urban Amenities using LISA. LISA analysis identifies local clusters of high or low values among multiple layers or themes in a spatial dataset.

Krueger's objective advanced a rebuttal to the economic and employment methods for delimiting the urban center of Los Angeles with a holistic, quality of life, community-centered approach. Krueger's literature review began by asking two key questions: (1) What are the existing methods for delimiting city centers?; and (2) What is known about the center of Los Angeles? The second part of Krueger's literature review introduced a new methodology for delimiting the postmodern urban center and built the case for this method drawing on

postmodern urbanism theory. The postmodern approach breaks from the concentric ring structure, established by the Chicago School, and proposes that urban centers are not defined by a CBD, but rather by the experience of place within urban structure to identify an ambiguously bounded and internally inconsistent central place: a postmodern urban center. Kruger argued that while employment has dispersed from the city center over time, cities retain a centralizing place of culture and place, and draw discretionary time and income from the metropolitan area.

The postmodern urban center Kruger proposes requires acceptance of Allen, Massey, & Cochrane's (1998) doily region analogy of a discontinuous, internally heterogeneous space. The doily metaphor refers to the fact that doilies have holes in them, and that an urban region can have holes within the region that are more or less relevant to the delimitation of the urban core, instead of seeing an urban region as having hard edges of "in" or "out." Garreau (1992) has stated that urban centers "just about never match boundaries on a map" (p. 6) and edge cities contain "all the complexity, diversity, and size of a downtown" (p. 9). Finding a way to measure this requires a definition of phenomena suitable to delimit the postmodern urban center. Leisure activities include destination and specialty retail districts, high-end restaurant areas, and late night leisure activities. Clusters of amenities drive cultural production, attract dispersed populations and add to the common experience of the city.

Five Urban Amenity categories were selected by Kruger (2012): "Trendy Hangouts," "High Culture," "Restaurants," "Hotels," and "Entertainment." These data all came from the Esri Business Analyst data package. This data set was chosen for its national coverage and consistency, facilitating comparisons between Los Angeles, Chicago, and New York City. The Esri Business data is classified using the North American Industrial Classification System (NAICS).

2.5   Local Indicators of Spatial Association

Anselin's (1995) LISA statistic gives an indication of spatial clustering of similar values around each observation and the sum of LISAs for all observations is proportional to a global indicator of spatial association. LISA analysis identifies local clusters of high or low values among a spatial dataset. Local spatial clusters, commonly called hot spots, would have a null hypothesis that no local spatial association exists and therefore the spatial distribution would be expected to be evenly dispersed and random. In this study, LISA is used to identify and rank clusters of Urban Amenities and to produce a sum of cluster membership for each cell. The higher the sum the more influential the cluster, and hence the assertion that the highest ranked clusters represent urban centers.

The key to delimiting postmodern urban centers requires intersecting clusters of different amenity types. Krueger (2012) constructed a series of cell arrays to analyze the Urban Amenity points, a process for aggregating amenity points into polygons, and then applied the LISA analysis method to the analysis polygons.

Krueger (2012) compared Los Angeles to two other U.S. cities, Chicago and New York. All three cities display strong centrality with gradual radial decay. Krueger argues that the spectrum is useful in revealing an urban center and regional centrality with nuance—better than the employment-based measures of urban centrality. Los Angeles exhibits more central scores outside of the central core than Chicago or New York. While Los Angeles exhibits polycentrism in the form of the Orange County cluster from Fullerton to Newport Beach, the San Fernando Valley cluster from Woodland Hills to Burbank, the San Gabriel Valley cluster from Pasadena to West Covina, and the South Bay cluster from Inglewood to Torrance, these subcenters do not prove non-centrality.

CHAPTER 3: DATA SOURCES AND METHODOLOGY

3.1   Data

Urban Amenities, obtained as business point locations, represented the majority of the data required for the analysis. Regional shopping malls, as defined by the Directory of Major Malls (DMM), represent the other data source.

3.1.1   Esri Business Analyst

This analysis required a dataset offering consistent coverage across the study area. In order to form a compelling analysis, the amenities needed to follow a standard classification system. Esri Business Analyst was selected as a source for comparison to Kruger's (2012) thesis and because it represented the most complete national classification scheme available. The point locations were extracted from Esri's Business Analyst data. Most Urban Amenities were classified according to the North American Industrial Classification Scheme (NAICS). Business Analyst's Major Shopping Centers dataset contained a database of shopping malls provided by the DMM. The shopping centers database is the lone data source not classified by NAICS.

3.1.1.1 Background

Esri Business Analyst is a specialized product maintained by Esri, the company behind the well-known ArcGIS ecosystem. Esri Business Analyst is a product designed for the commercial sector and contains tools that allow businesses to analyze demographics, customer data, sales data and territory design, facilitating data-driven decision-making. Part of the Esri Business Analyst extension is a business database consisting of more than 12 million records in point format. These records include most business locations in the U.S., and can be filtered by several different criteria, including NAICS code, the criterion of interest in this study. Dun and Bradstreet, a corporate research firm, provides the business locations. Business Analyst's Major Shopping

Centers database contains points representing shopping mall locations with several key attributes, the most important of which is Gross Leasable Area ("GLA"). These data are provided by the DMM. Esri updates the business location database annually.

3.1.2 *North American Industrial Classification System (NAICS)*

NAICS is an industry coding system used in the U.S., Mexico and Canada, all members of the North American Free Trade Agreement (NAFTA), to standardize the analysis and reporting of economic data between member countries. NAICS replaced the Standard Industrial Classification system that began in the 1930s and is built to better suit the advanced technology and services sectors that have grown over time.

3.1.2.1 Data Selection

NAICS codes were used for querying amenity inputs based on the categories listed below, and were selected according to the five categories of Urban Amenities identified by Krueger (2012):

Category 1: "Trendy Hangouts": Greene (2008) and Clark et al. (2004) identify Trendy Hangouts as important drivers of urban growth. Trendy Hangouts are defined as trendy retail stores, bookstores, brewpubs, and coffee shops.

Category 2: "High Culture": Greene (2008) and Clark et al (2004) stress the importance of high culture venues in urban growth. High Culture establishments include performing art venues, museums and art galleries. This category disproportionately serves a wealthier portion of the market, but still plays a role in urban growth.

Category 3: "Restaurants": This category comprises full-service, dine-in restaurants.

Category 4: "Hotels": Hotels are useful indicators of social activity in the city.

Category 5: "Entertainment": Entertainment includes establishments that serve a wider

public audience, including: theaters, bowling alleys, shopping malls, and stadiums.

Table 1 lists the Urban Amenity categories with the corresponding NAICS Codes and descriptions.

Table 1 Amenity Cateogries with NAICS Codes and Descriptions

Category	NAICS Code	NAICS Description
Category 1: "Trendy Hangouts"	722515 Snack and Nonalcoholic Beverage Bars	"[E]stablishments primarily engaged in (1) preparing and/or serving a specialty snack, such as ice cream, frozen yogurt, cookies, or popcorn or (2) serving nonalcoholic beverages, such as coffee, juices, or sodas for consumption on or near the premises. These establishments may carry and sell a combination of snack, nonalcoholic beverage, and other related products (e.g., coffee beans, mugs, coffee makers) but generally promote and sell a unique snack or nonalcoholic beverage."
	451211 Book Stores	"[E]stablishments primarily engaged in retailing new books."
	443142 Electronics Stores	Establishments primarily engaged in: "(1)...retailing a general line of new consumer-type electronic products such as televisions, computers, and cameras; (2)...retailing a single line of consumer-type electronic products; (3)...retailing these new electronic products in combination with repair and support services; (4)...retailing new prepackaged computer software; and/or (5)...retailing prerecorded audio and video media, such as CDs, DVDs, and tapes."
Category 2: "High Culture"	712110 Museums	"[E]stablishments primarily engaged in the preservation and exhibition of objects of historical, cultural, and/or educational value." Examples include art galleries (except retail); planetariums; art museums; science or technology museums; halls of fame; and wax museums.
	453920 Art Dealers	"[E]stablishments primarily engaged in retailing original and limited edition art works."
	7111 Performing Arts Companies	"[E]stablishments primarily engaged in producing live presentations involving the performances of actors and actresses, singers, dancers, musical groups and artists, and other performing artists."
Category 3: "Restaurants	722511 Full-Service Restaurants	"[E]stablishments primarily engaged in providing food services to patrons who order and are served while seated (i.e., waiter/waitress service) and pay after eating. These

		establishments may provide this type of food service to patrons in combination with selling alcoholic beverages, providing carryout services, or presenting live non-theatrical entertainment."
Category 4: "Hotels"	721110 Hotels (except Casino Hotels) and Motels	"[E]stablishments primarily engaged in providing short-term lodging in facilities known as hotels, motor hotels, resort hotels, and motels. The establishments in this industry may offer food and beverage services, recreational services, conference rooms and convention services, laundry services, parking, and other services."
Category 5: "Entertainment"	Shopping Malls (not an NAICS category)	Malls with a GLA greater than 400,000 square feet.
	51213 Motion Picture and Video Exhibition	"[E]stablishments primarily engaged in operating motion picture theaters and/or exhibiting motion pictures or videos at film festivals, and so forth."
	713 Amusement, Gambling, and Recreation Industries	Establishments that: "(1) operate facilities where patrons can primarily engage in sports, recreation, amusement, or gambling activities and/or (2) provide other amusement and recreation services, such as supplying and servicing amusement devices in places of business operated by others; operating sports teams, clubs, or leagues engaged in playing games for recreational purposes; and guiding tours without using transportation equipment."
	71121 Spectator Sports	"This industry sector comprises (1) sports teams or clubs primarily participating in live sporting events before a paying audience; (2) establishments primarily engaged in operating racetracks; (3) independent athletes engaged in participating in live sporting or racing events before a paying audience; (4) owners of racing participants, such as cars, dogs, and horses, primarily engaged in entering them in racing events or other spectator sports events; and (5) establishments, such as sports trainers, primarily engaged in providing specialized services to support participants in sports events or competitions. The sports teams and clubs included in this industry may or may not operate their own arena, stadium, or other facility for presenting their games or other spectator sports events."

Source: Census Bureau's NAICS Code Description Website, http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2012.

3.1.3   Directory of Major Malls (DMM)

Shopping malls are included in entertainment because they provide a destination for entertainment and leisure and serve as a counterbalance to the high culture amenities more commonly patronized by affluent populations (Nielsen Company 2014). The International Council of Shopping Centers categorizes malls by their size, measured by the GLA, a standard measure of mall size. For this analysis, malls greater than 400,000 square feet, the Regional Mall minimum threshold, were chosen for inclusion in the entertainment category (ICSC 2015).

3.2   Methodology

3.2.1   Research Design

This study delimited postmodern urban centers using clusters of Urban Amenities as the indicator of centrality. The crucial element of this technique involves the specification of cluster density across all five Urban Amenity categories.

After creating six regular cell arrays that cover the Bay Area, counts of designated Urban Amenities were aggregated by cell. Clusters of high concentrations of each Urban Amenity were evaluated and delimited within each array, classifying cells that are part of the cluster. Clusters from each of the cell arrays were then combined to develop a cluster score: a sum of how many clusters of a single Urban Amenity type coincided in each cell. These cluster scores were also summed to obtain a centrality score: the classification of how many clusters of all Urban Amenities were present in each cell. The centrality scores were then depicted cartographically.

The methodology employed several analytical tools, including LISA, GIS tools for aggregating points into polygons, and a method for constructing analysis cells. In the following sections I will discuss LISA analysis in more depth and how the Modifiable Areal Unit Problem ("MAUP") was encountered and addressed.

Krueger (2012) applied this methodology to three cities: Chicago, New York, and Los Angeles. Chicago and New York City were chosen as control cities because both cities contain acknowledged centers. Chicago's known centers are The Loop and the Near North Side. The centers of New York City are Midtown and Lower Manhattan. The control results aligned with the prediction and helped validate the analysis of Los Angeles and therefore I did not use additional control cities in this study.

3.2.1.1 Cluster Analysis (LISA)

I applied LISA, a statistical measure of local clustering for area data proposed by Anselin (1995), to quantify the concentrations of each Urban Amenity. The purpose is to determine clustering over space. Because the Bay Area is such a large area with significant amenity gaps due to mountains and water, the LISA method is appropriate because it does not require minimum or maximum thresholds to determine clustering—it is solely dependent on the study area.

LISA analyses identify four types of spatial clustering: clusters of high values, clusters of low values, isolated high values surrounded by low values, and isolated low values surrounded by high values. In this analysis, the clusters identified represent clusters of the five Urban Amenities described above. Clustering is based on contiguity of analysis arrays with significant p-values. The analysis arrays are randomly and imperfectly overlaid on the study area, but this problem is present in any polygon-based GIS study and the use of p-values at the computational limit will narrowly define how many Urban Amenities constitute a cluster.

Since the analysis area in this study includes mountains, water features, and open spaces, which lack the Urban Amenities that have been defined, clustering will provide, at the very least, an alternative method to delimiting urban areas.

LISA analysis compares the attribute being evaluated against the adjacent spatial units.

There are three primary adjacency choices: "rook," "queen," and distance. Rook adjacency occurs when the polygons share an edge. Queen adjacency occurs when polygons share an edge or a vertex. Distance adjacency occurs when a distance threshold is set such that all polygons within a specified distance are considered adjacent and contribute to the analysis.

The distance method is most useful when analyzing irregular polygons. Since this study applies a hexagonal tessellation, and hexagons are regular polygons that share both vertices and edges with all bordering polygons, rook and queen adjacency produce the same results. This analysis followed a previous example that applied hexagonal arrays, which mitigates for issues common to American cities such as rectangular gridded street patterns (Krueger 2012).

For inclusion in the core cluster, a cell and most of its neighboring cells must have high p-values. This analysis will include adjacent cells using a method Krueger (2012) developed. Core clusters received a value of two, adjacent cells received a value of one, and all other cells received a value of zero. This method allows cluster-adjacency to contribute to the sum and score of coincident clusters. This cluster fringe approach diminished the impact of the waterfront amenity clusters, while allowing cluster-adjacency to factor into the core at half of the value of a core cluster.

3.2.1.2 Modifiable Areal Unit Problem (MAUP)

A significant issue with spatial analysis involving polygons is the MAUP, which recognizes that different aggregations of the same phenomena can produce different analytical results. This thesis provided two foreseeable MAUP challenges. The first challenge was the large water body that separates the Bay Area. Many clusters will be near a major body of water and be scored lower because the cell is partially or primarily in the water. The second MAUP challenge is that a measurement cell can bisect clusters.
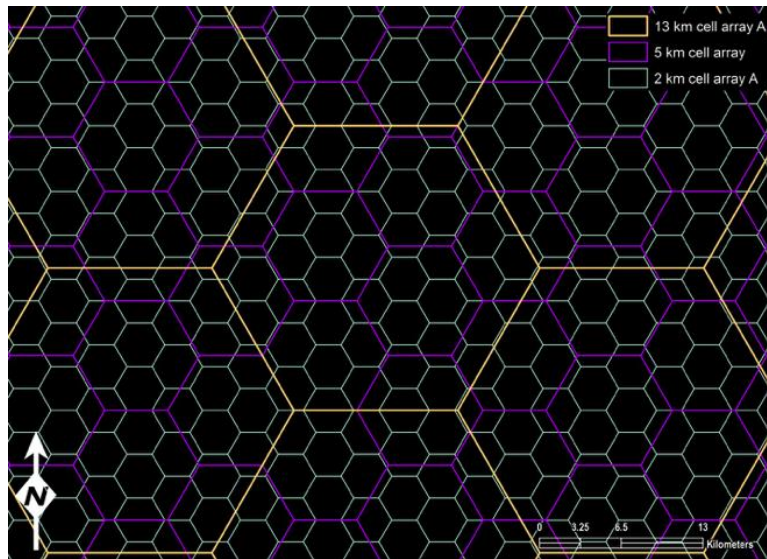
Figure 7 Three Cell Sizes for Capturing Urban Processes at Regional and Local Scales
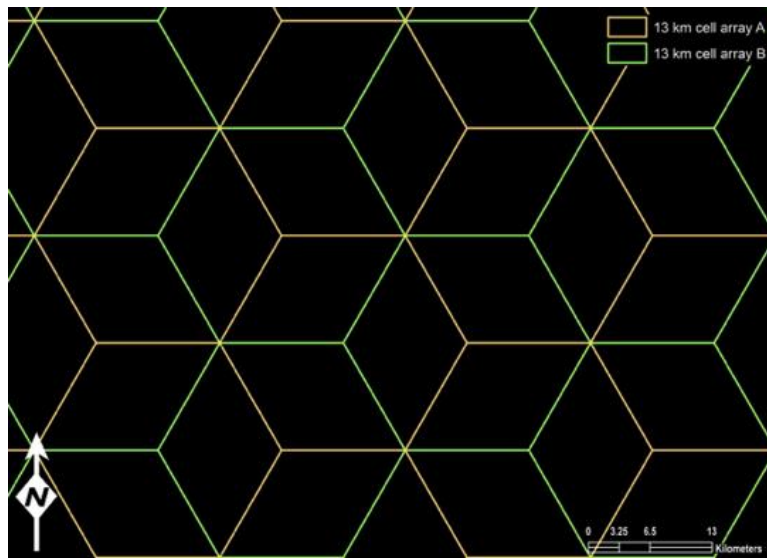
Figure 8 Offset Pair of Cell Arrays to Aggregate the Underlying Data in Different Ways

The example set by Krueger (2012), by which he used two sets of arrays offset by 60 degrees, and hexagonal cells with an internal diameter of 13, 5, and 2 km (Figures 7 and 8), were used for this thesis project as well. Kilometers were chosen as the unit of measure to avoid matching the street patterns found in most American cities. The larger cell size is intended to capture regional clustering trends while the smallest cell size is intended to capture neighborhoods. The proportional ratio of approximately 2/5 was selected to avoid larger cell

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boundaries coinciding with smaller cells. The intermediate cell size is between the two extremes. The six arrays were assigned unique identifiers, and then unioned into a single analysis array.

3.2.2 Analysis Process

3.2.2.1 Definition of Study Area

This study sought to analyze the urban structure at a city level. The US Census has multiple definitions of the Bay Area including the San Francisco-Oakland-Hayward Metropolitan Statistical Area ("MSA"), and the San Jose-Sunnyvale-Santa Clara MSA. San Jose-San Francisco-Oakland is the Census's 12-county definition of the Bay Area known as the Combined Statistical Area ("CSA"). The CSA includes seven MSAs: (1) San Francisco-Oakland-Hayward; (2) San Jose-Sunnyvale-Santa Clara; (3) Santa Rosa; (4) Vallejo-Fairfield; (5) Santa Cruz-Watsonville; (6) Napa; and (7) Stockton-Lodi. For this analysis, I selected the Bay Area commuter shed (Regional Plan Association 2007) to include a larger definition of the Bay Area and reflect the increased distances people commute for employment and the growing virtual and telecommuting population permitted by information technology and knowledge work. This larger definition was chosen to avoid unnecessary omissions, leaving open the possibility of discovering surprises, and with the belief that the less populous counties, like unpopulated waters and open lands, have minimal effect on the overall results of delimiting the Social Center.

This study is focused on the San Francisco Bay Area, which includes both the traditionally understood 9-county region plus the additional 8 counties that make up the 17-county northern California commuter shed megaregion. This area includes all of the counties that border the San Francisco Bay plus the Greater Sacramento Metropolitan Region (Yolo and Sacramento counties), the increasingly connected northern San Joaquin Valley (San Joaquin and Stanislaus counties) and the counties that have recently fallen into the Silicon Valley's sphere of

influence (San Benito, Merced, Monterey, and Santa Cruz) (Figure 1).

3.2.2.2 Create Analysis Arrays

The analysis cell arrays were created using a free Esri tool, "Create Hexagonal Tessellation" (Figures 9 and 10). These arrays were created in the native projection for the Bay Area: Zone 10 North, Universal Transverse Mercator, using the 1983 North American Datum. The 17-county commuter shed study area was used as the spatial constraint. The inputs into this tool are any shapefile that is used as the areal extent, and distance, which is the internal diameter of the cell. The tool runs a script that creates a rectangular grid of points across the spatial extent using Esri's "Fishnet" tool (Figures 9 and 10). Thiessen polygons are generated around the points and these are the hexagonal cells of interest. This process is repeated two additional times to create all three of the desired cell arrays sizes: 13, 5, and 2 km, respectively. After creating each of the three arrays, each array is copied, and offset by 60 degrees as described above. The tool created six arrays in this particular study.
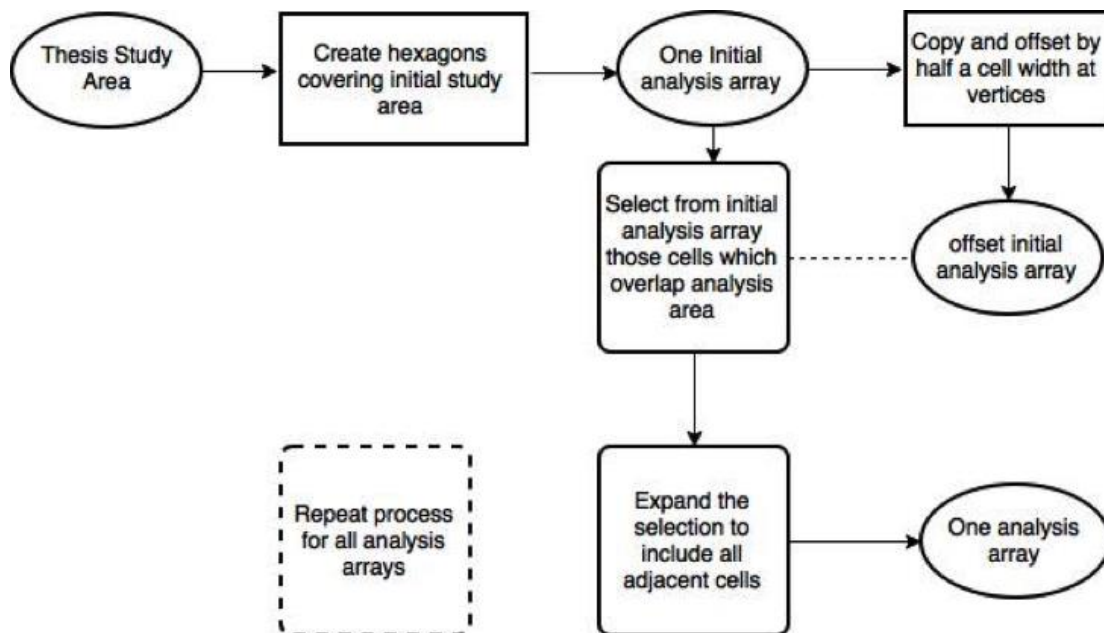
Figure 9 Analysis Array Development Process

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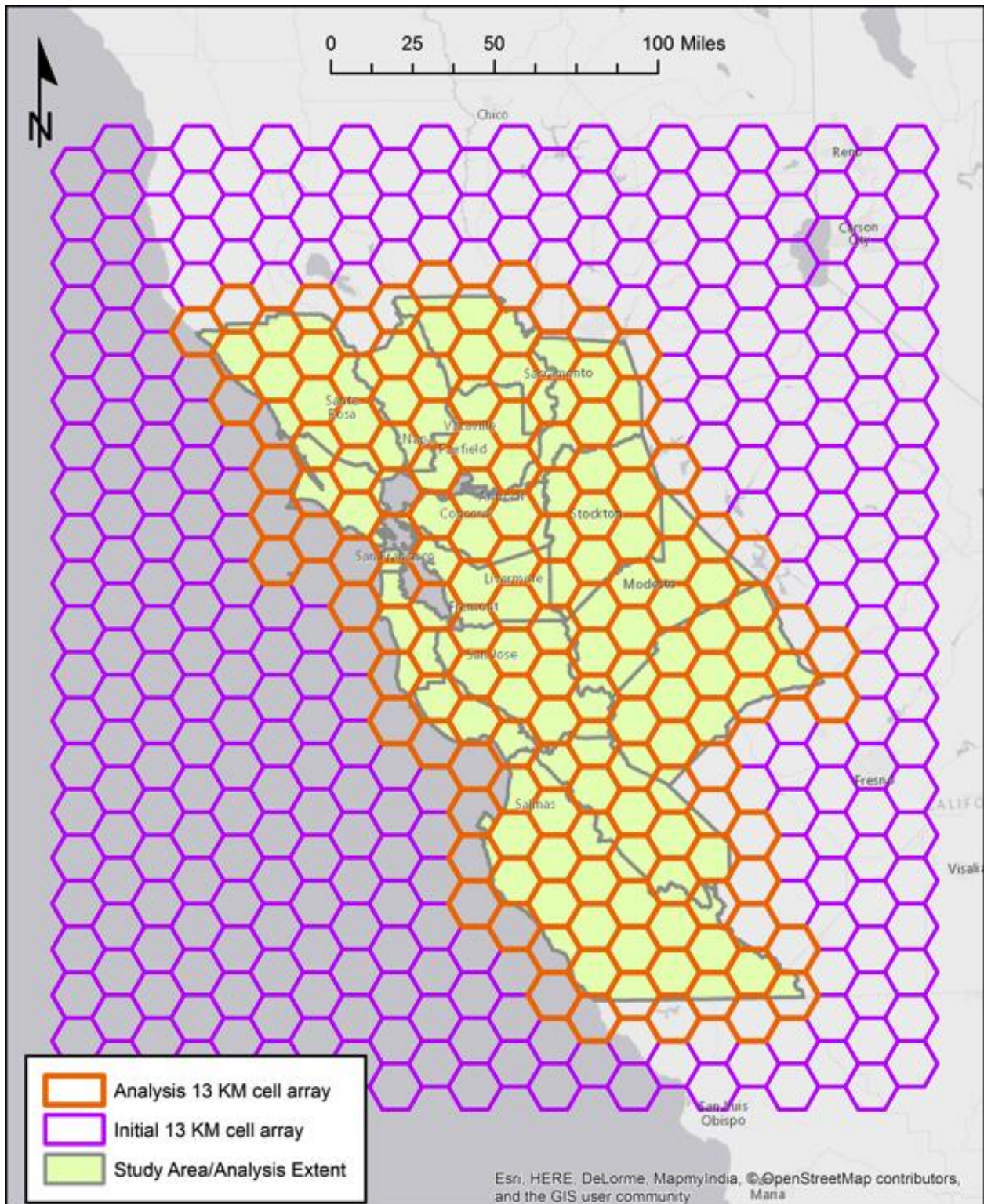
Figure 10 Example 13 km Cell Arrays Superimposed Over the Bay Area

3.2.2.3 Query Amenities

The five Urban Amenities were isolated by NAICS code from the Business Analyst business listings, and then exported into point shapefiles by each Urban Amenity: "Trendy Hangouts," "High Culture," "Restaurants," "Hotels," and "Entertainment." Each Urban Amenity query was saved as an individual shapefile and used for further analysis (Figure 11).
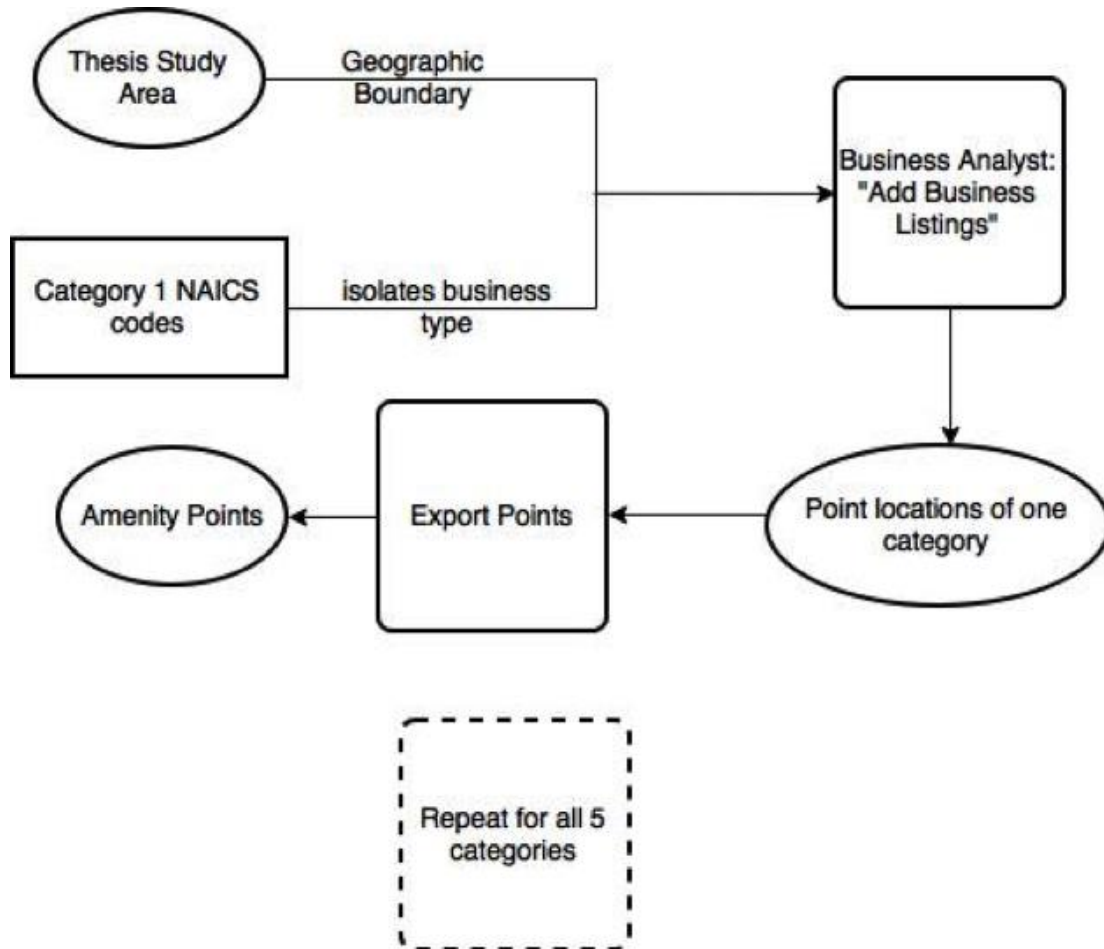
Figure 11 Amenity Point Collection Process

3.2.2.4 Aggregating Points to Polygons

Aggregating points to polygons was required to use the LISA (polygon-based) method and to capture regional clustering over point clustering. The Urban Amenities were not evaluated individually, but rather as part of a neighborhood, city, or region.

3.2.2.5 Joining Amenities to Arrays

LISA required polygons to quantify clustering at the block and neighborhood level. Urban Amenity points were aggregated into cells using Esri's geoprocessing tool "Spatial Join." This process involved spatially joining an Urban Amenity type to each analysis array, and was repeated for each Urban Amenity. The number of points (Urban Amenities) contained by each cell was summed and that count (sum) was joined back into the array of cells. The raw number of Urban Amenities in each cell is the attribute of interest so no adjustments were made to the count (Figure 12).
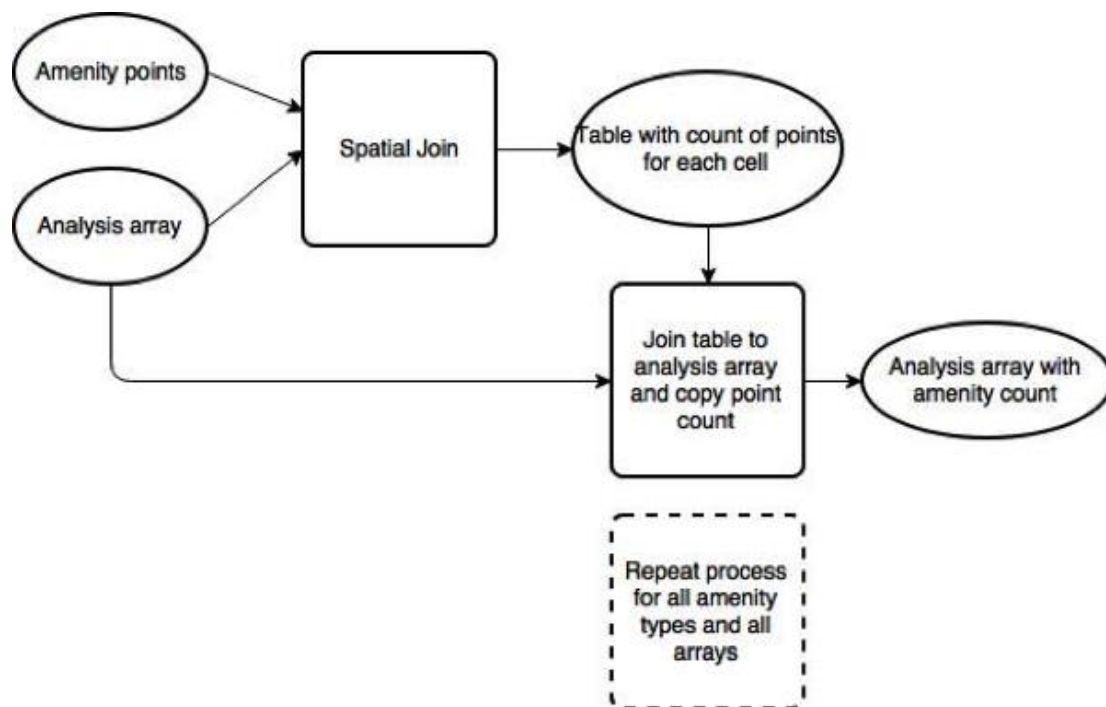

Figure 12 Amenity Point Collection Process

3.2.2.6 Identification of Amenity Clusters

The Esri tool for performing LISA analysis is called "Cluster and Outlier Analysis" (Anselin Local Morans I). Each of the spatial join polygon shapefiles, now containing the count of Urban Amenities per cell was input to the Cluster and Outlier Analysis geoprocessing tool to obtain the

high-high clusters and p-values.

3.2.2.7 Designation of Cluster Values

A new field was added to the analysis array and all values were assigned a zero. Using the Select by Location tool, all cells adjacent to a cluster with a high-high value at or below a yet-to-be determined significance threshold were outlined as Urban Amenity clusters. The high-high cluster was outlined as the core cluster and assigned a value of 2, all adjacent cells were assigned a value of 1, and all other cells were assigned a value of zero (Figure 13). This step was repeated for all cells, and the six arrays were unioned and then symbolized using graduated colors to show a scale of concentrations of Urban Amenities from high concentrations with a peak value of 12 to low concentrations with zero establishments. Once each Urban Amenity was completed, the five Urban Amenity files were unioned together resulting in a range of values from zero to 60 (Figure 14).
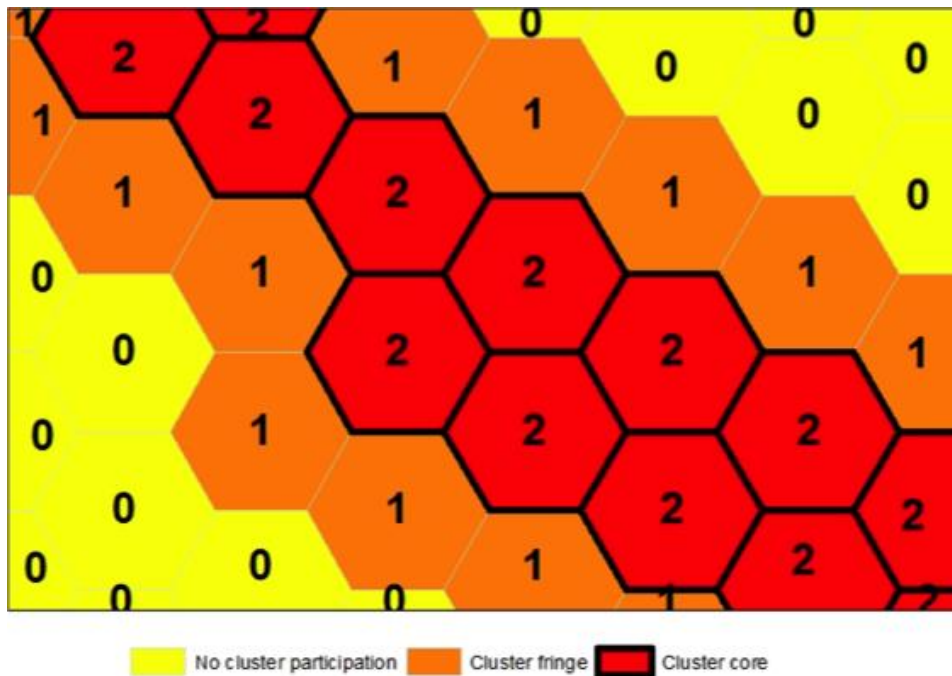
Figure 13 Cluster Scoring System
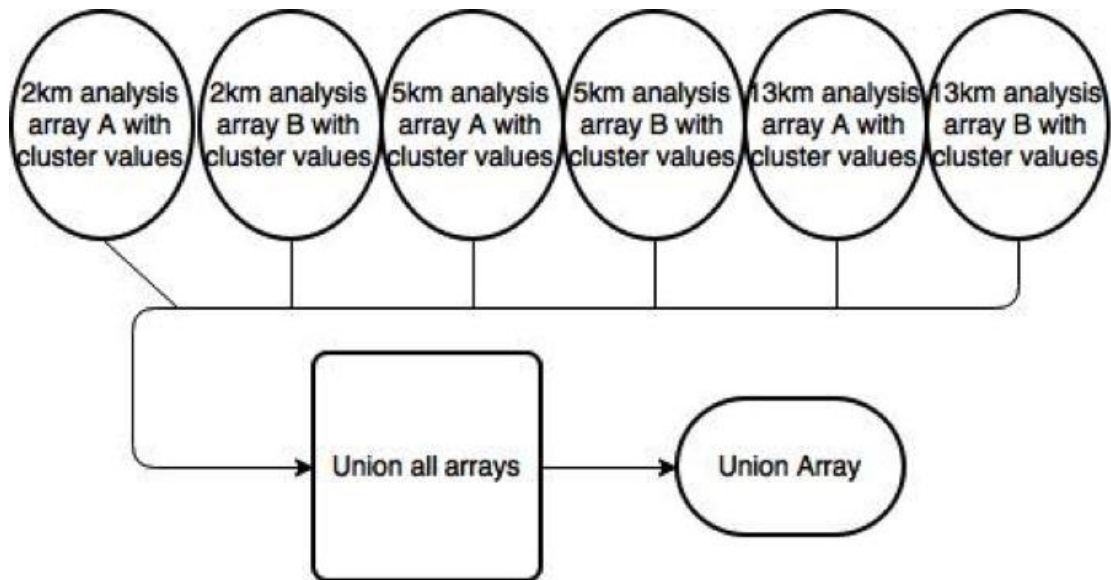
Figure 14 Union All Analysis Arrays

3.2.2.8 Visualization of Cluster Scores

A cartographic portfolio was one of the objectives of this thesis project and provided the simplest method for conveying the results of this analysis and for illustrating the centrality scores. Choropleth classification was applied to the centrality scores to both tell the story and reduce 60 colors down to a number the human eye can handle. The highest possible centrality score in this analysis was 60. For viewing purposes, the cells that satisfied the maximum cluster score were dissolved into a single polygon to depict the three urban centers.

CHAPTER 4: RESULTS

The cartographic results are presented in Figures 15 through 26. Figure 15 provides an overview of the Bay Area results. Figures 16 and 17 depict each of the three strong centers with areas reaching the maximum score of 60. In San Francisco and Oakland-Berkeley, there is a large contiguous area that reaches the maximum score of 60. In Silicon Valley, capturing Santa Clara, Sunnyvale and Mountain View, a small area reaches the maximum score. Additional maps, Figures 18, 21 and 23 depict exceptions to the decay from the primary centers: Sacramento, Santa Cruz and Monterey. Figures 19, 20, 22, and 24 through 26 compare and contrast the centrality results for 13, 5, and 2 km cells, respectively.

4.1   The San Francisco Bay Area

The overall analysis reveals that the historic cores of San Francisco and Oakland retain centrality scores indicative of urban centers. The Silicon Valley's sustained and rapid growth over the past 50 years as a global beacon of innovation and evolution, and as a magnet for capital investment has created a modern urban center that follows a corridor of High Tech campuses, from San Jose in the west to Mountain View in the east, as opposed to the high rises that distinguish the historic CBDs and the shape and structure of the often photographed city skyline (O'Mara 2005). Where the cities of San Francisco and Oakland-Berkeley make up the majority of their respective clusters, the Silicon Valley cluster is not centered on a traditional city center. The Silicon Valley corridor is made up of retail that supports the affluent cities along El Camino Real, now built up around the CalTrain stops located in San Mateo and Santa Clara Counties. Each major center contains multiple contiguous cells that reach the maximum score of 60, indicating overlapping clusters across all five Urban Amenities. Beyond the narrow delimitation of the centers, the Bay Area's highly urban structure is evident in the high scores surrounding the entire San Francisco

Bay (Figure 15).
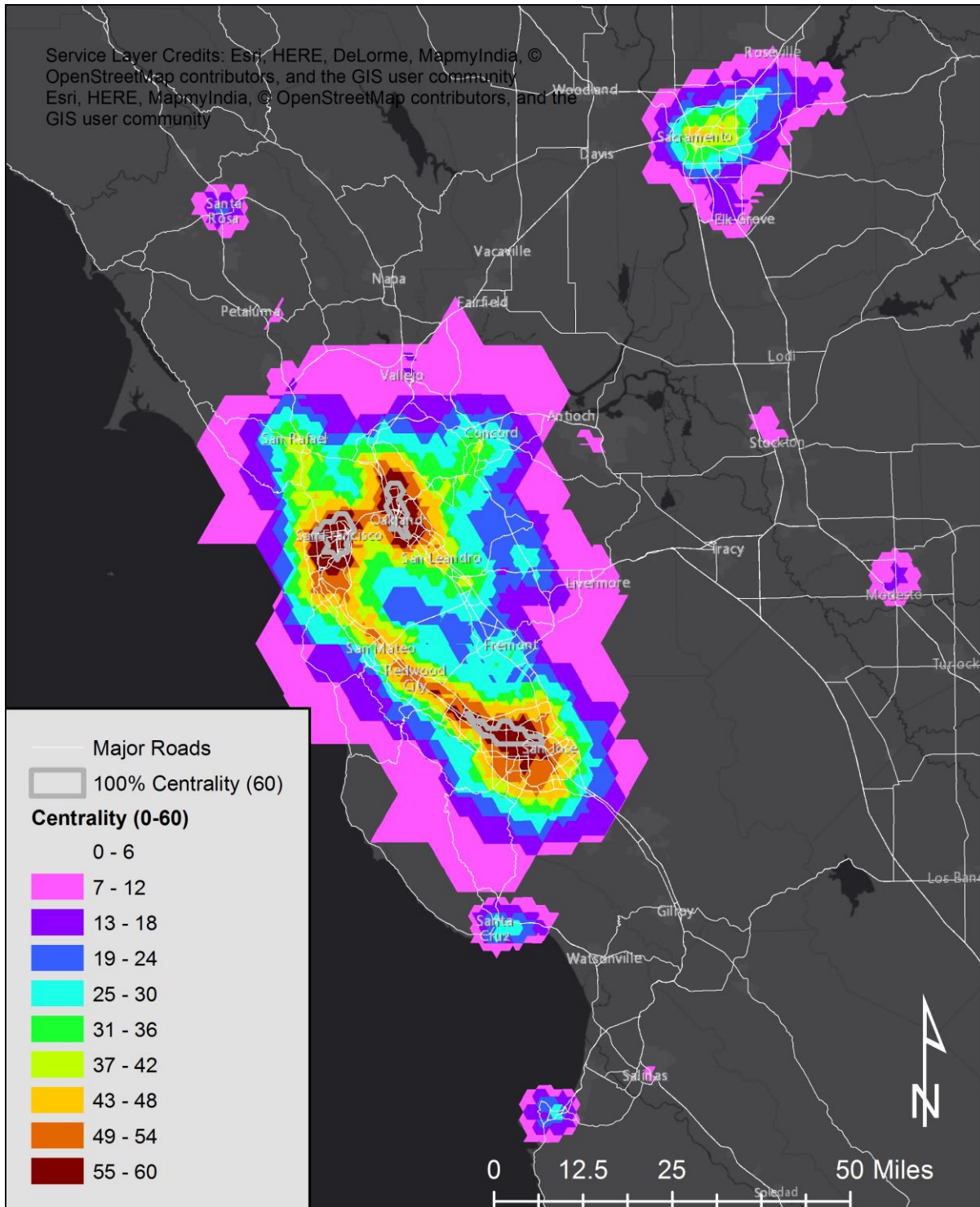
Figure 15 Bay Area Centrality Score for All Urban Amenities for Complete Thesis Study Area

In Figure 15, a crescent moon-shaped region encompassing the three urban centers can be seen in dark red, red, and orange colors. Some smaller pink and purple spots exist outside of the dominant urban center. The largest secondary center in the northeast quadrant of the map is California's capital, Sacramento. Four smaller centers appear outside of the Bay Area center: Santa Rosa to the north, Modesto to the east, and Santa Cruz and Monterey to the south. The outlier urban centers are depicted again in later maps for more detail.
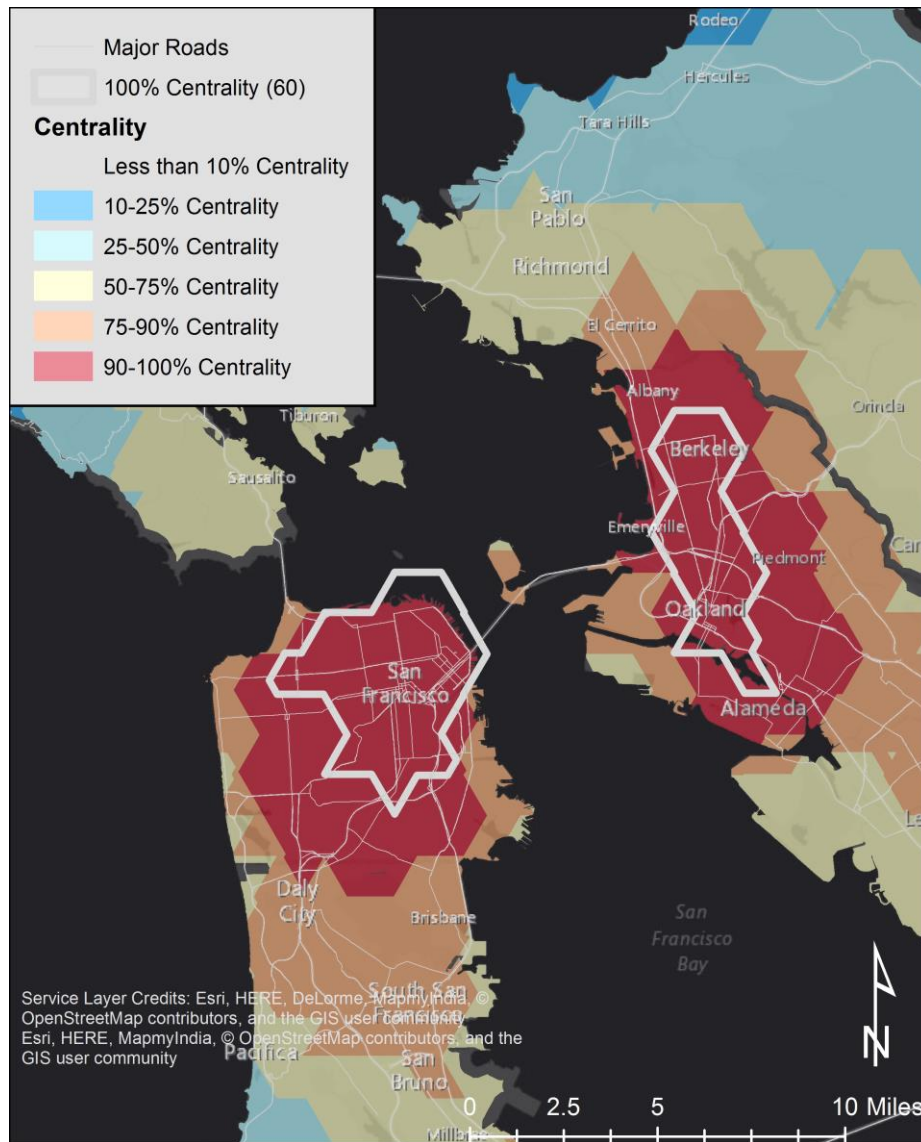
Figure 16 San Francisco and Oakland Centrality Score For All Urban Amenities

Figures 16 and 17 depict the three urban centers at the same scale for ease of visual comparison. Figure 16 contains two urban centers, San Francisco and Oakland-Berkeley. San Francisco and Oakland-Berkeley are separated by water rather than land giving the impression of a connected and continuous city. The urban center of interest in Figure 17, Sunnyvale-Santa Clara is approximately 50 miles from the San Francisco and Oakland. A significant portion of the greater Silicon Valley exhibits 90% or greater centrality while the area that reaches the maximum score is much more limited and depicted in the white boundary in the map shown in Figure 17.
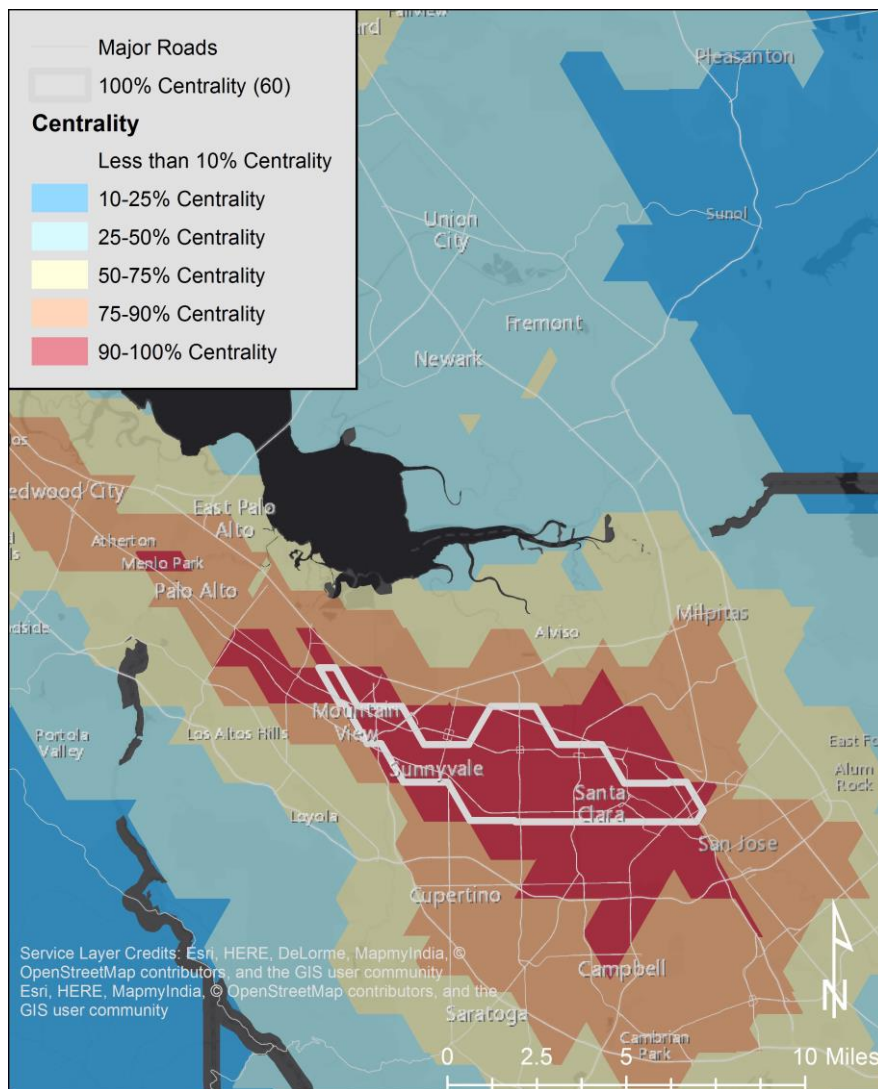
Figure 17 Sunnyvale-Santa Clara Centrality Score for All Urban Amenities

4.1.1 Outliers

Additional, although significantly weaker, urban centers exist in Sacramento (Figures 18 and 19), Santa Cruz (Figures 20 and 21), and Monterey (Figures 22 and 23). These three subcenters reflect the sprawl driven by the American ideal of single-family homes with yard space.

Sacramento has two areas that reach 75-90% centrality: a large area downtown and a smaller area just to the east of downtown capturing a large part of California State University at Sacramento campus. From the city center, the decay follows the predictable decay (Figure 18).
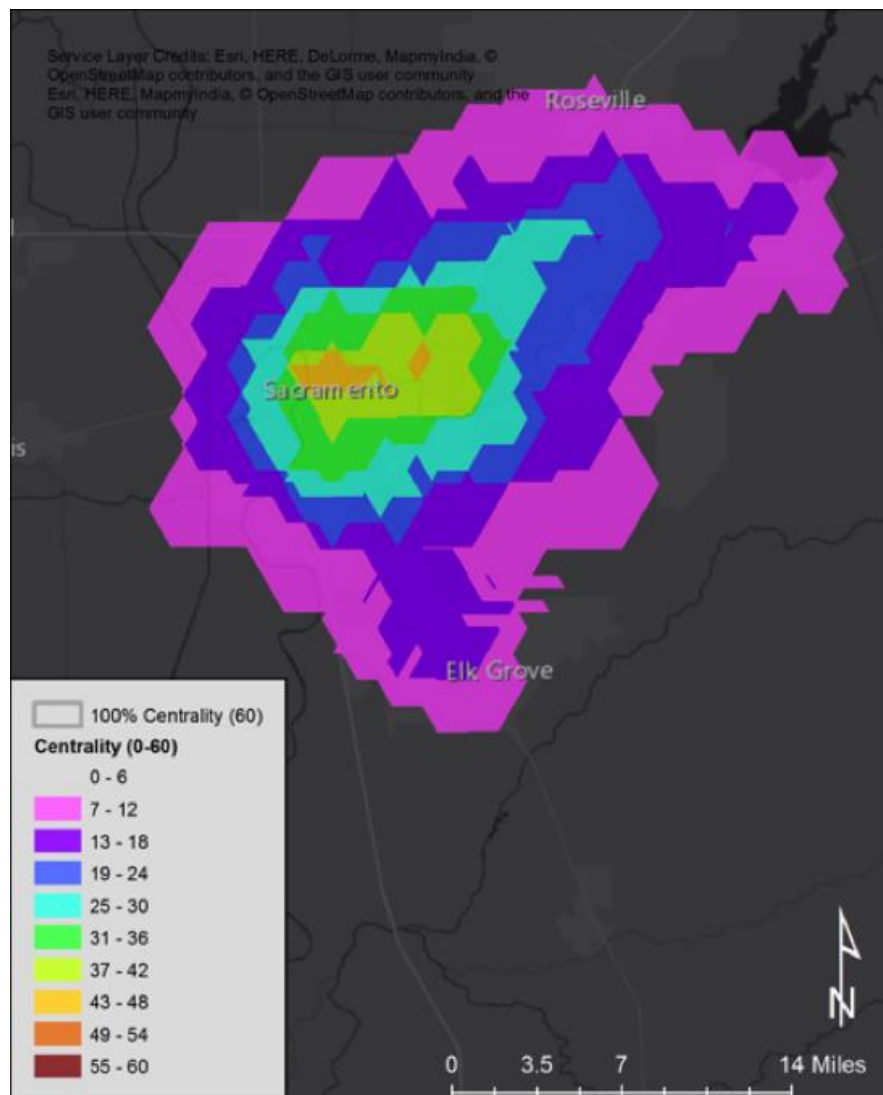
Figure 18 Sacramento Centrality Score for All Urban Amenities

Figure 19 depicts the two cell sizes where Sacramento reaches 100% centrality. The 2 km and 5 km arrays both achieve 100% centrality for downtown and an area just beyond. However, when compared to the Bay Area, the regional 13 km array does not achieve 100% centrality. Sacramento, like San Jose, is not as densely built out as San Francisco and Oakland and that comparison played a role in this result.
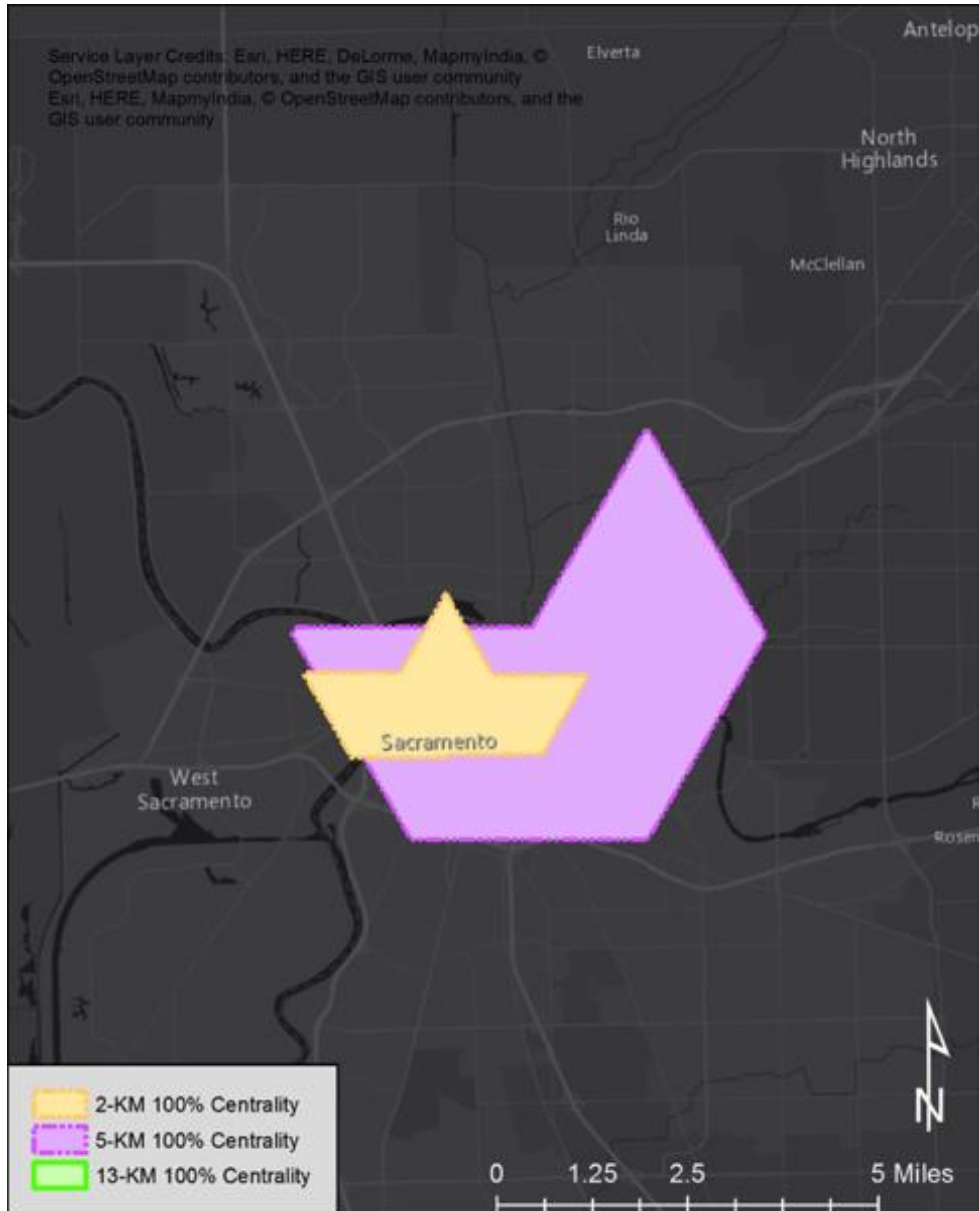
Figure 19 Sacramento 100% Centrality Scores

Santa Cruz is a small beach town southwest of the Bay Area's main population centers. Santa Cruz has approximately 60,000 people with a major University and a reputation as a beach resort town with good surfing. Santa Cruz only displays strong centrality at the 2 km array cell size (Figure 20), near the boardwalk and downtown tourist district that service the beaches. The 2 km 100% centrality area indicates the local importance of the Santa Cruz waterfront area, and the lack of centrality at 5 and 13 km shows the limited size and urban footprint of Santa Cruz. Beyond the waterfront, Santa Cruz is a rural residential city with mountainous, seismically active terrain creating a unique and challenging environment for home building.
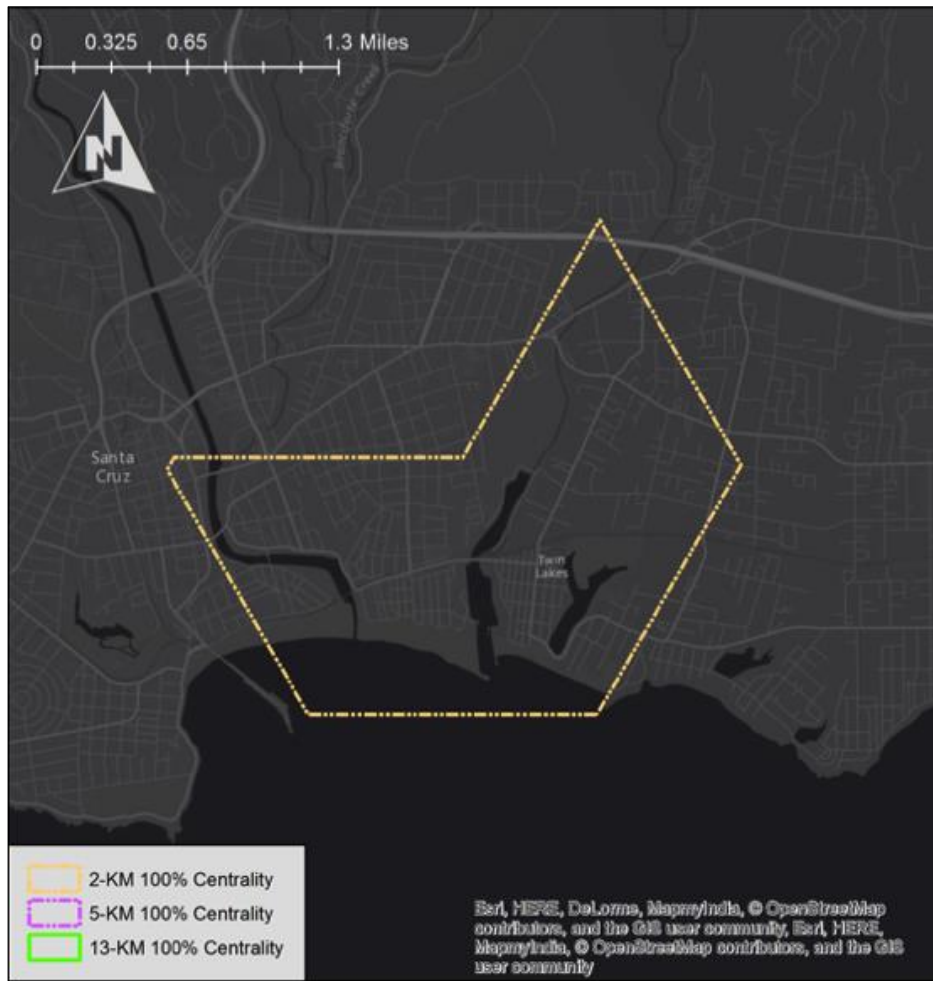
Figure 20 Santa Cruz Centrality Score for All Urban Amenities

The centrality of Santa Cruz only reaches 50% at the peak, covering the waterfront area, the University of California at Santa Cruz and extending east towards Capitola and Aptos, neighboring small beach towns (Figure 21). Figure 21 also shows how isolated Santa Cruz is from the greater Bay Area. The Santa Cruz Mountains separate Santa Cruz and the Pacific Ocean from Silicon Valley, the population centers of San Jose and the cities that line the San Francisco Bay from San Francisco to San Jose.
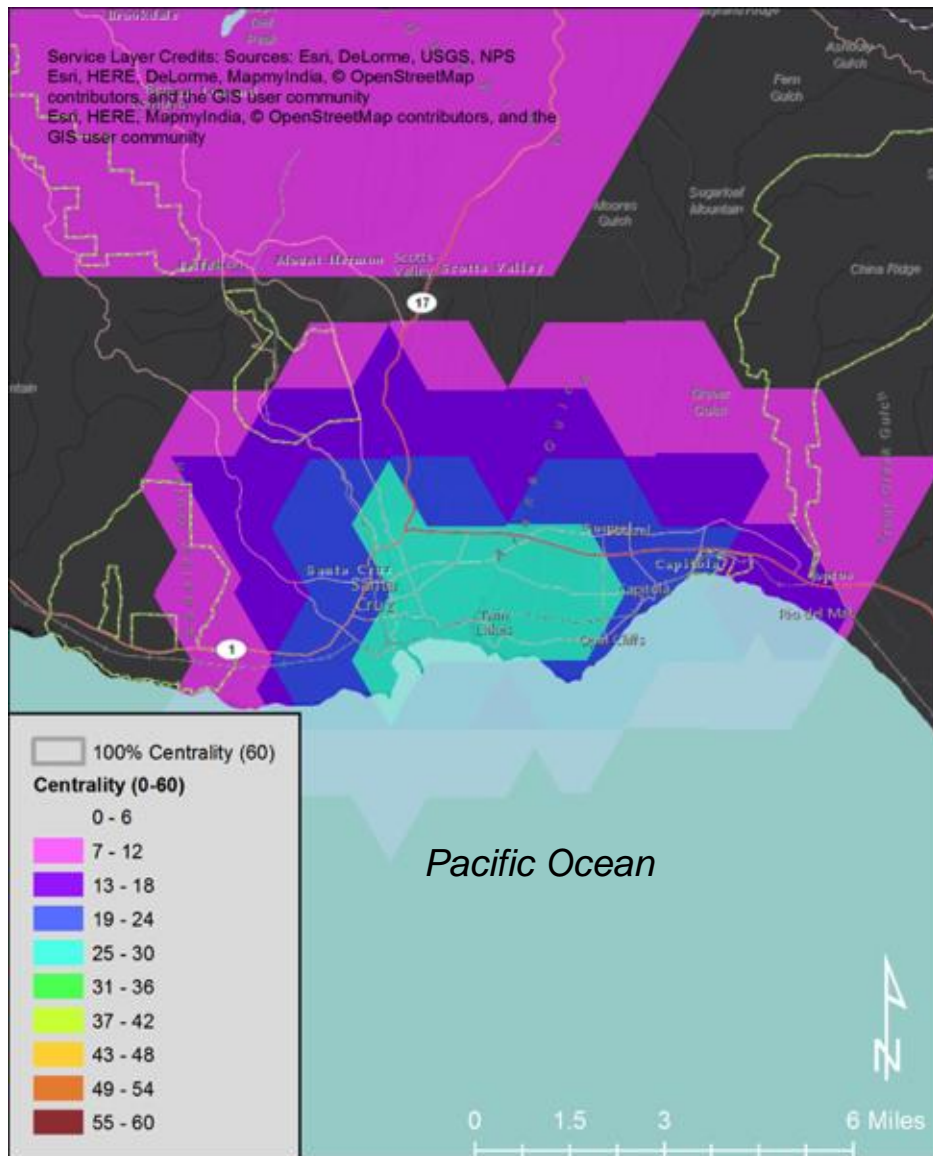
Figure 21 Santa Cruz 100% Centrality Scores

Monterey exhibits 100% centrality at the 2 km array size (Figure 22). The area of Monterey exhibiting 100% centrality is primarily focused on the waterfront tourist area that is a blend of retail, restaurants, hotels and entertainment. Monterey's major tourist attraction, the Monterey Bay Aquraium, is excluded from the 100% centrality area, highlighting the imprecision of the array cells. The Monterey Bay Aquarium plays a large role in the existence, location and vitality of the downtown district and the fact that Monterey has an area that reaches 100% centrality at all. Similar to Santa Cruz in size, coastal proximity and centrality score, Monterey's peak, like Santa Cruz's, reaches less than 50% centrality (Figure 23).
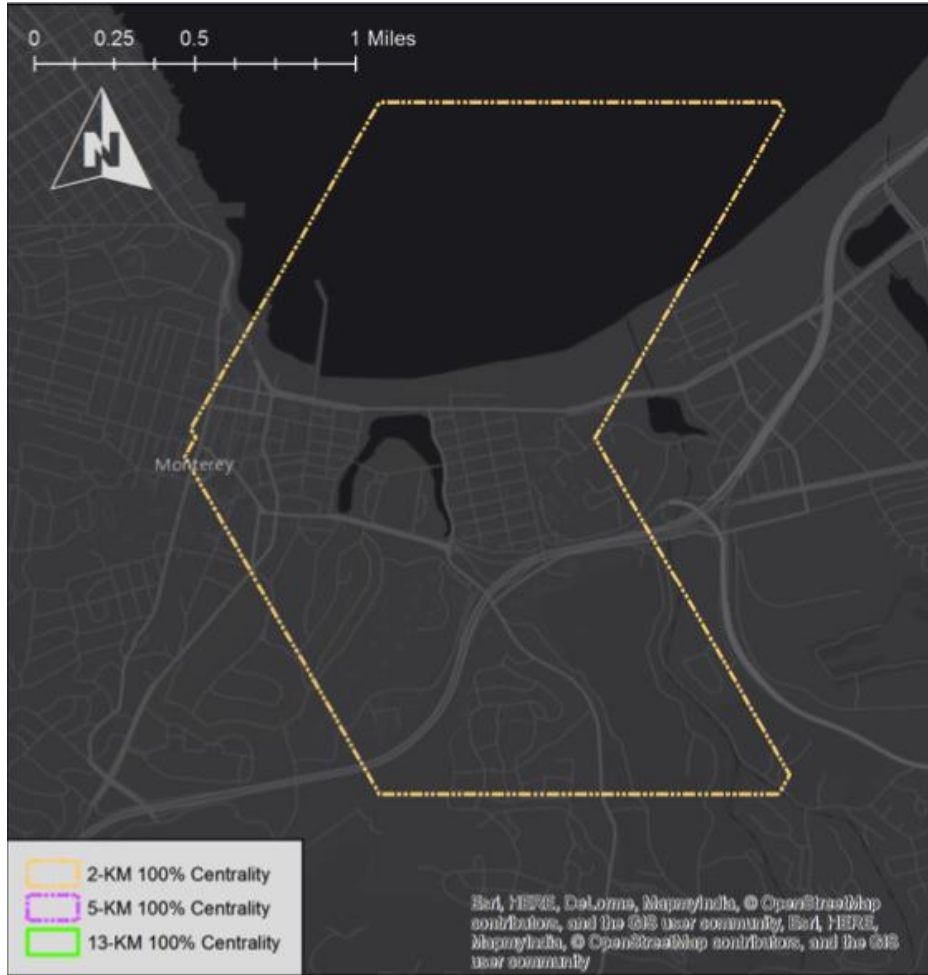
Figure 22 Monterey Centrality Score for All Urban Amenities
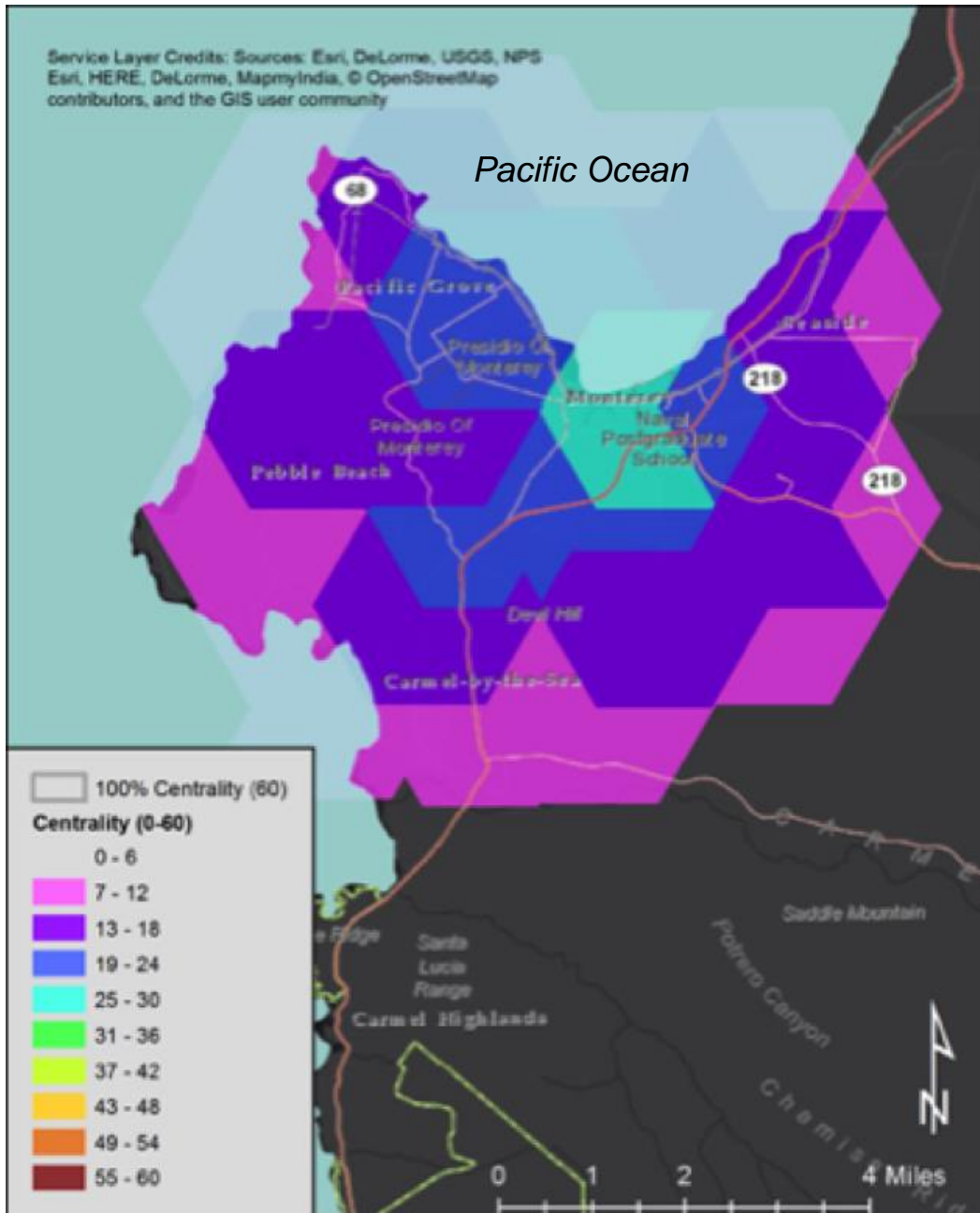
Figure 23 Monterey Centrality Score for All Urban Amenities

4.2   Impact of Cell Size

The large cell arrays classify regional centers while the the smaller cells define interesting local patterns. The primary purpose of the union arrays was to mitigate MAUP distortions caused by water features, protected lands, and mountains. The central areas are defined using a very high

threshold. Despite this, the cluster scores of two areas widely accepted as part of the center of the Bay Area, San Francisco's Financial District and SOMA, which are predicted high cluster score areas abutting or very near the San Francisco Bay, were not eroded as a result of their proximity to the water (a predicted low cluster score area). The size of San Francisco and Oakland's urban centers align with expectations, as does Silicon Valley's smaller urban center. However, the exclusion of Palo Alto, Cupertino and San Jose iteself from Silicon Valley's urban center is suprising. The overlapping 100% centrality polygons in Figure 24 depict a large urban center from San Francisco and Marin County up through San Rafael, and the East Bay from Oakland and beyond.
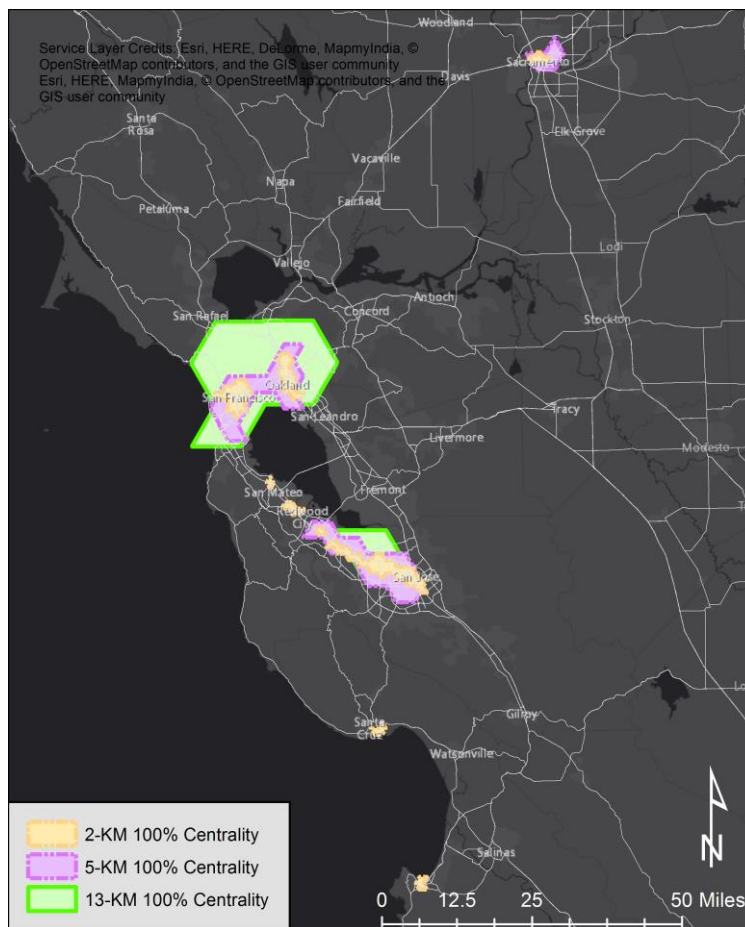
Figure 24 100% Centrality Score for the Three Analysis Cell Sizes (13 km, 5 km, 2 km)

The Silicon Valley's suburban structure hurts the scoring of the largest cell size. The centrality of this region follows the backbone of historic street El Camino Real, and current freeways and commuter train stops that service the retail nodes. At the 13 km scale, only part of a single cell achieves 100% centrality. The 5 km and 2 km cell scores align much more closely with the structure of the region (Figure 25).
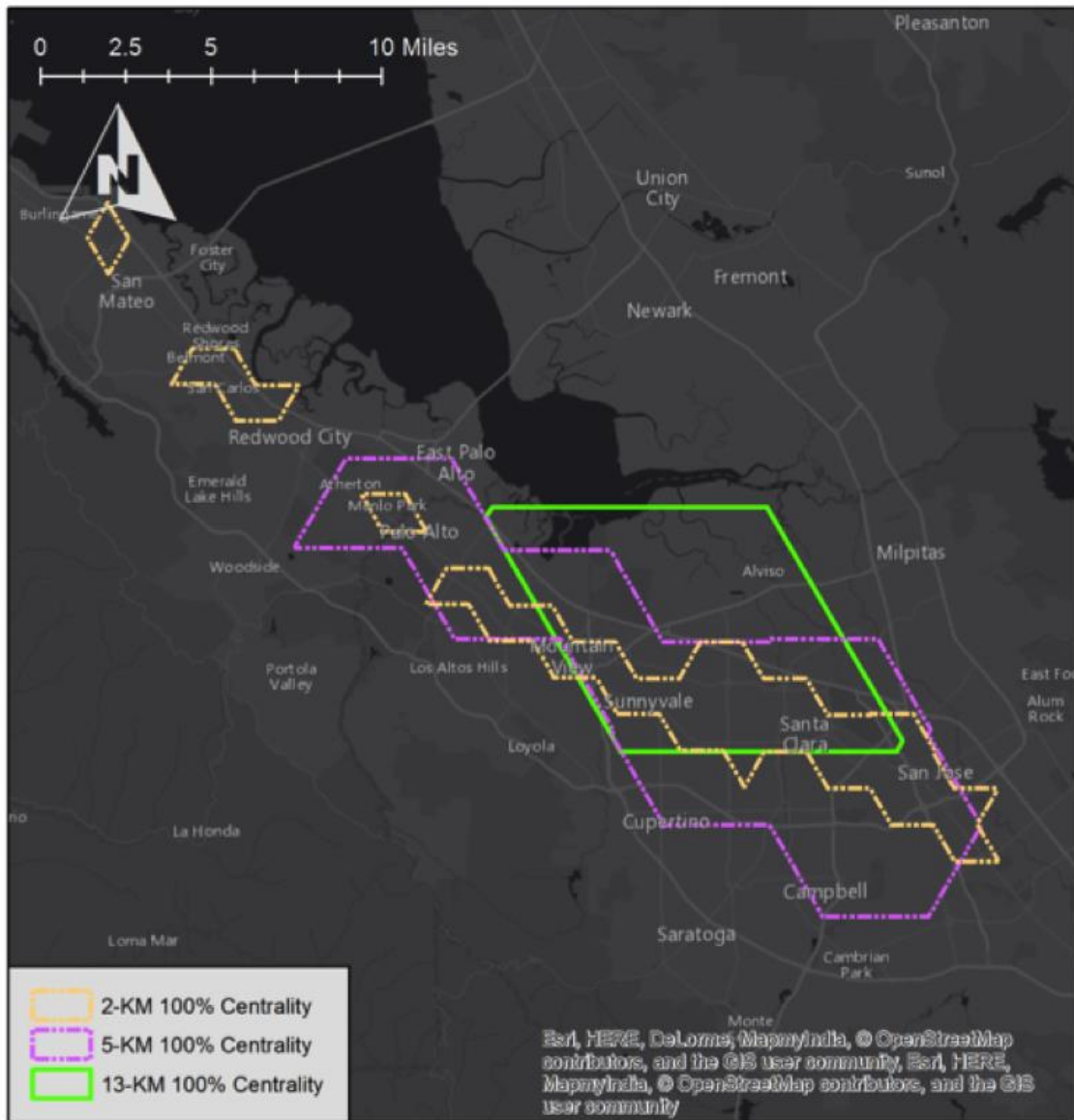
Figure 25 Silicon Valley 100% Centrality Score for all cell sizes (13 km, 5 km, 2 km)

The Silicon Valley's 100% centrality area in the 13 km cell analysis is much smaller than the 100% centrality area that runs north from South San Francisco to capture a large part of Southern Marin County as well as the East Bay cities from Alameda in the south, through Oakland, Berkeley, and Richmond, to the San Pablo bridge that connects the East Bay to Marin County. The 5 km 100% centrality captures the majority of San Francisco, connects with Alameda, Oakland, Emeryville, Piedmont and Berkeley. At 2 km, the San Francisco center is narrowly defined by the most vibrant neighborhoods, eliminating the more residential portions of San Francisco. The East Bay 100% area also contracts significantly to follow the major thoroughfares, retail nodes and employment centers (Figure 26).
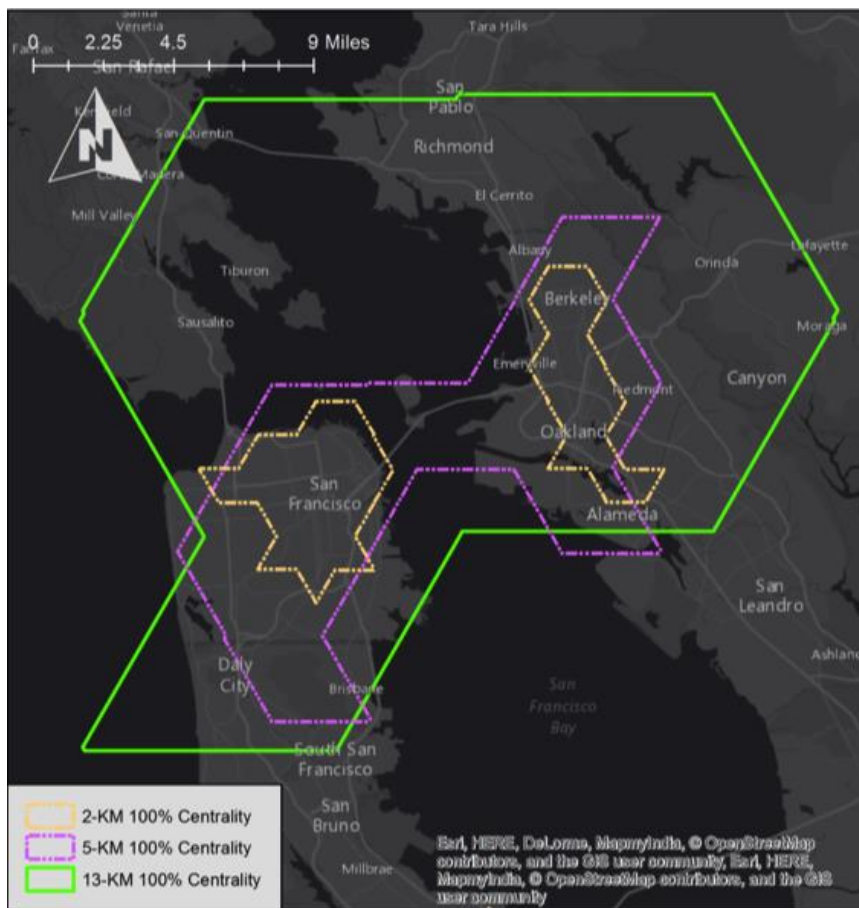
Figure 26 San Francisco-Oakland 100% Centrality Score for all cell sizes (13 km, 5 km, 2 km)

4.3   MAUP

MAUP issues crop up with the union array, but the 5 and 2 km arrays reinforce the centrality scores obtained by the 13 km array that captured both eastern San Francisco and western Berkeley as seen in Figures 24 and 26. Treating San Francisco and Oakland as separate entities while using a polygon for one of the six inputs that combined the two cities amplified both cities' centrality scores. The 2 km analysis cell with restaurants includes two cells in Marin County focused on San Rafael; three cells that delimit a Pleasant Hill/Walnut Creek urban center; two cells centered on Hayward and a single cell centered on San Leandro; and a 14 cell area extending from Berkeley and Oakland north to Albany and south to Alameda has two cells falling into the top category, one in Berkeley and one in Oakland. San Francisco has a large delimited center than runs south all the way to San Jose, with eight cells in the top category (Figures 24 and 25). The urban center at 2 km extends from San Francisco all the way to San Jose, but San Jose has just a single cell that fits into the top category (Figure 25).

MAUP is dramatically reduced by the inclusion of the six different arrays at three different sizes; however, there are some holes in the urban center. The most obvious holes in the Silicon Valley urban center are highlighted in the 2 km and 5 km cells that include Stevens Creek Boulevard to the south of the El Camino Real corridor, specifically Santana Row and Downtown San Jose (Figure 17). The 2 km cells narrowly identify clusters including western Mountain View, Palo Alto, and Menlo Park to the west of the Silicon Valley center. The omission of Cupertino is surprising (Figure 25).

CHAPTER 5: DISCUSSION AND CONCLUSIONS

5.1   Major Findings

The centrality score for an individual cell indicates coincident clusters of the five Urban Amenity categories. Each cell score characterizes the cell as more or less central, applying a spectrum rather than a binary central/non-central designation. This method gives an indication of the location of the central region. This analysis produced three clear urban centers: San Francisco, Oakland-Berkeley and Sunnyvale-Santa Clara, offering an alternative to the commute- and employment-based methods.

The 2 km array yields more detail and some remote urban centers far from the acknowledged urban centers. Three areas outside of the traditional Bay Area that reflect some centrality are Sacramento, Monterey and Santa Cruz. The tiny cell fragments create a sense of precision and granularity that can be misleading. Less central locations are included where two strong centers fall into the same hexagon. In the 13 km cell array both San Francisco and Oakland-Berkeley are contained by the same cell.

The delimited centers fall in the expected locations in all three parts of the Bay Area: San Francisco, Oakland, and the Silicon Valley. These three urban centers closely match the major cities identified by previous studies focusing on employment and commuting patterns by Walker & Schafran (2015), Cervero & Wu (1997), Hall (2003), and Garreau (1992).

The omission of San Jose as part of the primary urban center despite its position as the most populous city in the Bay Area is an interesting revelation and bolsters the case for seeing centrality across a spectrum, rather than as a strict "in" or "out" categorization. Small cell fragments that reach a score higher than bordering cells create a false sense of importance. The results are no less useful, but the scores and percentages should be accepted as only slightly

stronger or weaker than neighboring cells, particularly in this study where neighboring cells influence the scores of the cell under scrutiny.

This method for delimiting urban centers had previously been applied to New York City, Chicago and Los Angeles, all of which have some minor geographic challenges. Applying this method to the Bay Area, with its challenging physical geography, demonstrates the robustness of this method (Krueger 2012). In New York City, the Hudson River, East River, and Central Park represent voids of Urban Amenities. In Chicago, Lake Michigan represents a large natural barrier to the east, but the remainder of Chicago is one contiguous region. In Los Angeles, the Pacific Ocean to the west and the Santa Monica Mountains to the north represented Urban Amenity voids, but, like Chicago, the majority of Los Angeles is one large contiguous region. The San Francisco Bay Area's geography is considerably more complicated with the San Francisco Bay separating all of the major cities in a ring that spans hundreds of miles of shoreline. The water surrounding the San Francisco peninsula on three sides (the San Francisco Bay to the north and east, and the Pacific Ocean to the west) represents a major Urban Amenity void, with significant distances isolating San Francisco from Marin County to the north and Oakland to the east. The boundaries of Silicon Valley and San Jose are constricted by the San Francisco Bay to the east and mountains to the west. Additionally, the Bay Area's culture of environmentalism has led to the largest percentage of open space, parks, farmland, beaches and area zoned for low development and rural uses of any urban area in the United States.

Krueger's (2012) Urban Amenities clustering method for delimiting the urban center not only works in largely contiguous cities like Los Angeles, Chicago and New York, but, as shown in this study, in cities with challenging physical geography like the San Francisco Bay Area. This method should, therefore, produce results in any urban region in the United States and provide

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new opportunities to compare and contrast the way in which large metropolitan regions are organized.

5.2   Principal Centers

The largest of the three urban centers, capturing the northeastern portion of San Francisco, measures 19.75 square miles, and is home to 456,318 residents—by far the largest of the urban centers. The Sunnyvale-Santa Clara urban center is 17.87 square miles and home to 133,595 residents. The smallest of the three urban centers is located in the East Bay, focused primarily on Oakland and Berkeley. The East Bay urban center measures 13.49 square miles but has the second largest population of the three principal areas with 175,511 residents. The San Francisco region is slightly larger in terms of area than the Silicon Valley and East Bay regions but has at least twice as many residents as the other urban centers.

The density of the San Francisco urban center (23,105 residents per square mile) indicates stronger centrality than that exhibited by the Oakland-Berkeley center (13,011 residents per square mile) and the relatively weak centrality exhibited by the Sunnyvale-Santa Clara center (7,505 residents per square mile).

San Francisco's highest centrality score is attained by the neighborhoods widely considered the center of San Francisco: Hayes Valley, Civic Center, Mission, Castro District, Cow Hollow, North Beach, Telegraph Hill, Pacific Heights, Western Addition, Nob Hill, Russian Hill, Tenderloin, Financial District (CBD), Downtown, Yerba Buena, SOMA, Van Ness, Eureka Valley/Dolores Heights, Cole Valley, Haight Ashbury, Noe Valley, Twin Peaks, Corona Heights, Duboce Triangle, and North Waterfront, which contains tourist destinations Fisherman's Wharf and the Alcatraz ferry tour point (Figure 27). San Francisco's urban center closely matches its historic core.

Figure 27 San Francisco Neighborhoods

Oakland and Berkeley's maximum centrality scores are also attained within their historic cores. In Oakland this region runs from the Bayfront's Jack London Square, north to Old Oakland, Downtown, Chinatown, Lake Merritt District and the Civic Center north, connecting with South Berkeley, Downtown Berkeley and the University of California Berkeley campus's Telegraph Avenue and Gourmet Ghetto neighborhoods.

Sunnyvale and Santa Clara, while central to the Silicon Valley, are not dense urban centers. The 100% central area follows El Camino Real from the furthest west portion of Downtown San Jose, through the San Jose Airport, Santa Clara University (the oldest university in California), to downtown Sunnyvale, and dissipates once reaching the Mountain View city center where Highway 101 and Moffett Boulevard meet. Mountain View and Sunnyvale both grew affluent and vibrant downtowns because of military investment during and after World War II.

San Francisco has a clear and dominant urban center that makes up more than one-third of the city. Oakland and Berkeley are dense historic cities, which, due to the close proximity of their downtowns, have grown into a single strong urban center. The Silicon Valley is a linear region because of its unique physical geography. The San Francisco Bay water body to the east and a mountain range to the west restrict urban growth.

5.2.1 Expanded Central Definition

To add some context, the urban center calculations were conducted on all areas that exhibited at least 90% centrality. The results of this more lenient definition produced a San Francisco center containing 48.1 square miles and nearly double the population with 815,806 residents (16,960.6 residents per square mile). The San Francisco cluster extends south beyond the boundary of San Francisco and includes parts of Daly City. The 90% centrality score for the East Bay more than

doubles the population to 480,585 residents and contains 50.2 square miles (9.573.4 residents per square mile), almost four times the size of the 100% centrality region. The Silicon Valley's 90% centrality center grows to encapsulate 56.2 square miles but contains only 434,235 residents (7,726.6 residents per square mile).

5.3   Peripheral Centers

The central areas are clear in San Francisco and the East Bay. There are large contiguous areas centered on the population centers of San Francisco and Oakland-Berkeley, respectively. The case for the Silicon Valley is less clear. Sunnyvale and Santa Clara make up the majority of the 100% urban center. Sunnyvale has fewer than 200,000 residents and Santa Clara has slightly fewer than 125,000 residents, as compared with San Jose, the most populous city in Silicon Valley with over 1 million residents. The expected gradual decay away from the previously mentioned urban centers includes a large portion of San Jose, Palo Alto, Menlo Park, San Mateo, Redwood City, and San Carlos in the Silicon Valley region. The expansion of the San Francisco polygon is so large, capturing nearly all of San Francisco, bolstering the case for San Francisco being the 'true' center of the Bay Area, fitting its local nickname "The City," while losing any nuance.

While San Jose is the most populous city in the Silicon Valley urban center, San Jose is not the center of the Silicon Valley. Stanford University spawned Hewlett-Packard, followed by Cisco Systems, Yahoo!, Google, Electronic Arts and Sun Microsystems and has played a critical role in the growth and sustained vitality of the Silicon Valley.

Sand Hill Road, synonymous with venture capitalism and described in the same vein as both K Street in Washington DC and Wall Street in New York, is located in Menlo Park near Stanford University and is the economic power center but not the urban center of Silicon Valley.

The constant evolution of the Silicon Valley makes defining a center a difficult task. The employment center, a useful factor in assessing centrality, shifts with each newly built corporate campus. The corporate campuses of large technology companies employ as many people as a large high rise, but unlike high-rise towers, corporate campuses are not anchored to a CBD, proximity to subcontractors, or financial institutions. Silicon Valley is no longer dominated by the semi-conductor industry that requires large Research and Development facilities and thus needs to be in the Silicon Valley where land is cheaper. High tech companies are moving to SOMA in San Francisco, and to Oakland, and software- and services-oriented companies associated with Silicon Valley are moving to high rises in the dense urban centers. Silicon Valley lacks a central point that can be quantified using this urban amenities method. San Jose is the city with the most people in this urban center, but the downtown is not particularly dense with culture. The economic center of the Silicon Valley is Sand Hill Road, in Menlo Park, near Palo Alto and Stanford University (Figure 28).

5.4   Further Research

5.4.1   Use of Arrays

The addition of smaller cells, as well as cell arrays of different sizes, or of a third array of the same size as one of the existing pairs of cell arrays would be a useful experiment to test whether there is a change or shift of the delimited urban center based on the arbitrary nature of the hexagonal tessellation.

A deeper understanding and comparison between the individual Urban Amenities, meaning size and importance of the Urban Amenity relative to the cluster score, would be useful in determining the rankings of like-ranked clusters.

HOLDINGS KEY

● IPO ● Private ● Acquired ● Defunct

Battery Ventures
● Glassdoor
● MetroPCS
● Groupon
● Jeeves Information Systems
● Angie's List
● Panjiva
● Pets.com
● Skullcandy
● Freescale Semiconductor

DFJ
● Tesla Motors
● SpaceX
● SolarCity
● Athenahealth
● Microsoft
● Hotmail
● NanoOpto
● Skype
● Baidu
● AdMob

The firm is the biggest backer of Elon Musk's ventures

Battery Ventures bet on the poster child of the dot-com bust

Kleiner Perkins Caufield & Byers
● Alibaba
● Amazon.com
● Coursera
● Facebook
● Google
● Groupon
● LendingClub
● Fisker Automotive
● Nest Labs
● Quirky
● Spotify
● Twitter
● Zynga

Restaurant 3000, a local VC favorite

The firm's $35 million investment netted $650 million when the online video-game maker went public in 2011

Sand Hill Road

The Valley's biggest VC firm manages more than $13 billion

Andreessen Horowitz*
● Airbnb
● Fab
● Facebook
● Foursquare
● Groupon
● Instagram
● Jawbone
● Lyft
● Pinterest
● Quirky
● Skype
● Twitter
● Zinga

Andreessen Horowitz was a late investor in the once-highflying daily deals merchant but still managed to make $14 million on its $40 million investment

The firm's $50 million bet in 2009 quadrupled when Microsoft acquired the company two years later

New Enterprise Associates
● 23andMe
● Intarcia Therapeutics
● Loopt
● Millennial Media
● Vuclip
● SugarCRM
● Tintri
● Houzz
● Upworthy

Sand Hill is the most expensive U.S. street for office space at $111 per square foot, beating Fifth Avenue in Midtown Manhattan by $9 a foot.

*BLOOMBERG LP, WHICH OWNS BLOOMBERG BUSINESSWEEK, IS AN INVESTOR IN ANDREESSEN HOROWITZ
PAUL HAMES/CALIFORNIA DEPT. OF WATER RESOURCES/GETTY IMAGES; JUSTIN SULLIVAN/GETTY IMAGES
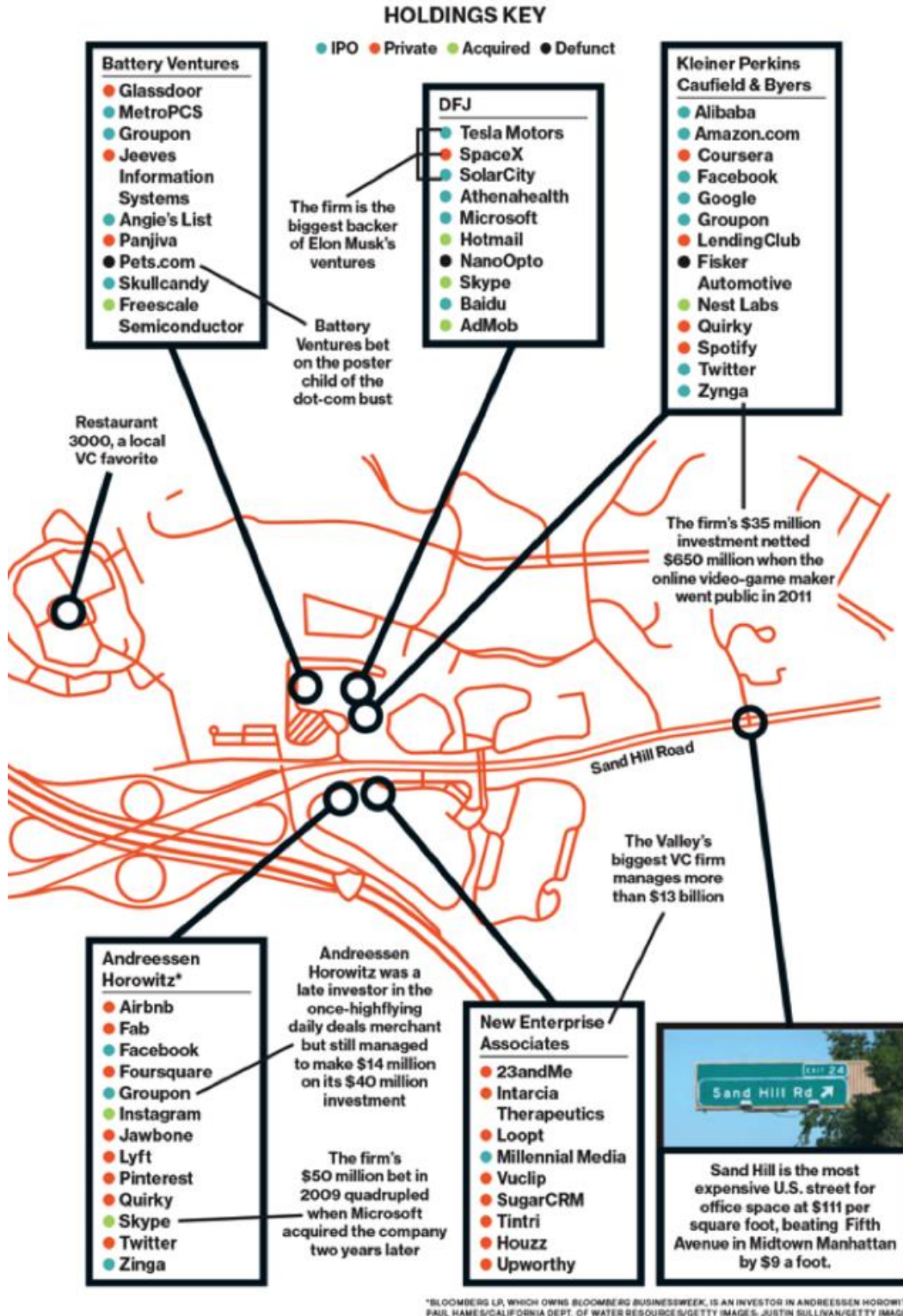
Figure 28 Sand Hill Road
Source: Bloomberg Business (2014)

5.4.2 Amenity Corridors

This analysis method holds up well in San Francisco but has some obvious omissions in both the East Bay and Silicon Valley urban centers where arrays bisect key Urban Amenity-rich corridors.

In the East Bay, half of the UC Berkeley campus is in and half is out of the 100% centrality polygon. Telegraph Street on the southern edge of the campus is also bisected. In South Berkeley, the amenity corridor of Piedmont Street is bisected by the arrays. In Oakland, the Grand-Lakeshore district northeast of Lake Merritt is mostly excluded from the 100% centrality region despite being both amenity rich and very popular with residents and tourists alike. The Grand-Lakeshore district is another casualty of the arrangement of the cells.

In the Silicon Valley, downtown San Jose, Santana Row and Palo Alto, particularly the part of Palo Alto that borders Stanford, are excluded from the 100% centrality region.

5.4.3 Amenity Data and Choices

While Esri's Business Analyst data is the most comprehensive and standardized dataset available, retail is a rapidly evolving sector, and the 12-month lag between data collection, data enrichment by the vendor, and release may add significant error to the full-service restaurant category. Trendy Hangouts as a category is difficult to define—music stores, once Trendy Hangouts, used to be all over the place, but have been nearly eliminated by digital music and e-commerce. Coffee shops, juice bars, yoga studios, certain retailers, and Wi-Fi hot spots are the Trendy Hangouts of today. The NAICS codes are useful for this type of broad study area, but are limited by the accuracy and frequency of the data collection.

Data mining techniques are becoming accessible to researchers and would be useful to apply in future analysis of this type. Collecting data from the Internet would have some error, but

no more than the error already present from the existing market research firms.

Krueger mentions clothing stores as amplifying the centrality scores of known popular shopping districts in Los Angeles that score lower than expected given their prominence and popularity with both residents and tourists. I would assert that in the 3 years since Krueger's analysis his theory has only become more true. While Lululemon and Apple stores have not become Third Places in the same way coffee shops are, malls have gone through an evolution. Enclosed malls are less popular as a destination, but open-air, walkable shopping destinations with a larger proportion of food and sit-down restaurants, and large open seating areas have become the trend. The consumer experience is an important and growing part of the way residents and tourists engage with cities.

5.4.3.1 Social Media

Data science and big data offer an alternative method for capturing business points, and a shorter lag in capturing Trendy Hangouts by extracting business locations from the Internet and websites such as Foursquare, Twitter, Yelp, and Facebook, and by using web crawling techniques. While this method requires some computer programming, it offers an alternative for future researchers engaging this urban geography field and would improve on the relevance of the Urban Amenity inputs.

5.4.3.2 Institutions

Institutions were omitted from this analysis to match the comparative study conducted by Krueger (2012), but churches and universities would be interesting to include in future analyses since they are central to the social fabric of communities. Large institutions like universities prevent or limit other Urban Amenities from forming and can lead to explainable gaps in centrality. Stanford and the surrounding Stanford Mall, and greater Palo Alto are amenity rich,

but were excluded using the Urban Amenity clustering method. The University of California Berkeley, the other major university in what was expected to be part of an urban center, is only partially included due to the arrangement of the analysis array. Both Stanford and the University of California Berkeley would have been better accounted for if employment were a factor.

Though I have made a strong case against employment as an appropriate gauge of centrality in 2015, for a more nuanced analysis of urban centrality, the inclusion of employment as a factor would be interesting to test. Employment would help capture large institutions that prevent commercial uses.

5.4.4   Ethnic Centers in the Bay Area

Established in 1848, San Francisco's Chinatown is the largest Chinatown outside of Asia, and is home to the largest Chinese community outside of Asia. Ethnic centers provide a sense of community, and in this case, represent centrality from the most recent immigrants to people several generations removed from the immigration experience that participate in the traditions of their ancestors. Ethnic enclaves are important for community. Ethnic grocers are relied on to carry special food items essential for holiday traditions. Parks and streets serve as a meeting place for national (Chinese new year) and religious customs (Hanukah).

The Bay Area is home to several well-known ethnic centers (Figure 29), including African-American neighborhoods in San Francisco and Oakland; Asian-American neighborhoods such as Chinatown and Japantown in San Francisco, as well as Asian communities in the Richmond and Sunset Districts, Alameda, and San Jose; Little India in Berkeley; and Latin American communities in San Jose, Oakland and the Mission in San Francisco. Fremont, Hayward and San Jose are home to large South Asian communities but these did not score well at all in the 2 km array.

Figure 29 Ethnic Enclaves Across the Bay Area

While the common core has been delimited in this analysis, studying and quantifying ethnic centers would be a useful expansion of this discussion. I believe that to delimit an ethnic core accurately, the choices of amenity inputs would need to be reviewed and modified to reach a reliable set of interpretations and conclusions.

The lack of new housing in the core urban centers and the high cost of housing have caused notable tension between new residents and the historic ethnic communities that make cities like San Francisco and Oakland diverse. A study of ethnic centrality would also aid in quantifying the significance of the impact of the current gentrification and cycle of immigration to and from the Bay Area.

Comparing the centrality of the Bay Area according to different well-represented ethnic communities and their cultural engagement, organization and structure would be beneficial to gaining a broader understanding of the diversity of the Bay Area.

5.5   Further Applications

By applying this methodology to more U.S. cities, and regions, and to other countries, the blend of amenity inputs, and the source of the amenity data could be further refined, and this methodology could be used to better understand urban structure.

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