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LEED IN THE UNITED STATES: WHO REALLY BENEFITS?

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ABSTRACT

As global climate change becomes an increasingly more prominent problem, we need to implement sustainability measures. The built environment offers many opportunities to promote greener and more sustainable practices. The Leadership in Energy and Environmental Design certification program has come to dominate the green building market. It can be found in a number of countries around the world and it is one of the most widely-known programs, certifying buildings that meet at least a minimum sustainability requirement. It promises to benefit people, profits, and the planet. In practice, it does allow businesses to benefit, it decreases buildings' environmental footprints, and it can improve indoor environmental quality. This thesis aims to examine whether LEED is having a significant enough impact on all fronts and whether or not it benefits people equally. Environmental injustices have historically affected certain segments of society, namely racial minorities, those with less education, and lower-income individuals. I employed a three-stage analysis to test my initial hypothesis that LEED is an elite sustainability measure, mirroring environmental injustices by primarily benefitting whites, the better educated, and those with higher incomes. One stage focuses on LEED at a national (macro) level, the second at a Core-Based Statistical Area (meso) level, and the third at an individual building (micro) level. This provides insight into how LEED has changed and how it is distributed nationally, what inequalities can be seen at smaller, regional levels, and how LEED buildings impact the individuals who occupy them. LEED continues to develop and satisfy its promises. But more importantly, LEED is a program that actually manages to benefit most segments of the population equally, at least preliminarily speaking.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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Chapter 1

Setting the Context

Earth's human population continues to grow at an exponential rate, meaning that ever-more resources will be needed to sustain the population. The continued increase in demand creates scarcity. Resource scarcity in itself is a substantial problem to tackle, but it is further compounded by climate change. The population is only growing, and exponentially at that, as is energy and resource consumption. Countries around the world follow a basic economic paradigm focused on increasing the human population, economic development, and standard of living (Brown). Resources and energy accessibility are what help propel developing countries forward. If a country can gain more access to electricity and energy, 24-hour lighting, refrigeration, sanitation, and transportation improvements, among many other things, will follow, leading to a meeting of the aforementioned economic paradigm. However, many of the developed countries in the world achieved their status by consuming natural resources at unsustainable rates (Brown). Growth was the focus and resource management typically only occurred once a resource was in jeopardy, as happened with deforestation in the Amazon Rain Forest or whales and their oil. As countries continue to pursue development, resource use increases, leading to a greater human contribution to climate change as well as resource scarcity.

This is particularly problematic, as buildings consume relatively large amounts of resources and energy and larger buildings are a byproduct of economic growth. With continued population growth and changing climates, shifting food production patterns, strains on potable water sources, and higher usages of electricity for indoor cooling are but a few examples of

scarcity creation. Given these strains on Earth and the ramifications for life as we know it, human actions need to change to meet the challenge. Emphasizing sustainability is one approach to balance both the needs of our social and environmental systems, as it inevitably interacts with three spheres: economy, environment, and society.

According to the Cambridge Dictionary, sustainability in an environmental context is the ability to continue something for a long time while causing little or no damage to the environment ("Sustainability Meaning"). The keys within this definition are the consideration of long-term effects and a minimization of environmental degradation. Implementing methods that lessen environmental impacts and contribute to a higher quality of living while still making fiscal sense is imperative if sustainable actions are to make a lasting impact. Buildings are one of the largest users of resources and energy. In fact, residential and commercial buildings alone consumed nearly 41% of the United States' energy in 2014 (EIA). Consequently, efforts to improve building sustainability while improving quality of life are quite logical. The built environment shapes how humans interact with each other, aids in determining quality of life, and it is simply where people spend the majority of their time. Thus, investigating solutions to improve the sustainability of the built environment is essential for using resources more wisely and consequently reducing environmental impacts. But just as importantly, buildings designed sustainably can also improve the indoor environment for inhabitants and enhance the quality of life while indoors.

Green building strategies aim to reduce a building's overall environmental impact. This is achieved through energy and water efficiency, environmental disturbances from the building site, and access to public transportation, among other solutions (Allen). While individuals have the ability to construct green buildings that lessen environmental impacts while improving building inhabitant and visitor experiences, initiatives headed by governments and other organizations have the largest capacity to promote the greatest changes. A number of green

building programs attempt to address sustainability in the built environment in their own way. Some of these programs include the Living Building Challenge, the Green Building Institute, and perhaps most notably, Leadership in Energy and Environmental Design (LEED).

Figure 1. A non-LEED certified medical center

Figure 2. A LEED-certified medical center

The LEED green building certification program is one of the most widely known efforts to improve building sustainability. Its program is point-based; it awards points for everything from energy and water efficiency to public transportation access to using environmentally friendly materials. LEED projects earn points across nine green-building categories: integrative process, location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation, and regional priority ("LEED"). Based on the number of points achieved, the building achieves one of four rating levels. In order from lowest to highest, these are "Certified," "Silver," "Gold," and "Platinum." According to their website, LEED is the "triple bottom line in action, benefitting people, planet, and profit." This movement is not only growing within the United States, but the world as a whole. Currently, LEED projects are found in 38 countries around the world, from Japan to Mexico to India (USGBC).

One of the most important elements regarding green building programs is the notion of equality. One of the largest concerns regarding LEED is whether or not it creates an elite sustainability. De Souza and dos Santos Junior discuss how a highly exclusive neighborhood in Brasilia aimed to achieve LEED certification, stating "an enterprise which does not contemplate social equity cannot be considered green." Historically, environmental racism has been a very real concern, as tales of "disproportionate placement[s] of unwanted land uses, including waste sites, in minority neighborhoods" have plagued the United States (Colten). It is not only racial minorities who suffer from worse environmental living conditions; in fact, environmental gentrification can also lead to the poorer segments of the population only being able to move to areas that are significantly less desirable environmentally (Abel et al.). The question then

becomes whether LEED also benefits only selected segments of the population; namely higher income, higher educated, and/or white individuals.

LEED has been around for a while and many buildings are LEED certified. It theoretically adds value to the areas where LEED buildings are found, but are all communities equally exposed to these benefits? This thesis preliminarily aims to determine whether LEED is indeed an elite sustainability measure, concentrating where value already exists or whether it can add value and benefit a diverse population. These questions will be addressed at three levels; nationally (macro), regionally – more specifically, within cities and Core-Based Statistical Areas – (meso), and locally within individual buildings (micro). This structure allows us to see how LEED works at finer and finer levels of detail to more fully understand the program's effects. Nationally, we can see how LEED is changing over time; how many LEED projects are there? What areas of the US have the most LEED buildings and does these areas also have important demographic characteristics that correlate with the LEED density? While this paints a broader picture of LEED's effects, focusing on one CBSA offers more detail into how demographics interact with LEED development. At this level, we can also separate commercial LEED buildings from residential projects, helping to understand whether LEED is tied into differences between where people live and where they work. Finally, the micro level provides an opportunity to examine how LEED buildings directly affect the people who occupy or visit them. The literature helps address some of my questions, but utilizing spatial and statistical analyses helps to answer the remaining questions.

Chapter 2

The Built Environment and Green Building

Before delving into the complexities of the LEED Green Building program, it is important to understand the potential effects of the built environment. Neighborhoods and groups of buildings can shape how people interact with each other as well as the types of services and amenities they can easily access. This in combination with building interiors can dramatically influence one's quality of life. Of course, buildings both directly and indirectly impact the environment and it is important to understand how they do so. Once the effects of the built environment are better understood, we must then look at green buildings broadly to see how they differ from their counterparts and how successful the building strategies are.

The built environment heavily influences how people live their lives and interact with each other. This environment of course does not affect everyone equally. Areas within cities, for instance, have varying levels of walkability and bikeability, land use, accessible destinations, and transit options. This can either increase physical activity and reduce the likelihood of childhood obesity, usually for the wealthier individuals, or it can result in an increased access to high-caloric foods and convenience stores, leading to obesity, as well as higher traffic and worse air quality (Rahman). Similarly, the interiors of buildings greatly influence an individual's experience within. Productivity, attraction and retention of skilled workers, and health status are directly related to the built environment (Lockwood). Building design and location can drastically affect the individuals who visit or live in or near these buildings.

Just as buildings greatly affect people, they also impact nature. Certain building materials might be unsustainably sourced, new buildings might be constructed on open land

instead of replacing older structures, and they might not be designed for efficient use of electricity, water, or other resources (van den Berg et al.). Throughout their entire life cycles, buildings can have a significant detrimental impact on the environment. Green building is a rapidly growing field that aims to tackle problems related to scarcity and climate change as well as how people experience the built environment. Environmentally speaking, green buildings reduce energy and water consumption, improve air quality, use more sustainable materials, and reduce waste disposal, among other things ("Eco-Architecture").

However, one of the biggest problems with green building is the ambiguity associated with the term "green" (Burney). There is no common standard definition of green and this can lead to false promises. Burney notes that claiming a building will result in a certain amount of energy savings is risky, as that directly depends upon the inhabitants' lifestyles and geographic location. Since green building is rapidly growing, new technologies and products are constantly being released. Some of these are inevitably going to be more thoroughly tested than others, end results may be significantly different than what was previously thought, leading to disappointed inhabitants. These various mistakes, exaggerations, or lies can be labeled as "greenwashing" (Freedman). One of the largest contributors to this so-called greenwashing is the financial incentives that accompany a growing field (Crawford). Crawford explains that building tenants prefer to rent spaces in green buildings and that green buildings earn higher rents, increase resident happiness, and decrease sick time. These benefits certainly appeal to businesses and governments, which translates into incentives throughout all stages of the construction process (Freedman).

The green building process itself is plagued by other problems. Perhaps one of the greatest complaints of green building is that it does not focus enough on preserving or renovating

older buildings. Instead, it focuses more on tearing down buildings that have stood for eighty years to throw up another building (Powell). Powell also notes that just because a new building here has a solar panel or some other "green" feature, destroying an in-use, preexisting building is not green, no is it smart growth. If an existing building is not in desperate need of repair, it could very well be a waste of resources and materials to replace it. While the new building might be more "green" than the old one, using more resources than necessary instead of retrofitting the existing building is indeed wasteful.

One of the other potential problems with green building is the fact that it needs to be pursued from the beginning of the planning and building or renovating process and not part way through. While one would not expect a group to decide to build green part way through a building process, if it were to happen, it would demonstrate that green building is not always the most flexible. Building is a relatively complex process that involves vendors, suppliers, and designers; "replacing, altering, or failing to correctly install any links in [the] chain can create a house that isn't green" (Burney). Even one seemingly small and insignificant element can prevent a project from being officially green. Burney cites an example on an office building that promised to be LEED certified, but the painting job was finished with health-hazardous paint, preventing certification.

Green building solutions are also location-dependent. Not all green building strategies can be applied effectively in all regions of the world. For instance, green roofs and walls can increase the thermal performance of buildings and reduce negative heat transfer (Feng and Hewage). However, Feng and Hewage also demonstrate that green vegetation is not always cost-effective in winter months, especially in cold climactic regions due to a low energy savings performance.

Green building would not be a growing movement if it did not at least appear to have positive benefits. One of the main reasons it is growing is because it makes for good business. According to Crawford and Morris, "many project teams are building green buildings with little or no added cost and budgets are similar to non-green buildings." Furthermore, these buildings also provide higher productivity, greater attraction and retention of skilled workers, and have lower overhead costs (Lockwood). This harkens back to sustainability efforts today driven to benefit environment, society, and the economy and it seems that LEED achieves just that.

Chapter 3

LEED

LEED has stepped up to the plate, so to speak, and has transformed the United States' construction industry and has helped foster innovation (Chance). It is one of the most widely-adopted green building programs in the country and many have at least heard of it. More importantly, no green building program is perfect, but LEED has grown and changed over time. Currently, LEED is on its fourth version of the rating system. The US Green Building Council has refined the rating system with each iteration. Overall, LEED is a program that encourages people to move beyond government regulations in an effort to implement greener building strategies (Heijden). It is a point-based system that lays out specifications to achieve certain levels of certification. This makes it relatively easy to determine what steps need to be taken in order to achieve a desired level of certification.

LEED is not without its shortcomings, however. The point system is also the culprit of some of LEED's biggest problems. LEED projects are able to pick and choose which points they wish to pursue. So long as a project meets minimum requirements in each of the categories (sustainable sites, indoor environmental quality, location & transportation, etc.), the points can be distributed in any manner. For instance, even though LEED buildings are occupied by people for a significant portion of the day, the average LEED building only achieves 6% of its total points from the indoor environmental quality (IEQ) category (Wargo). This means that many buildings are not significantly improving IEQ in comparison to non-green buildings and this is arguably one of the aspects of LEED buildings that the inhabitants would readily notice. It is

also the LEED category that most strongly ties into health. One of the main reported benefits of green building is its ability to improve the working environment and reduce worker sick time (Garland). Garland notes that green housing can improve respiratory health, especially in poorer housing areas that might have been constructed using hazardous materials or paints. The freedom of choice overall, however, does not always do the most good. Instead, developers can simply pick and choose what is easy and cheap, but not necessarily the most effective (Kamenetz). Placing bicycle racks on building property is technically just as important as reducing indoor water consumption by 25% (USBGC). One has a much larger and longer-lasting effect that the other, yet both are worth the same amount of points.

The potential economic benefits of LEED can also work in tandem with the point system to create systematic problems. Green building is in large-part driven by performance and marketing-based benefits (Matisoff). Companies or governments are likely not going to pursue green building solely for the sake of saving the environment. If LEED certification can lead to reduced costs in the long term, both in terms of the environment and employees, it seems that pursuing LEED certification would be a no-brainer. However, due to these economic incentives, organizations are not going to be inspired to be as green as absolutely possible; instead, they will just want to reach a certain level in order to reach the next highest certification level (Matisoff). A vast majority of LEED certified buildings just barely reach a certification level, whatever that level may be. This is indicative of organizations doing the least possible to achieve some kind of benefit. This illustrates a crucial setback for LEED, as it is set up in a manner to grow, but not to make the largest environmental impact possible.

LEED was created with the idea to drive the building market in a green direction, but that is just it. A direction might not be enough to make sustainable, significant change. One of

LEED's harshest criticisms is that it only "[rewards] incremental solutions towards sustainability" (Boschmann). LEED tends to focus on tech and gadgetry as opposed to "focusing on local geographic conditions to work with natural climate systems through design informed by vernacular architecture, as well as . . . adaptive reuse" (Boschmann). LEED does offer a few credits for addressing geography-specific priorities, but that does not prevent developers from choosing to pursue credits that will ultimately have minimal effects given the geographic location of the project. Based on the somewhat flawed point system, LEED seems to have sacrificed some quality for quantity to make LEED more accessible and subject to growth.

Kamenetz notes that LEED certification sells buildings to high-end clients and governments, gives architects and builders free publicity, and creates a green hook for selling new products or the buildings themselves. Khashe et al conducted a study that revealed LEED branding as motivating occupants to take up some pro-environmental behaviors, attesting to LEED's ability to influence building occupants and members of the public. LEED is certainly entrenched in the economic landscape, as many companies and individuals have the opportunity to profit from it given its general positive perception, which tends to minimize the competition and silence the critics.

Although they are usually not as economically driven, other green building programs attempt to address the comparative lack of quality LEED indirectly encourages. As previously noted, one complaint about LEED is that it does not give enough priority to where a structure is actually sited; the location is a part of the standards, but it simply does not represent a large enough proportion of potential credits to make it as effective as possible (Hiskes). The Living Building Challenge, on the other hand, presents more stringent standards than LEED. For instance, buildings cannot be constructed on new sites and "one hundred and five percent of the

project's energy needs must be supplied by on-site renewable energy" with "on-site energy storage for resiliency" (living-future.org). These are requirements, whereas for LEED, they would be optional for the pursuit of a higher certification. Of course, such standards will impose more of an initial burden than some individuals and companies might be willing to face, but the environmental impacts are more significant than LEED's. Having a variety of green building programs is beneficial, though, as they ultimately find a way to cater to a larger audience. Architecture 2030, for example, also has somewhat higher standards than LEED, as it aims to reduce energy usage by 50% compared to LEED's 25-30% (Kamenetz). It also aims to require any new Architecture 2030 buildings to be carbon-neutral by 2030 (architecture2030.org). These more aggressive programs will likely be the norm in the future, but for now, the more feasible, but less effective, LEED building program will continue to dominate the market.

Chapter 4

LEED Macro Level Lit Review

Understanding LEED at the broadest perspective is a critical first step in assessing LEED's overall impact. Is LEED a growing movement? Does LEED and green building in general contribute to social inequality? These are important questions to determine LEED's overall impact.

Ascertaining whether LEED is growing or not is important to determine the significance of any potential inequalities. If the movement is in decline, the ramifications of inequality are smaller than if the movement is experiencing rapid growth. LEED is "the most widely known program of its kind" and has grown with time (Alfano). Alfano mentions that cities like Chicago, Portland, and New York have all taken steps to make green construction a citywide focus. If a city aims to make green building a priority, green buildings are inevitably going to become a growing movement in those areas. However, based on data from the online LEED project directory, it seems that LEED hit a wall in terms of growth ("LEED's Limited Uptake"). The author claims "annual LEED-NC [New Construction] project registrations peaked in 2009 and have dropped by more than 50% since then." A 50% decline is very significant, though it conflicts with some of the other literature.

But does inequality exist? First, it is helpful to know whether different populations are segregated or clustered within the United States. According to Seamster, the United States has a racialized system where "racial understandings and boundaries" that are "created by and reproducing our historical and present-day patterns of segregation." People within the United States are not evenly distributed among populated places and not all segments of the population experience equality, whether it be in terms of education, income, or quality of life.

The question then becomes whether green building and LEED tend to contribute to this inequality or if they add value equally. Inequality certainly exists in regards to affordable housing. As Foy notes, "environmental benefits are sometimes viewed as a luxury that those with a low or moderate income cannot afford," indicating that not everyone can experience the same environmental living conditions. This is a classic example of an environmental injustice. Many of these projects have "poor ventilation, toxic building materials, and pest problems that result in serious health problems and affect child development" (Levin). Levin also notes that low-income families also suffer economically, as they have "rapidly escalating energy costs due to building inefficiency" and "limited transportation options." Not only does the initial cost of housing sometimes create a barrier, the costs of living within a home can also degrade the quality of life for those who cannot afford anything better. LEED, unfortunately, does not always provide an opportunity to improve this; according to Szibbo, LEED ND (New Development) certified homes cannot be counted on to "ensure the provision of affordable and mixed housing in sustainable neighborhoods," as the LEED system does not encourage the construction of affordable housing enough.

Green building does have the opportunity to lessen inequalities, though. As Levin mentions, green buildings improve indoor environmental quality and health, increase usage of previously developed sites, and provide an opportunity for underprivileged and marginalized groups to have a voice via the integrated design process of green building programs and LEED. Furthermore, in 2014, the U.S. Green Building Council, the National Housing Conference, and Enterprise Green Communities met in order to implement green building features into newly constructed affordable multifamily rental housing ("Green Building"). These heavy-hitters of building within the US "[helped] developers better integrate green features and building practices

into [Low Income Housing Tax Credit] developments and ultimately improve low-income residents' quality of life" ("Green Building"). This directly helps those who, if anyone, would be the least likely to experience the benefits of green building.

Similarly, one of the most well-known home-building organizations, Habitat for Humanity, has turned to LEED to help build green housing. Habitat for Humanity affiliates "across the United States" are "building more LEED certified homes" that are "energy-efficient, healthy, and sustainable" ("Project Examples"). This partnership certainly caters to those who are less fortunate and less able to find affordable housing, let alone housing that improves the quality of both the environment and the living conditions for those in need. At least at the macro level, there is conflicting evidence regarding the growth of LEED and the potential for green buildings to bridge inequalities. Further literature review and analyses at national and smaller levels will help to shed more light on this matter.

Chapter 5

Meso Level Literature Review

As LEED buildings are inevitably woven into the urban fabric, focusing on LEED's effects over a smaller region proves to add valuable insight into the program as a whole. A meso level analysis focuses on Core-Based Statistical Areas and cities and understanding how LEED and people interact; my analyses focus only on Denver, however. At this level, a smaller scope allows for a deeper understanding of LEED, particularly because we can analyze relationships between where people live and work compared to the locations of residential and commercial LEED projects respectively. Are LEED buildings accessible to a large demographic? Where within cities and urban areas are LEED buildings largely located? Does where one lives or works impact LEED access? Do LEED buildings have the ability to gentrify an area?

Green building is one step on the path to sustainability, which can be defined as "'the need to ensure a better quality of life for all, now and into the future, in a just and equitable manner, whilst living within the limits of supporting ecosystems" (Agyeman). It is important to question whether LEED-certified buildings work towards this definition in determining LEED's overall influence. Agyeman lists characteristics of a sustainable society or community that focuses on three main topics that also happen to intersect LEED's triple-bottom line – protect and enhance the environment, meet social needs, and promote economic success. Specific characteristics include using energy, water, and other natural resources efficiently and with care, create or enhance places, spaces, and buildings that work well, wear well, and look well, and create a vibrant local economy that gives access to satisfying and rewarding work without damaging the local, national, or global environment (Agyeman). At a meso scale, we can see

how these characteristics play out, as this scope allows us to actually see how LEED fits in at a regional level and to better assess inequalities that may be reinforced via LEED.

The relationship between where people live and work can help determine whether LEED buildings improve all of the aforementioned sustainability characteristics, a very daunting task at a macro level. In Sweden, more and more individuals are beginning to do more paid work from home (Hermelin). This means that these individuals will spend less time outside of their homes, so unless their homes happen to be LEED-certified projects, they will not be as significantly impacted by LEED buildings. For those who do live in the city, location can be very important. Governments divide lands, forming municipal borders. These borders have a "strong role . . . in shaping people's activity," where livelihoods can cross borders and indicate "a shift in peoples' behaviors and perceptions of that area" (Cranshaw). Borders are rather tricky things, as they are observed in some instances but ignored in others. This is important to keep in mind for some of the analysis in this thesis, as much of the analysis depends upon municipal borders that may or may not reveal underlying patterns.

Separating residential buildings from commercial buildings in looking at LEED's impacts at a smaller scale becomes increasingly imperitive. Boundaries can become somewhat meaningless when looking at where people live and work. People often do not live in the same area they work. The "mobile life of cities – the traffic, the crowds, the people" makes cities vibrant mixing pots where large amounts of people come and go with the time of day (Edensor). With the near-constant flux, separating out the types of LEED buildings becomes important.

Although determining whether LEED helps to provide these characteristics is important, exploring how LEED contributes to the built environment and alters people's perceptions of a city is just as much so. Kevin Lynch, an American urban planner and author, discusses how

people perceive cities they live in or visit and how different pieces of the environment come together to create an individual image of a city. Lynch's first and arguably most famous book, *The Image of the City,* was written in large part to "improve the empathy between public space and its users" (Hospers). He also claims that cities have come to realize that "a poor image of a place can devalue its attractiveness and thus its local-economic performance in the long run" (Hospers 2076). As individuals in society become increasingly aware of the need for sustainable and greener practices, cities that at least have buildings that are cleaner, able to produce better indoor environments, and can display that they are moving in a green direction will likely be viewed more favorably. Even with non-LEED spaces in cities, "the new spaces created look to be brighter and more welcoming, but not simply so, and not for all" (Edensor). Edensor's last statement is perhaps one of the most important, especially for determining whom LEED affects and how.

Green building does not always help out the less fortunate; as Mehdizadeh and Fischer studied, CalGreen, a green building program, in association with government mandates, "helped turn the building industry against the minority and inner-city housing market, and its policies supported the income and racial segregation of suburbia." People in low-income areas were unable to meet new building requirements and were unable to have new green buildings built in this situation.

However, it would be inaccurate to say that LEED and green building in general do not a variety of populations. Levin cites an example in San Francisco, California that promoted collaboration among housing and service providers and client families to greatly improve indoor environmental quality for formerly homeless mothers with HIV/AIDS and their children, a vulnerable population, by revamping an old commercial building. This resulted in higher initial

investments, but durability of interior products and the building itself will make up for those costs in the long run (Levin). LEED also seems to benefit people fairly equally. Mehdizadeh et al. conducted a statistical analyses for LEED buildings in California to determine whether "wealthier cities and towns would have a greater number of LEED certified homes with higher levels of LEED certification." Ultimately, they found no statistically significant relationship between either the number of LEED homes nor levels of certification and the socio-economic characteristics of the places in question (Mehdizadeh et al.). LEED does not seem to work to everyone's benefit based on the literature, but further examination with my own statistical and spatial analysis will help empirically determine LEED's effects.

Chapter 6

LEED Micro Level Lit Review

Understanding how individual buildings affect occupants at this smaller scope is the final examination level for determining LEEDs significance. Does LEED live up to its claims of improving occupant satisfaction while still being environmentally friendly? Does LEED make an impact at an individual level, both in terms of people and buildings?

When designing an office, it is essential to understand the characteristics of the future employees, the nature of the work and tasks, and what constitutes a positive work environment ("OFFICE DESIGN"). Some jobs require interaction with the public, while others may require relative isolation. Workspace design has a direct effect on an employee's sense of well-being and their productivity levels, and must be carefully designed (Hills). When employees spend a significant portion of their day within one building, the workspace design is essential.

The LEED rating system has a specific credit category dedicated to indoor environmental quality (IEQ), aimed at improving the interior as experienced by building occupants and visitors. This category addresses the use of low-emission materials, lighting, temperature, and air quality among others. Theoretically, a LEED certification should mean that a LEED building results in higher occupant satisfaction in regards to these subcategories when compared to a non-LEED certified building. However, since there is no single standard for LEED design, this outcome is not always met. Hua et al. conducted a post-occupancy evaluation of a LEED Platinum building in 2014, aimed at studying the IEQ. They found that occupants overall were satisfied with the IEQ, but were unhappy with the thermal comfort, air movement, light levels, and speech privacy.

These seemingly insignificant problems can actually have a profound impact on occupant productivity and experiences within a building. Driza and Park discovered these same problems, noting that thermal set points, lack of thermal controls, and cold material finishes were the main culprits for a lack of satisfaction within their study. Another study revealed that LEED occupants tend to be more satisfied with air quality, but more dissatisfied with lighting (Altomonte and Schiavon). Many of the same complaints appear in many LEED buildings, begging the question "Is there a better way to achieve occupant satisfaction without compromising the environmental benefits of green building?" (Altomonte and Schiavon).

Of course, occupant satisfaction is not only limited to IEQ. While IEQ correlates with satisfaction, other considerations, like office type, spatial layout, and time at workspace, also determine how an occupant views his or her building (Schiavon and Altomonte). Spatial layout is not a defined characteristic of a green building so these characteristics are not particularly helpful in determining whether LEED buildings provide a better working or living environment than non-LEED buildings. In fact, Altomonte and Schiavon found that, generally, people are not more satisfied with LEED buildings, though they also noted that LEED might be more effective in creating certain environments. For example, LEED seems to be more effective in providing higher satisfaction in open spaces rather than enclosed offices, in small rather than large buildings, and when occupants have spent less than one year in a LEED building. It seems that the positive value of LEED certification from an occupant's point of view decreases with time as they adapt to their environments. It seems as though LEED certification does not make a noticeable and lasting effect on an occupant's experiences with a building.

Chapter 7

Methods

Although the literature provides insight regarding the growth, development, and experience of green buildings and the LEED program, many questions remain. Following the same tri-level structure, I utilized spatial and statistical methods to help address these remaining questions. At the macro scale, I examine how the LEED movement has grown over time and how it exists now; I do this by looking at the number of LEED projects certified per year, counts of buildings by certification level, building types. To address the potential inequality aspect of LEED, I analyze the locations of buildings in relation to population demographics. At a meso scale, looked at who benefits from LEED at a smaller scale within a core-based statistical area. This level of analysis allows for an in-depth study of the types of people LEED effects as well as where LEED buildings tend to be located. Finally, a micro scale analysis helps determine how people individually interact with and view LEED. It is possible to see whether people directly benefit from occupying a LEED certified building and whether it benefits everyone equally within an individual building.

At the macro level, I extracted individual building data for all LEED-certified projects from the Unites States Green Building Council's website and database. This list contains all projects from March 2000 through March 2015 for a total of 53,327 projects. However, a significant portion of the projects within this database are listed as "Confidential" and do not location information which I need for a spatial analysis . These projects were thus removed from any mapping processes, but were left in-tact for broader analyses regarding certification level, certification date, and project type. 7,501 projects were geocoded. One of the categories of

interest is whether a project is residential or commercial. 752 projects are unlisted, 2,916 are residential, and the remaining projects (49,568) are non-residential. The pertinent data attributes from this dataset were the certification year, certification level, project type, city location of project, and state location of project. With the data compiled, I conducted non-spatial analyses ,including determining which states have the most LEED buildings, which building types were the most prominent, a count by certification level, counts of LEED buildings by year, and a count of LEED buildings by state over time.

Once non-spatial analyses had been completed, it was necessary to geocode the 39,000 non-confidential projects so that the point data could then be mapped. ArcMap was unable to handle such a large dataset for geocoding, so I used QGIS instead. I split the dataset into two sets of 20,000 in order for the geocoding process to run and complete.

With a point shapefile in hand, I needed to obtain polygon data. I extracted core-based statistical areas (CBSAs) from the National Historical Geographic Information System (NHGIS) and supplemented them with race, income, education, and employment data for the CBSAs in 2013 from NHGIS. I used percentages, rather than counts, for this data, as that offers a basis of comparison for the data. I joined this data to the county shapefiles.

Table 1. Data Source Summary

Source	Year(s)	LEED Buildings	Non-Confidential	Residential	Commercial	Geocoded
U.S. GBC	2000-2015	53,327	39,000	2,916	49,568	7,501
NHGIS CBSAs, Census Tracts, and Block Groups	2013					
OnTheMap	2013					

I then obtained useful spatial characteristics like the number of LEED buildings per people, number of LEED buildings within a county, and the total number of LEED buildings within a county by adding columns to the shapefile's attribute table and filled in with the field calculator. The number of LEED buildings per person was then adjusted to the number of buildings per 100,000 people to make future analyses easier to interpret and more meaningful. I mapped attributes of interest using a graduated color scheme and Jenks classification. To obtain statistical correlations, I used R to generate a correlation matrix for all the variables (Wickham, R Development Core Team). GeoDa supplemented this by allowing me to use a univariate local Moran's *I* analysis to determine whether clustering among certain variables existed or not (Anselin). The spatial weights matrix I used was a k-nearest neighbors, with k being 4, as this seemed to balance class boundaries and noise well for this data. I filtered the resulting cluster and significance to the areas with at least a .01 significance.

I conducted the analysis at the state level in a similar fashion to the national level, at both the Census Block Group level as well as the Census Tract level. The block groups were clipped with the CBSA for the Denver area to exclude the block groups not located within the CBSA. I obtained further data concerning where people work and live within the Denver area via the US Census' OnTheMap online tool. I then exported the data as shapefiles and loaded into ArcMap to facilitate comparisons with the LEED building data. I compared the commercial LEED building data to the OnTheMap data looking at the city limits of Denver, while the residential data was compared with the ACS Census data with the Denver CBSA.

Perhaps the best method to understand how people perceive and interact with the buildings they live and work in was to conduct interviews. Geisinger Gray's Woods hospital, a LEED Gold certified building, provides the opportunity to understand how both employees and

visitors experience the building. Interviews consisted of three main questions: 1) What do you hate about this building? 2) What do you really like about this building? And after a brief description of LEED and some of the LEED features that the hospital has, 3) Do you notice any of these features? Do the green features noticeably affect you? I interviewed 31 total visitors and employees and their responses were recorded and coded. It is worth noting that each column of Table 7 in the Micro Results chapter represents responses to each of the three questions. Hence, it is possible for someone to say he noticed a feature or that said feature was important to him, but not have expressed an opinion on it earlier.

Chapter 8

Macro Results

Understanding LEED at the broadest perspective is a critical first step in assessing LEED's overall impact. Is LEED a growing movement or has it already peaked? Are people across the country gaining access to LEED buildings or are new LEED buildings mostly situated within areas that have traditionally had more? If not, where in the United States is LEED not making an appearance?

The LEED green building program has indeed managed to achieve its goal for growth.

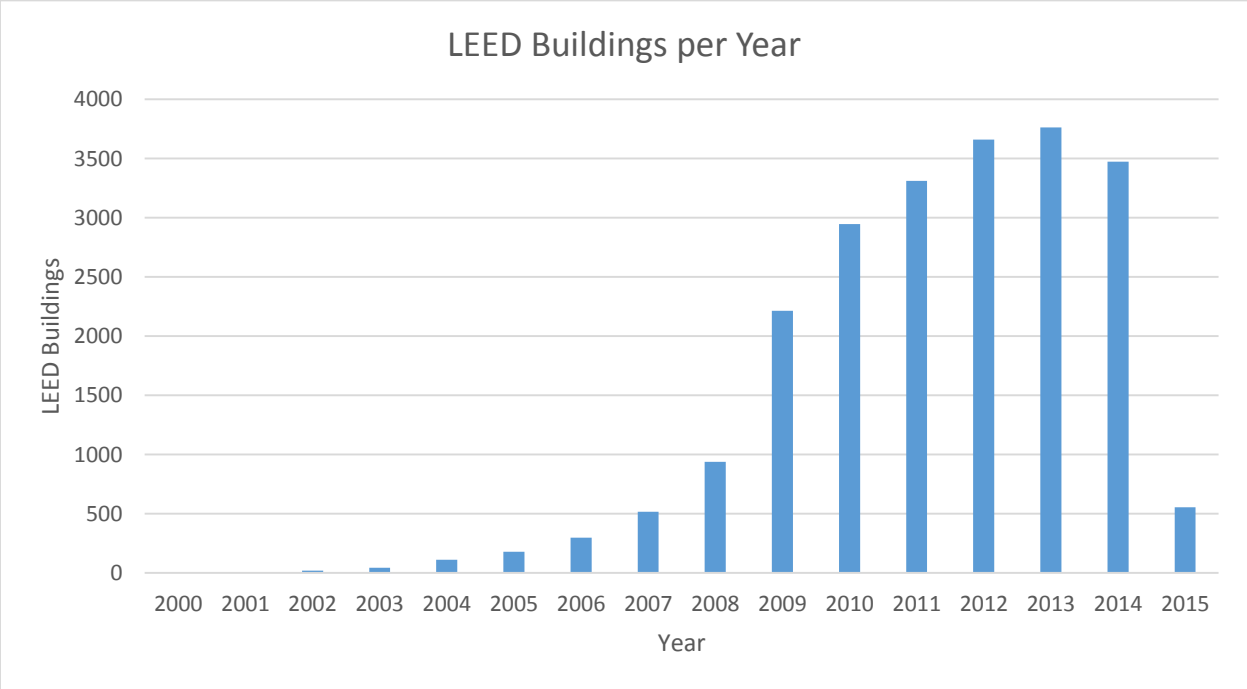

Figure 3. Number of US LEED-certified projects by year

With only a handful of certified projects by 2001, the movement certified more than 2,500 buildings in 2013 alone and the total number of LEED buildings has been increasing as well, as seen in Fig.1. The apparent drop-off of certified buildings in 2014 may be a result of a large number of projects registered for certification in 2014, but they were not actually certified within

that year. Overall, however, LEED and green building programs in general seem to be continuing to grow in terms of the number of projects, contradictory to the literature. LEED tends to grow in places that already have LEED certified projects. The states of California, Florida, Illinois, New York, and Texas have had the largest number of LEED certified buildings over three 5-year periods (2000 – 2005, 2005 – 2010, and 2010-2015).

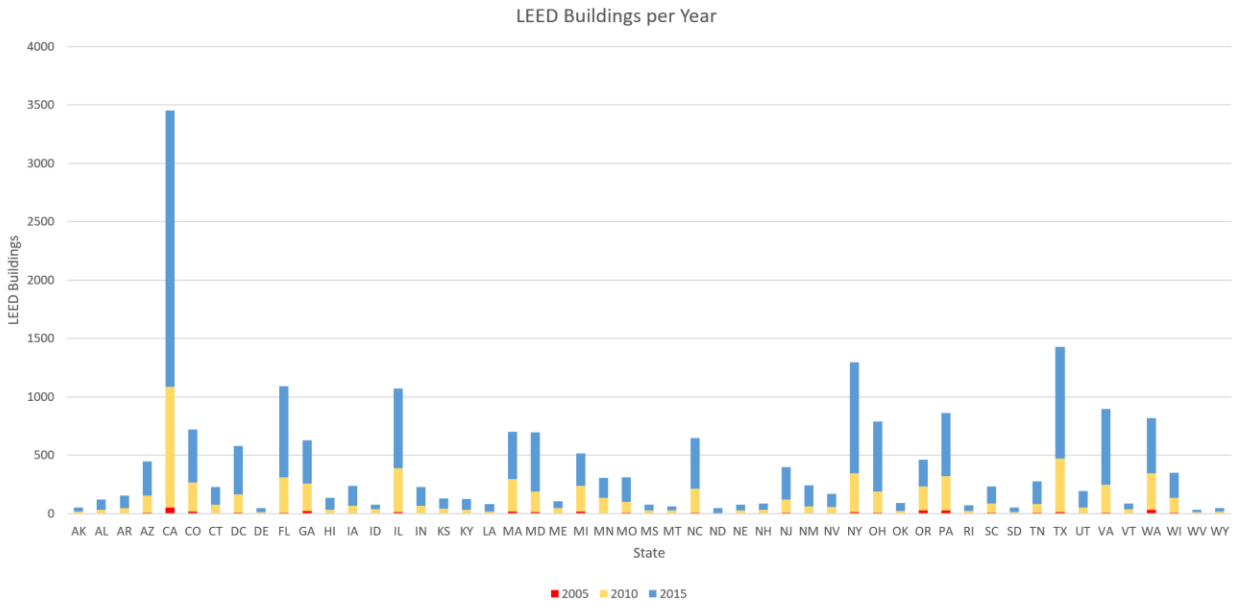

Figure 4. LEED Buildings by Year by State

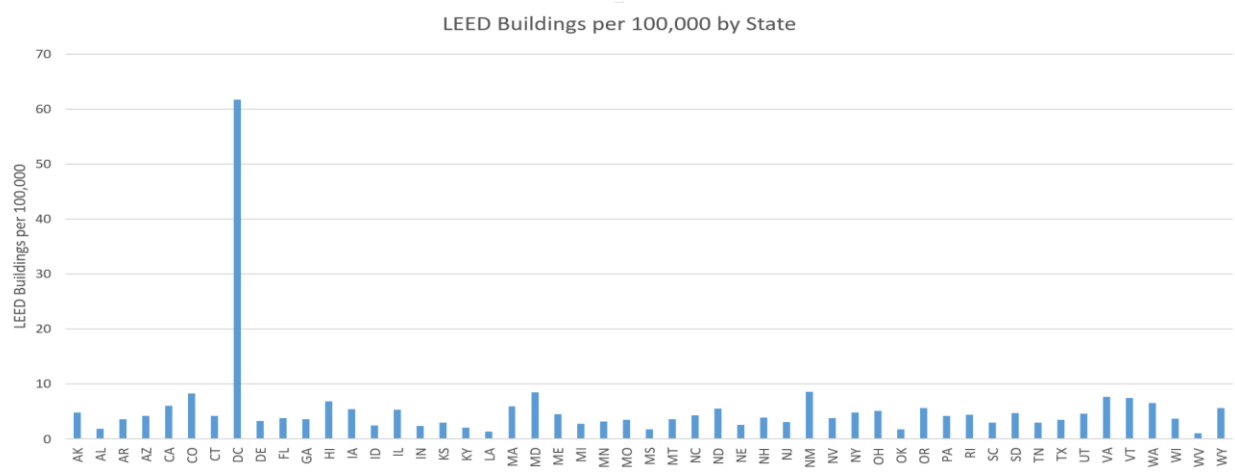

Figure 5. LEED Buildings per 100,000

However, these few states do not have a rate of growth over the time period studied that differs greatly from other states. They simply have more total buildings desiring LEED certification. This is likely in part due to the fact that these states have some of the largest concentrations of people within the United States and have multiple large cities. However, when normalizing the data by the number of people per state, a slightly different pattern emerges. Washington DC clearly has the most LEED buildings for its population. Colorado, Maryland, New Mexico, Virginia are distant runners-up. This demonstrates that states with larger populations and LEED buildings do not necessarily provide greater access to LEED.

Most of the LEED projects do not reach the highest LEED rating (platinum), but tend to be Certified, Silver, or Gold. It seems that project owners wish to make some step in a green direction, likely to better realize LEED's triple bottom-line of people, planet, and profit. Reaching for the highest LEED certification level would require more initial investment in green practices or products and as was described by Matisoff, LEED projects tend to only barely reach any given level of certification. When project owners are businesses, maximizing profit is usually a top priority, not maximizing sustainability and green practices. LEED thus seems to be much more economically focused for those who pursue LEED certification. It seems to be a tool for economic benefit, as consumers learn more about sustainability and resource scarcity and might then respond more favorably to green products and businesses. Of all the non-confidential projects, offices and retail spaces are the two most common building types to attain some level of LEED certification. This further emphasizes the notion that LEED is not focused on being the most sustainable green building program, but instead wants to make many smaller steps towards sustainability by appealing to businesses.

Implementing a statistical analysis helps to determine whether LEED exhibits inequality at a national level. Table 1 demonstrates the correlation coefficients and p-values for the number of LEED buildings per 100,000 people and demographic variables of interest as percentages.

Table 2. Correlation analysis of LEED Buildings and Demographic Variables

		White	Black	Completed at least High School	Median Household Income	Employment
LEED Buildings per 100,000 People	Correlation Coefficient	0.0396	-0.0839	0.1017	0.0927	0.0450
	P-value	0.2213	0.0095	0.00166	0.0042	0.1649

We can see that the being white or employed is not significantly correlated to a higher number of LEED buildings. However, the higher the percent black, the fewer LEED buildings are present per 100,000 and for CBSAs with more people who completed at least high school and have higher incomes, more LEED buildings are present. Based on this basic statistical analysis, it appears that LEED does indeed exhibit some inequality in that blacks, the less-educated, and the lower income tend to have lower access to LEED buildings, though these three variables also tend to occur together as it is.

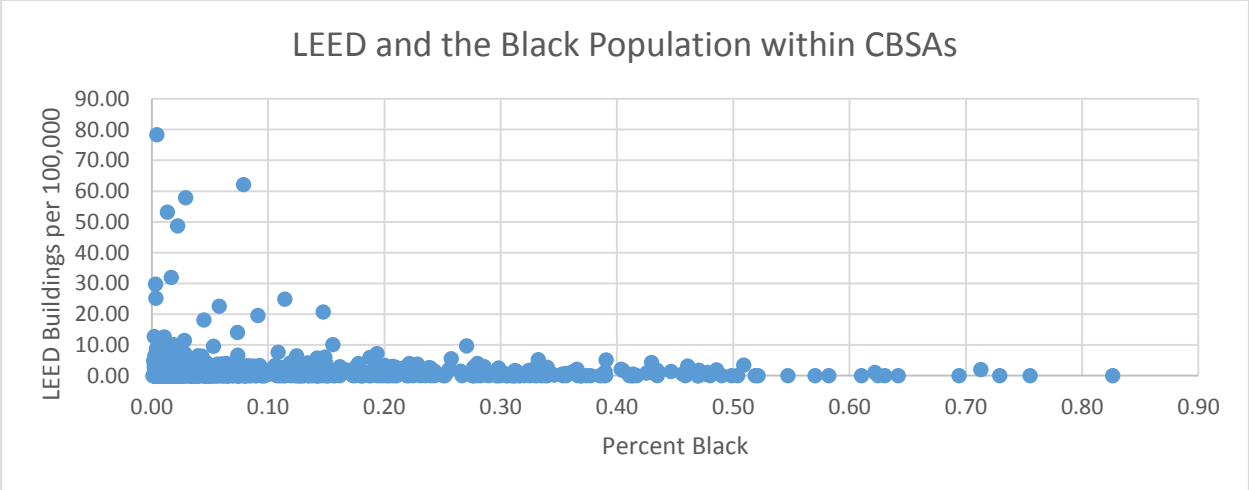

Figure 6. LEED Buildings and the Black Population

Although the statistical analysis offers some insight into general characteristics of LEED buildings in relation to people, a spatial analysis can reveal important geographical relationships that may demonstrate inequality. By utilizing a Univariate Local Moran's *I* LISA map, it can be determined that spatial clustering exists for some of the important demographic variables. All demographic variables are significantly clustered, which is consistent with the literature (Seamster).

Table 3. Univariate Local Moran's *I* Values for National CBSAs

	LEED Buildings per 10,000	White	Black	Educational Attainment: Completed at least High School	Employment	Median Household Income
Moran's *I* Value	0.025	0.742	0.823	0.626	0.606	0.613
Pseudo p-value	0.103	0.001	0.001	0.001	0.001	0.001

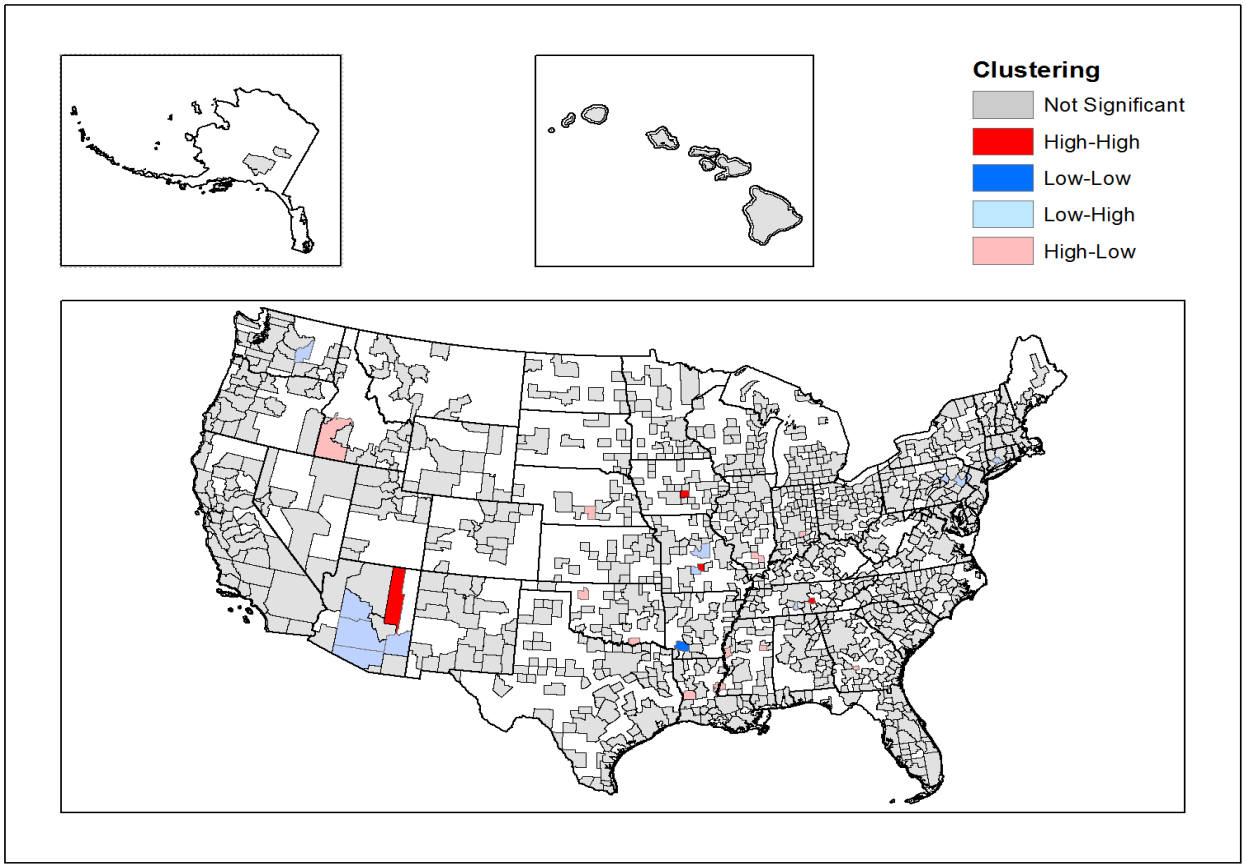

Figure 7. Univariate Local Moran's *I* cluster map for the number of LEED buildings per person

The LEED buildings per 100,000 variable exhibits minimal clustering. As Figure 5 shows, very few CBSAs have any significant autocorrelation, let alone high or low clusterings of LEED buildings. This implies that LEED projects do not tend to be strongly clustered, but are somewhat spread out spatially. However, CBSAs with more LEED projects are also correlated with whites, higher education, less unemployment, and higher incomes. As seen in Figure 6 below, a fair number of CBSAs have no LEED buildings, but very few have more than 32 per 100,000 people. The CBSAs with higher LEED percentages are fairly spread out and every state has at least some LEED in the most populated areas, indicating that LEED is well-distributed.

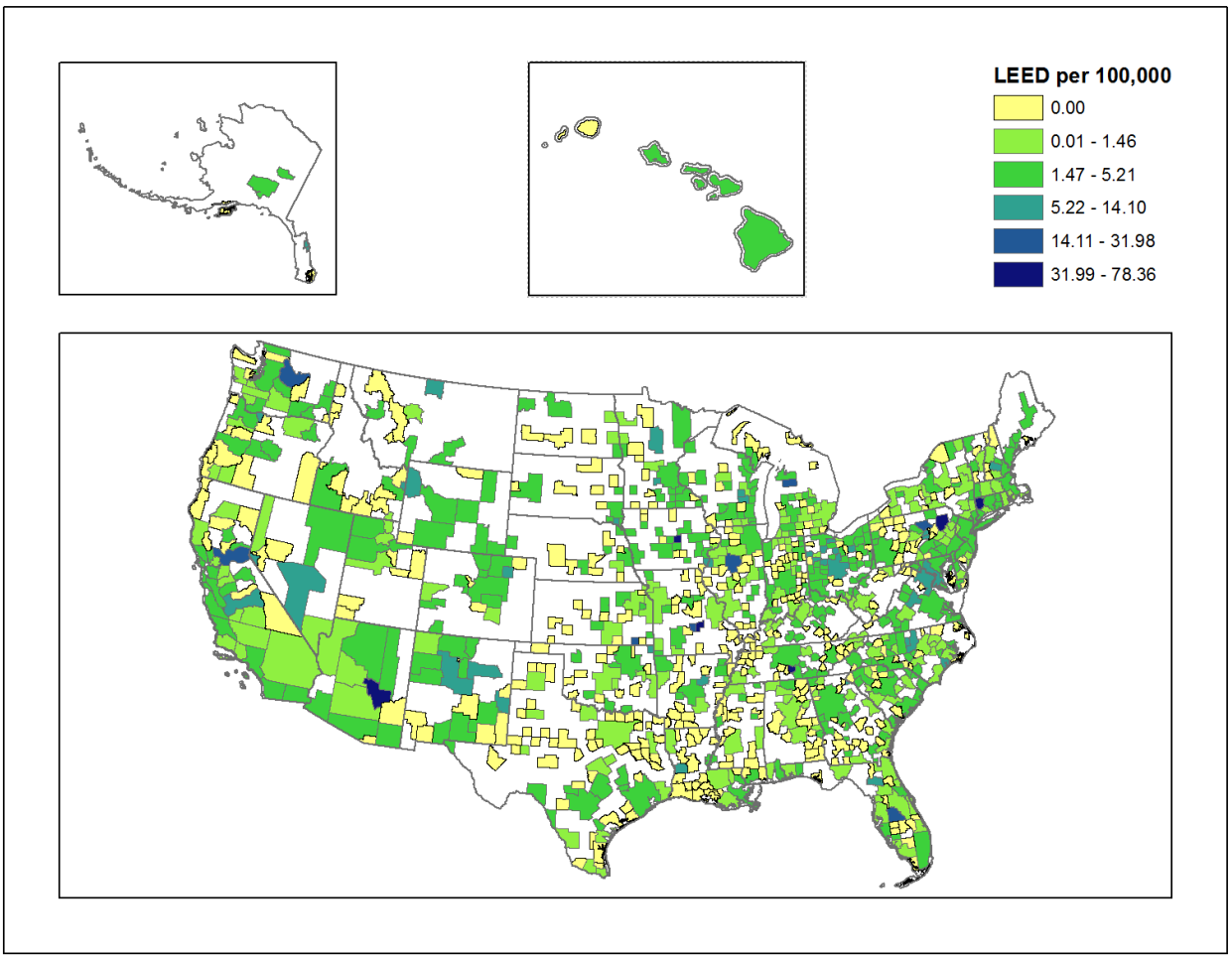

Figure 8. Number of LEED Buildings per 100,000 People per CBSA

At least at the larger scale, it seems that LEED is not exclusive to the more privileged demographics and geographic inequality does not exist within CBSAs at the national level. From here, it is useful to examine one specific CBSA and determine whether these results still hold true, especially one with a diverse base.

Chapter 9

Meso Results

Although we know where LEED buildings are located across the country, it is still unclear whether people in individual areas have equal access to LEED buildings. Are LEED buildings accessible to a large demographic? Where within cities and urban areas are LEED buildings largely located? Do LEED buildings have the ability to gentrify an area?

Similar to the macro level analysis, a univariate local Moran's *I* value was determined for the same variables, looking at LEED building measures against demographic measures for the Denver area. Denver is a fairly diverse city; it has the largest population in Colorado, it is home to a number of different races, and has a number of both higher- and lower-income jobs. As can be seen in Table 3, all individual variables exhibit statistically significant spatial autocorrelation. However, the most meaningful given the intent of this analysis is the LEED Buildings per 10,000 category. A Moran's *I* Value of 0.2051 indicates a relatively small degree of clustering. Figure 7 below shows that most tracts do not have any LEED buildings; however, the highest concentrations of LEED can be found in the heart of downtown Denver. This area is largely characterized by businesses and government offices, but is also amidst clusters of different segments of the population, as can be seen in the Cluster Maps in Appendix A.

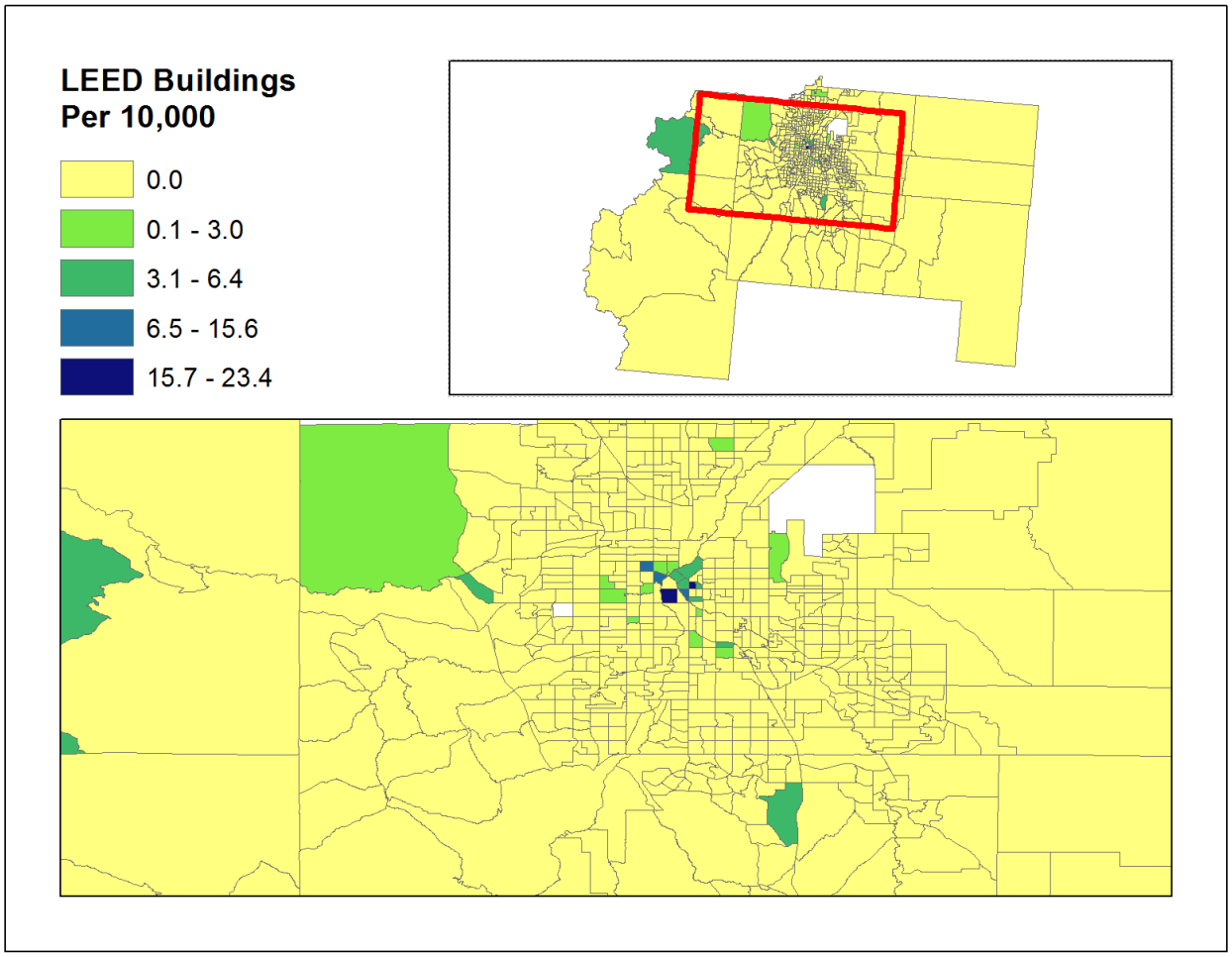

Figure 9. Number of LEED Buildings per 10,000 People in Denver

Table 4. Univariate Local Moran's *I* Values for Denver Census Tracts

	LEED Buildings per 10,000	White	Black	Educational Attainment: Completed at least High School	Employment	Median Household Income
Moran's *I* Value	0.205	0.734	0.720	0.763	0.308	0.550
Pseudo p-value	0.001	0.001	0.001	0.001	0.001	0.001

Using the Census' OnTheMap data, one can also see that a significant portion of these buildings also coincide with the areas that people work. Based on this, it is logical to assume that a relatively wide demographic works in or near a LEED-certified building and can thus

enjoy certain aspects of the LEED certification, whether that be the indoor environmental quality for the workers of those buildings or nearby amenities and modes of transportation.

Spatial clustering only tells one side of the story, however. One must also consider the correlations between the demographic variables and the number of LEED buildings in a given area. The first stage of this phase of the analysis focuses on the residential data. Correlations between the residential LEED buildings and the ACS Census demographic data yielded interesting results. The only statistically significant correlation is median household income. As the correlation coefficient is negative, this indicates that areas of Denver with lower incomes tend to have fewer residential LEED buildings.

Table 5. Correlations between residential LEED buildings and demographic variables at the tract level

	White	Black	Completed at least High School	Median Household Income	Employment
Correlation Coefficient	-0.008	0.025	-0.035	-0.082	0.001
P-value	0.841	0.531	0.376	0.037	0.978

An analysis of the commercial LEED buildings offers a very similar story. Neither the count of commercial LEED buildings nor the count per jobs in a given tract were correlated with low income jobs, mid income jobs, nor high income jobs. The main problem with these two analyses is that the block group is too small a unit, as most block groups have 0 or 1 LEED-certified buildings which makes it hard for useful information to be extracted. Consequently, I performed the same analysis, using RStudio to test correlations between the variables of interest, at the Census Tract level, as these are larger units. Despite this, the analysis yielded similar results. No statistically significant correlations between the percentages of low-, mid-, or high-income jobs and the ratio of LEED-certified buildings to total jobs existed, as can be seen in

Table 4 below. This result indicates that LEED apparently does not unevenly benefit different segments of the population based on income measures alone.

Table 6. Correlations for the number of commercial LEED buildings per total number of jobs in relation to the number of job types

	Low-Income Jobs	Middle-Income Jobs	High-Income Jobs
Correlation Coefficient	-0.008	-0.004	0.117
P-value	0.857	0.934	0.802

Chapter 10

Micro Results

Spatially, LEED tends to benefit a select demographic more than others, but how do individuals view LEED? Does the LEED program actually improve occupant satisfaction levels while reducing environmental impacts? A continuation of the macro- and meso-level analyses at this finer scale would be ideal, but the population composition in State College does not make this reasonable or broadly meaningful. Instead, an interview approach seemed a reasonable alternative, though this was only one experience in one building.

Table 7. Interview Response Counts

Characteristic	Approve	Disapprove	Notice/Importance
Spacious/Open	17	5	11
Accessible/Navigable	12	5	2+/2-
Lighting	11	1	11+/1-
Modern	1	0	7
Clean	4	0	4
Services	2	0	0
Architecture	2	0	1
Comfortable/Welcoming (waiting areas)	2	0	0
Nice	2	0	2
Windows	5	0	1+/1-
Green/Environmentally Friendly	1	0	0
Privacy (workspaces)	1	4	1-
Comparable to other buildings	0	0	10
Phone Reception	0	1	1
Thermal comfort	0	2	1
Narrow hallways	0	1	0
Bathrooms	0	1	1+/1-
Better than other buildings	0	1	2
N/A	0	15	0
Transportation access	0	1	3
Outdoor paths/nature access	0	0	2
People (number of public, quality of staff)	0	1	1
Small individual spaces	0	1	1
Parking	0	1	1+/1+
Landscaping/Outdoor design	0	0	1
Doors hard/slow to open	0	1	0
Feels like a hospital/design suits purpose	0	0	2
Air quality	0	0	1
Pests	0	0	1
Eco-friendly	0	0	2+/1-

Prior LEED experience – comparable	0	0	1

After conducting a series of interviews at Geisinger Gray's Woods Hospital, one can begin to understand how individuals view LEED certified buildings. Overall, people have relatively positive views on the building. After coding the participant responses, there were significantly more positive views than negative, especially in terms of building design. For example, most people, if they noticed, appreciated the spaciousness, accessibility and navigability, lighting, windows, and the cleanliness of the building. Not all of these features are necessarily green nor did they contribute to LEED certification, but they are some of the easiest for visitors to notice. Of course, not everyone viewed these features in the same manner. The openness and accessibility and navigability also received the most negative opinions. People claimed the design was "a waste of space" and that "it's hard to find [one's] way around." Many of the other features of the building that people liked or hated were only noticed by a very small number of people. Only one person, for example, complained about the green features of the bathrooms at the hospital, including small paper towels and finicky faucet sensors. However, one of the most intriguing results is that ten people (32%) stated that the hospital is comparable to other buildings. Geisinger Gray's Woods, a gold LEED-certified building, seems just like any other building. Perhaps the most unexpected response was an older man who, to paraphrase, believes that climate change is a hoax and that individual buildings pursuing green building strategies and practices is a waste of money unless every building everywhere does the same thing.

LEED's impact at an individual building level is quite uncertain. A significant portion of interviewees may view some features positively, but a significant portion of interviewees found these same features to be annoying or inconvenient. Daylighting is perhaps one of the hallmark signatures of green building. Green buildings tend to bring in the maximum amount of sunlight

to light and heat the building throughout the day. While some people enjoyed having large windows that provide nice views and provide working light, others had concerns with the windows. Depending on one's desk or seating orientation within the building, the sunrise or sunset temporarily blinds the individuals. The windows are equipped with a shade, but some employees complained that "whoever operates the shades does a pretty poor job," as the shades were not put in place in a timely manner for consistently satisfactory working conditions. As previously mentioned, one individual found the bathrooms unsatisfactory. The faucets operate via a motion sensor, but the individual found the sensors to not be very accurate. Using water only when a hand is present reduces water use since the faucet cannot be left running unattended nor will it drip from someone not turning a handle completely to the "Off" position. If only one person (3%) has a problem with it, it is more likely that this is an individual problem given the fact that everyone needs to use a bathroom. Perhaps this man's most salient point was that the paper towels for hand drying were doing more harm than good. Smaller paper towels might seem like a way to use less paper to dry one's hands, but if it is too small, then multiple paper towels will need to be used to accomplish the task resulting in no significant paper reduction. LEED certainly is not a perfect program and it seems to do more beneficial than detrimental, but continually addressing the negatives in an effort to improve is imperative for LEED to be greener and for it to be more appealing to everyday people.

Overall, Geisinger Gray's Woods has a more positive environmental impact than other ordinary buildings. It reduces energy and water usage, provides an outdoor environment that people can enjoy, and it is accessible to public transportation. But when these features go somewhat unnoticed or do not stand out from other buildings, LEED and green buildings become rather intangible for visitors and even some employees. Nearly one third of the

respondents felt that the hospital was comparable to other buildings and the vast majority of the rest only noticed the spaciousness and the daylighting. Only one of these features is directly associated with being green, but as previously mentioned, it received some negative opinions.

Chapter 11

Conclusion

Climate change is a very real problem that requires very real action. Sustainable efforts will need to be put in place in order to make a meaningful impact that will improve the lives of all. As more and more people move from rural areas to urban areas, the built environment becomes an increasingly large opportunity to implement sustainable practices. The LEED green building certification method is but one attempt to better the environment, society, and the economy.

At a macro level, LEED is continuing to grow not only within the United States, but across the world as well. Although LEED buildings are not evenly spread across the country, they are not significantly spatially clustered, nor are they found disproportionately in areas with statistically significant inequalities between race, income, unemployment, or educational attainment. Analyzing LEED at a smaller scale, the Denver CBSA, reveals a similar story. LEED buildings are consistently found more in highly urbanized areas, yet even at both the Census Block Group and Tract levels, do not statistically benefit different segments of the populace unevenly. Separating where people live from where people work is an important step in examining the impacts LEED can have. Parsing the data in this manner does not reveal any significant inequalities either. LEED buildings in both environments appear to be evenly accessible to the different segments of society. Even at an individual building level, LEED buildings are designed to improve the quality of everyone who occupies or visits a building. Some building design components may be built with good intentions, but they are problematic for some while useful for others.

LEED certainly makes an effort to benefit both people and the planet while still being profitable in the long-run for those pursuing certification. After conducting an analysis at three different levels that offer insight into a variety of different aspects of LEED, LEED seems to impact all segments of society relatively equally. LEED, preliminarily speaking, does not appear to be an elite form of sustainability. But does LEED do enough to make a significant difference amidst climate change concerns? As of now, that still remains questionable. Other green building programs certainly do more for the environment, but none have become as widespread as LEED. With continued improvements over the years, LEED can potentially make a sustainable and equitable difference around the world.

Appendix A

Additional Figures

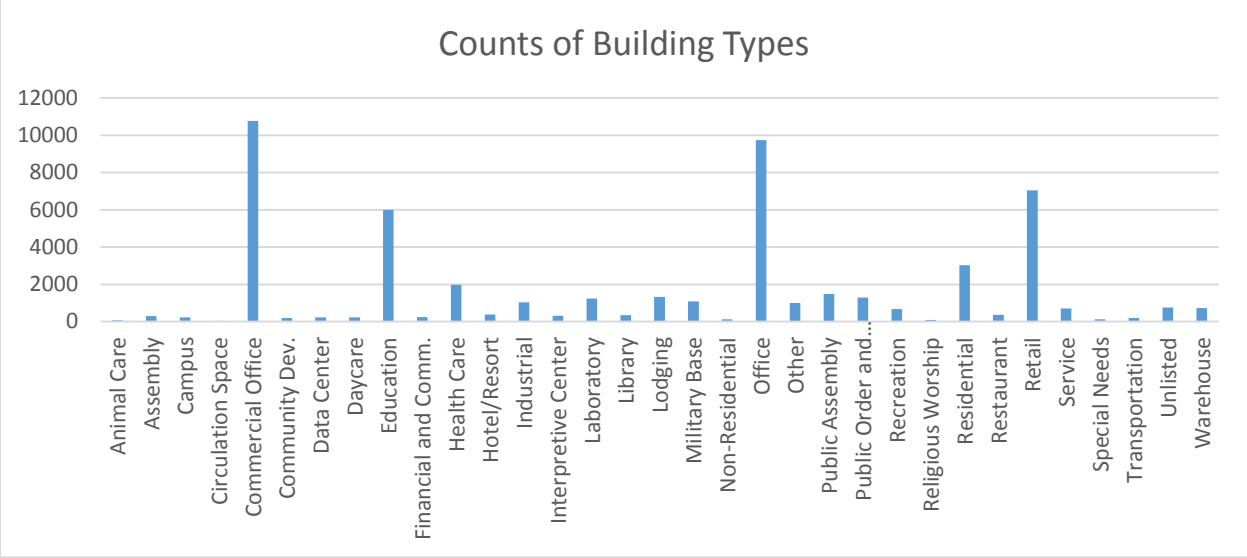

Figure 10. LEED Building Type Counts

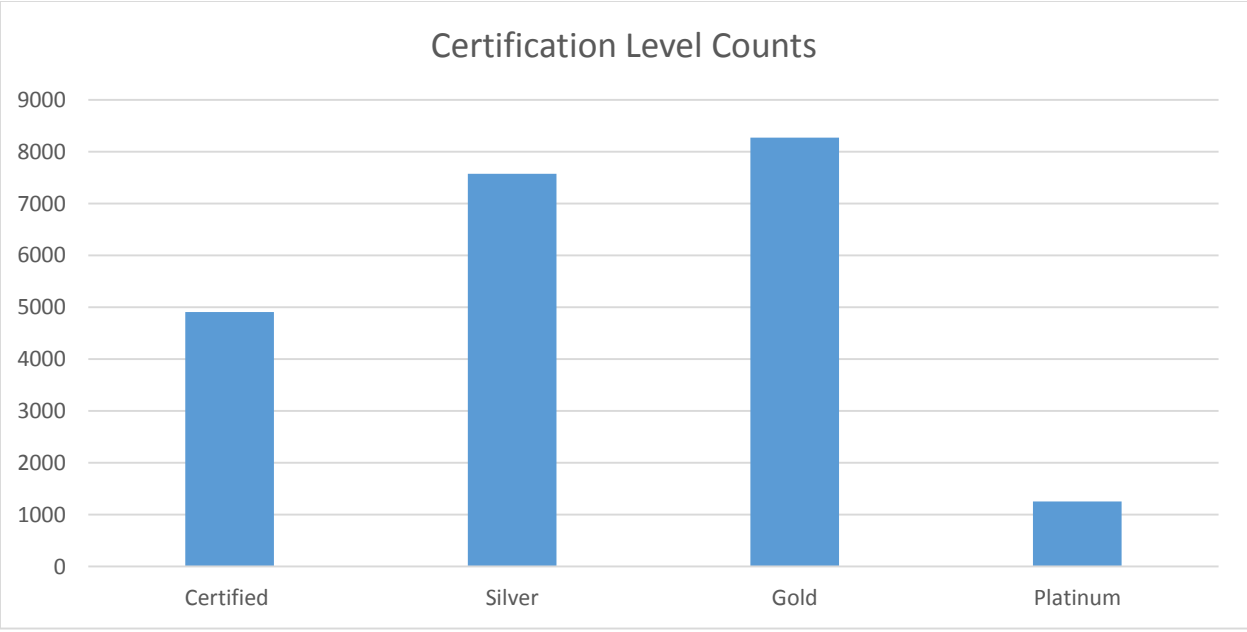

Figure 11. Count of LEED Certification Levels

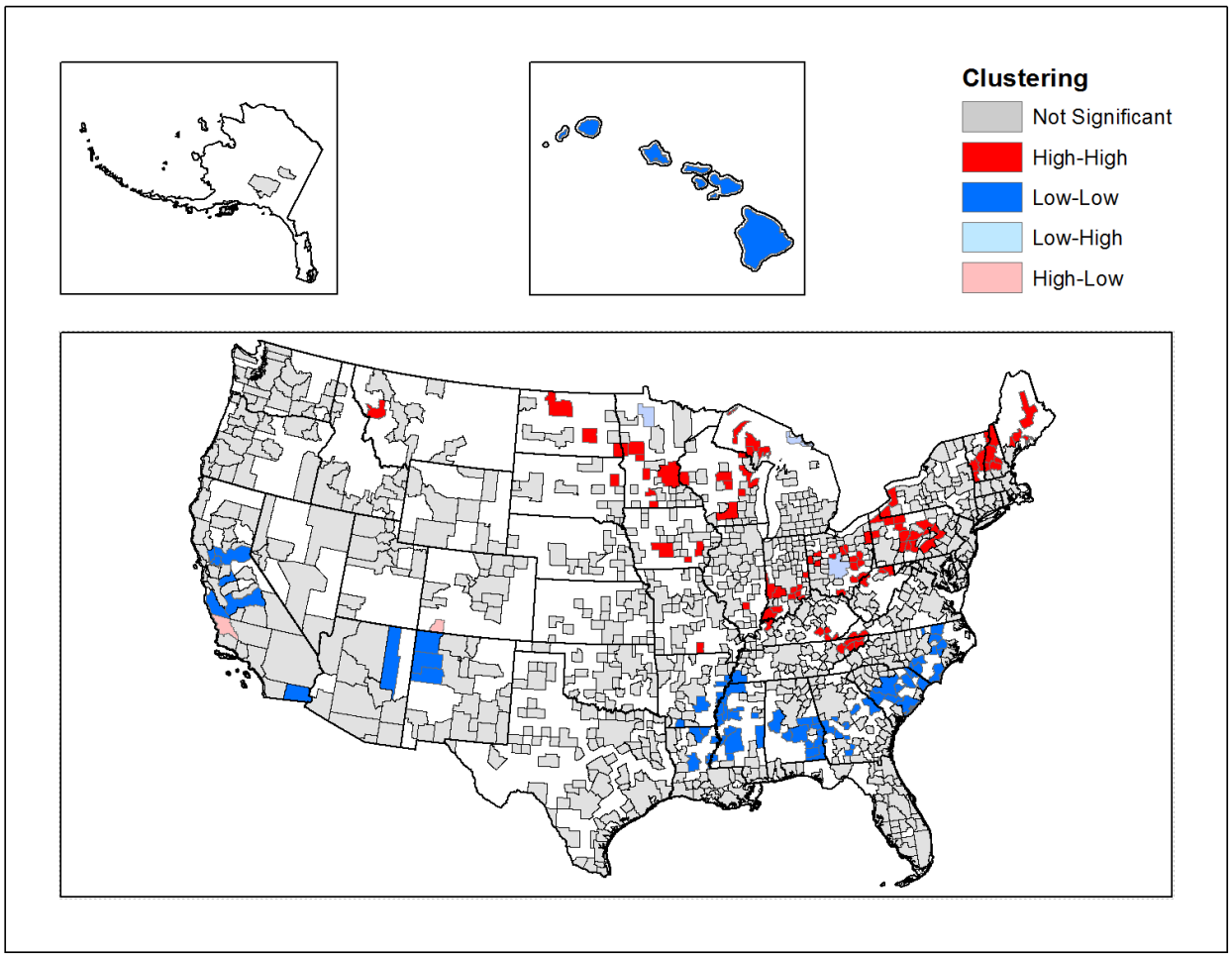

Figure 12. Univariate Local Moran's *I* cluster map for percent white

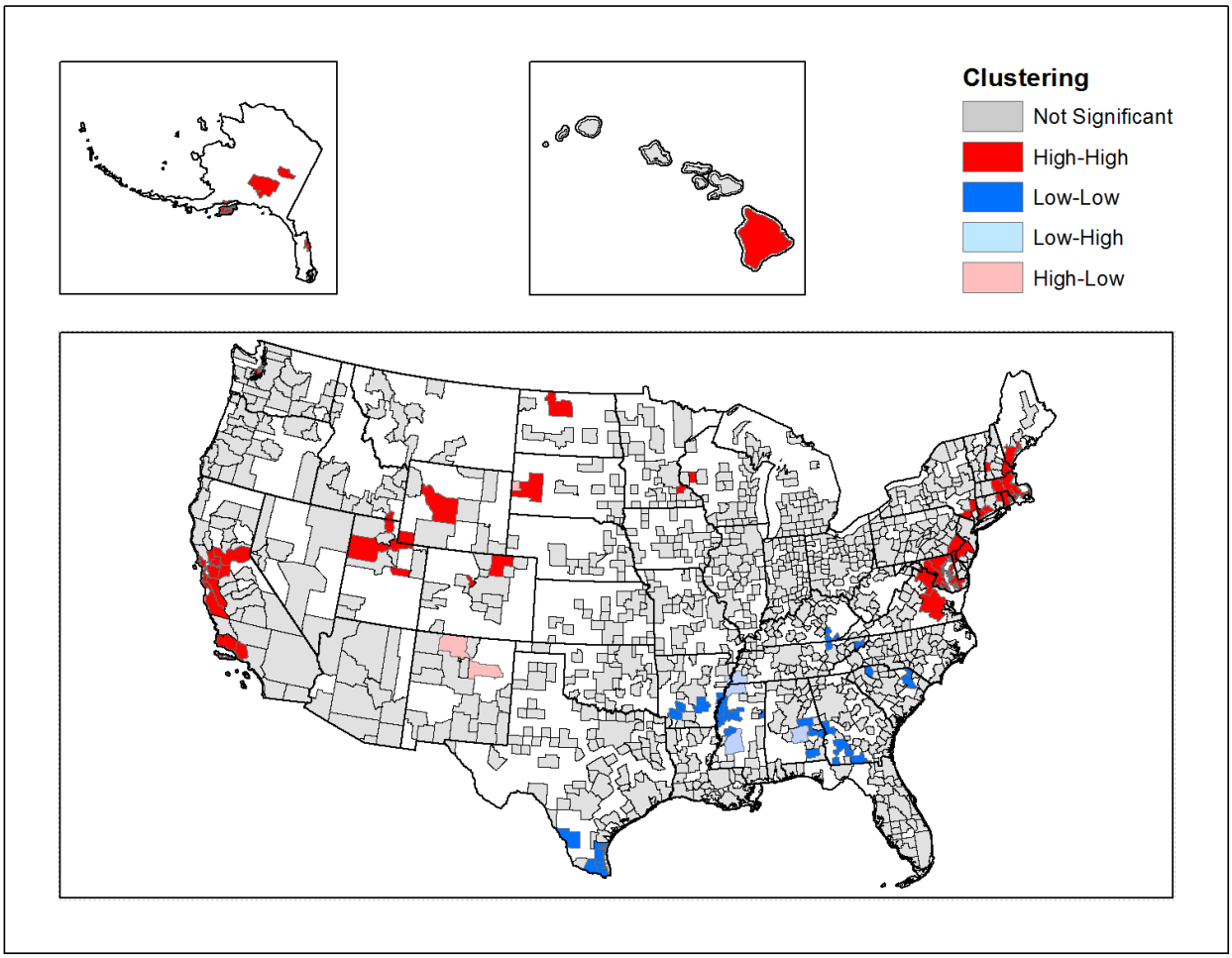

Figure 13. Univariate Local Moran's *I* cluster map for median household income

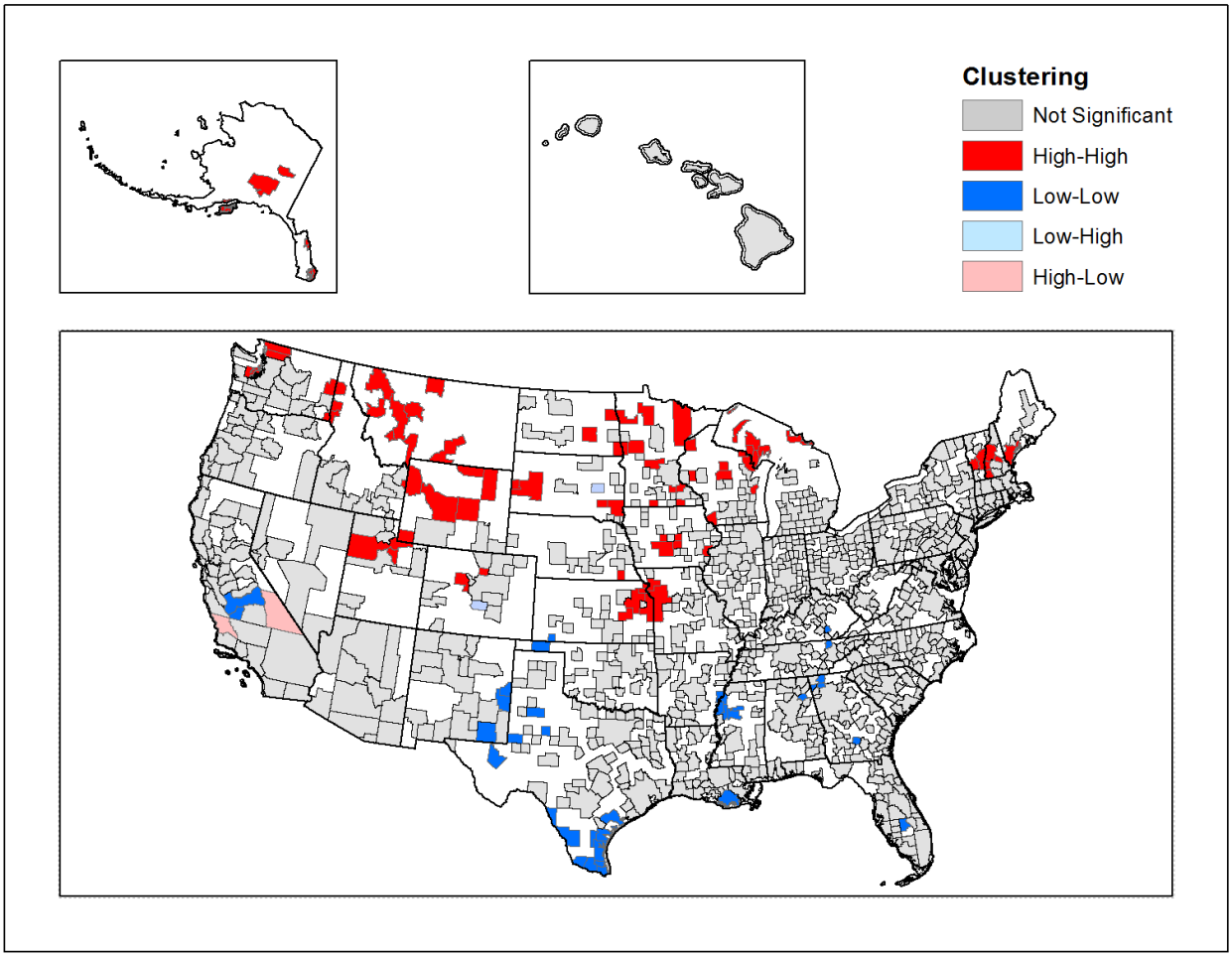

Figure 14. Univariate Local Moran's *I* cluster map for those at least graduated high school

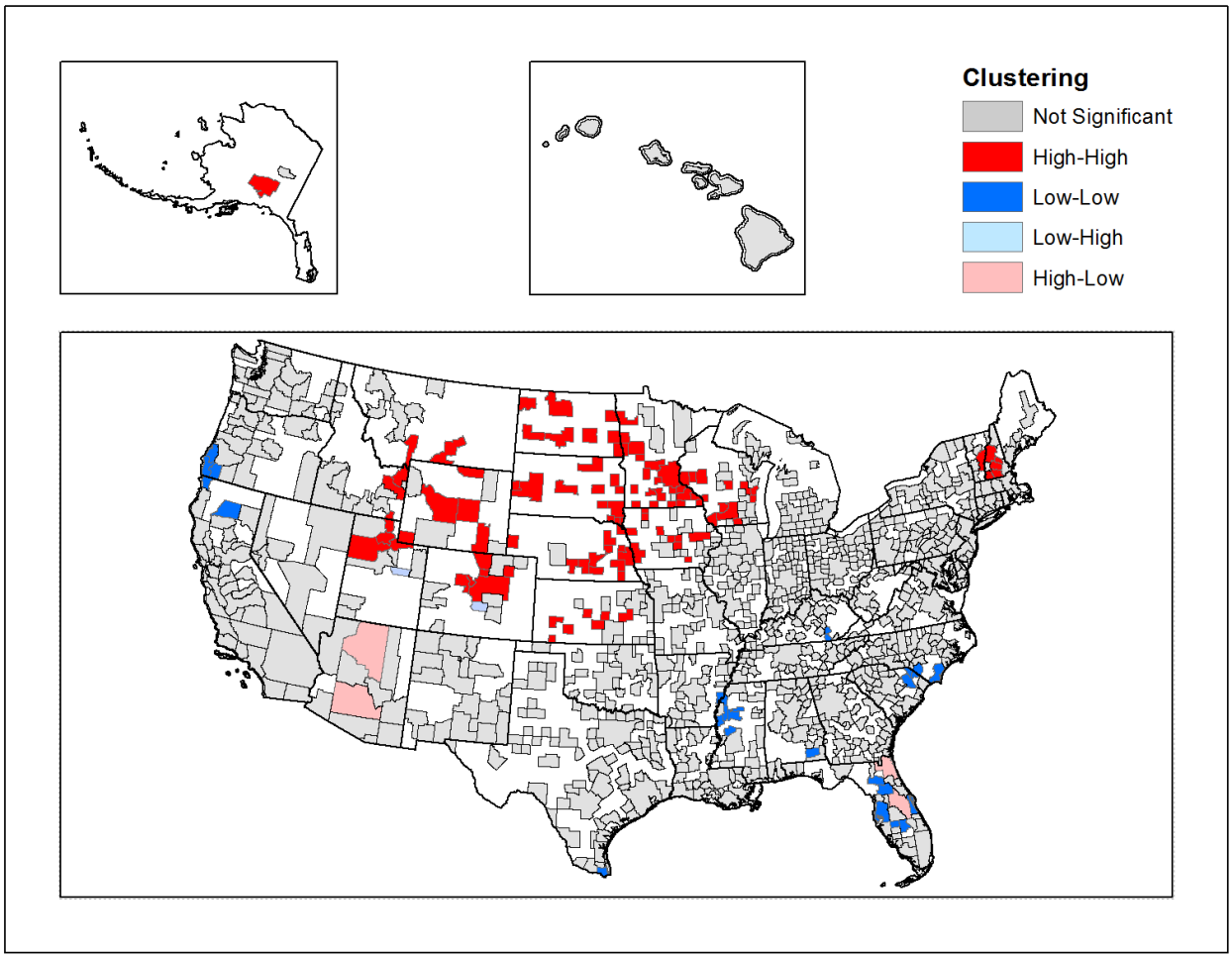

Figure 15. Univariate Local Moran's *I* cluster map for employment rates

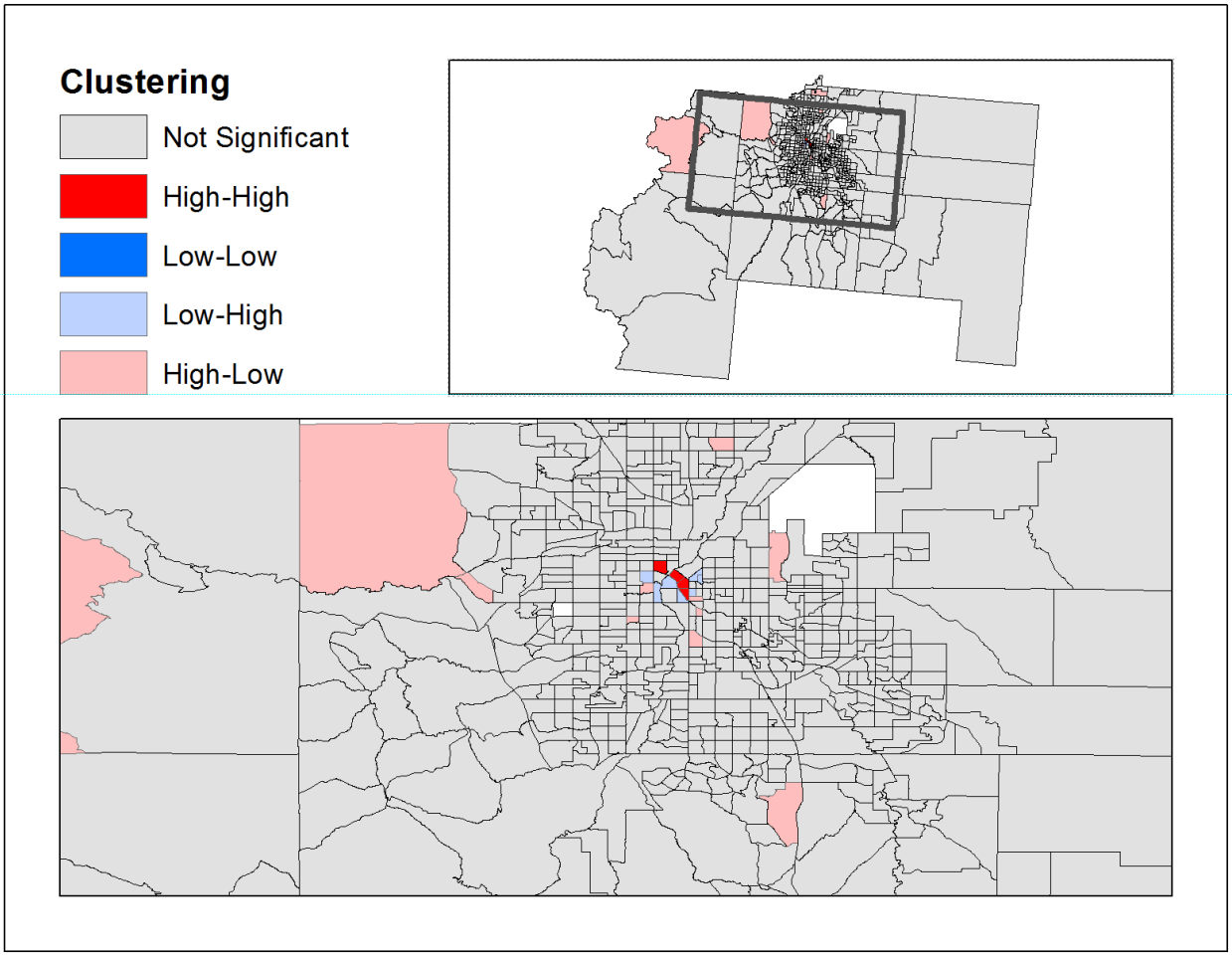

Figure 16. Univariate Local Moran's *I* cluster map for the number of LEED buildings per 10,000 people

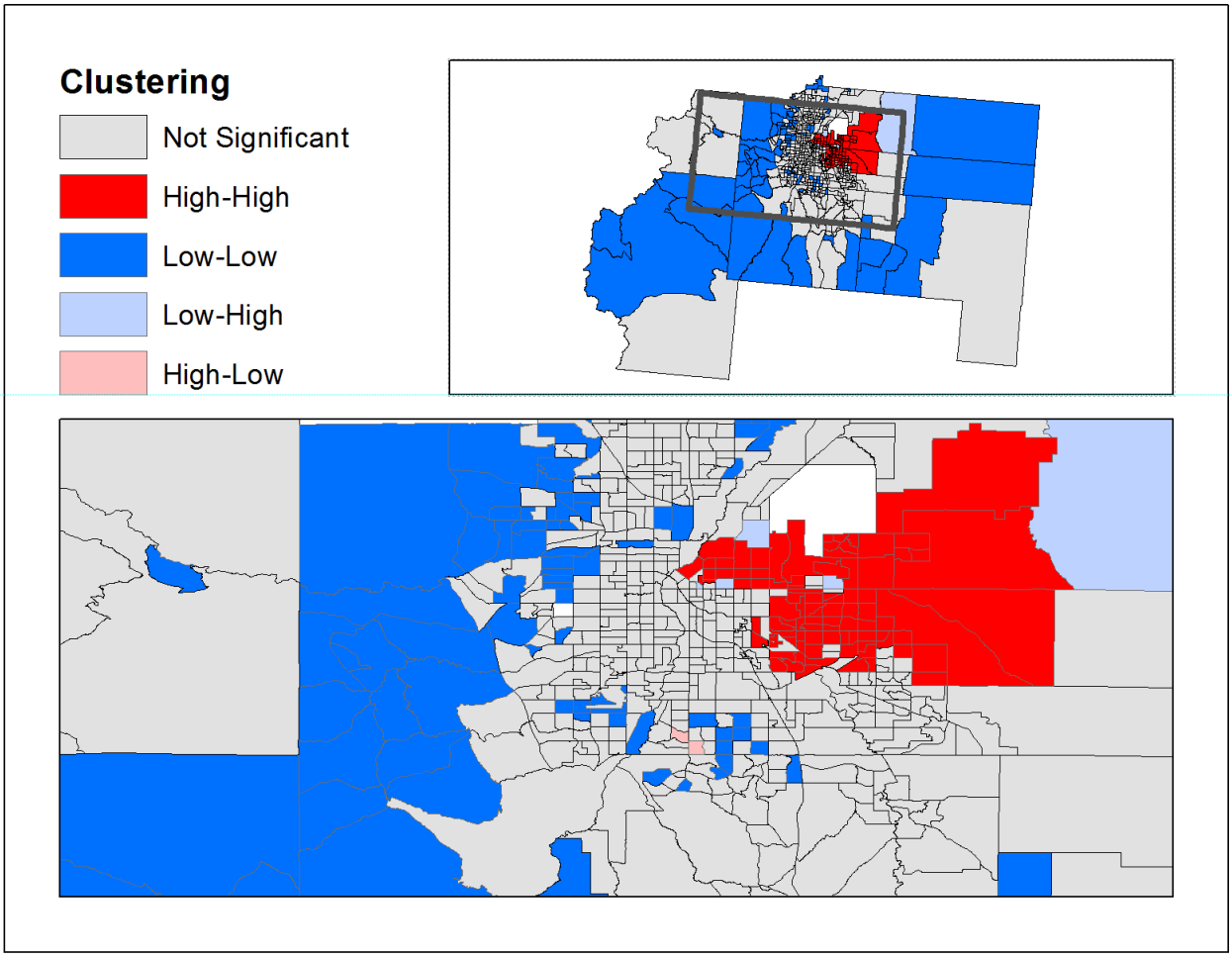

Figure 17. Univariate Local Moran's *I* cluster map for the percent white

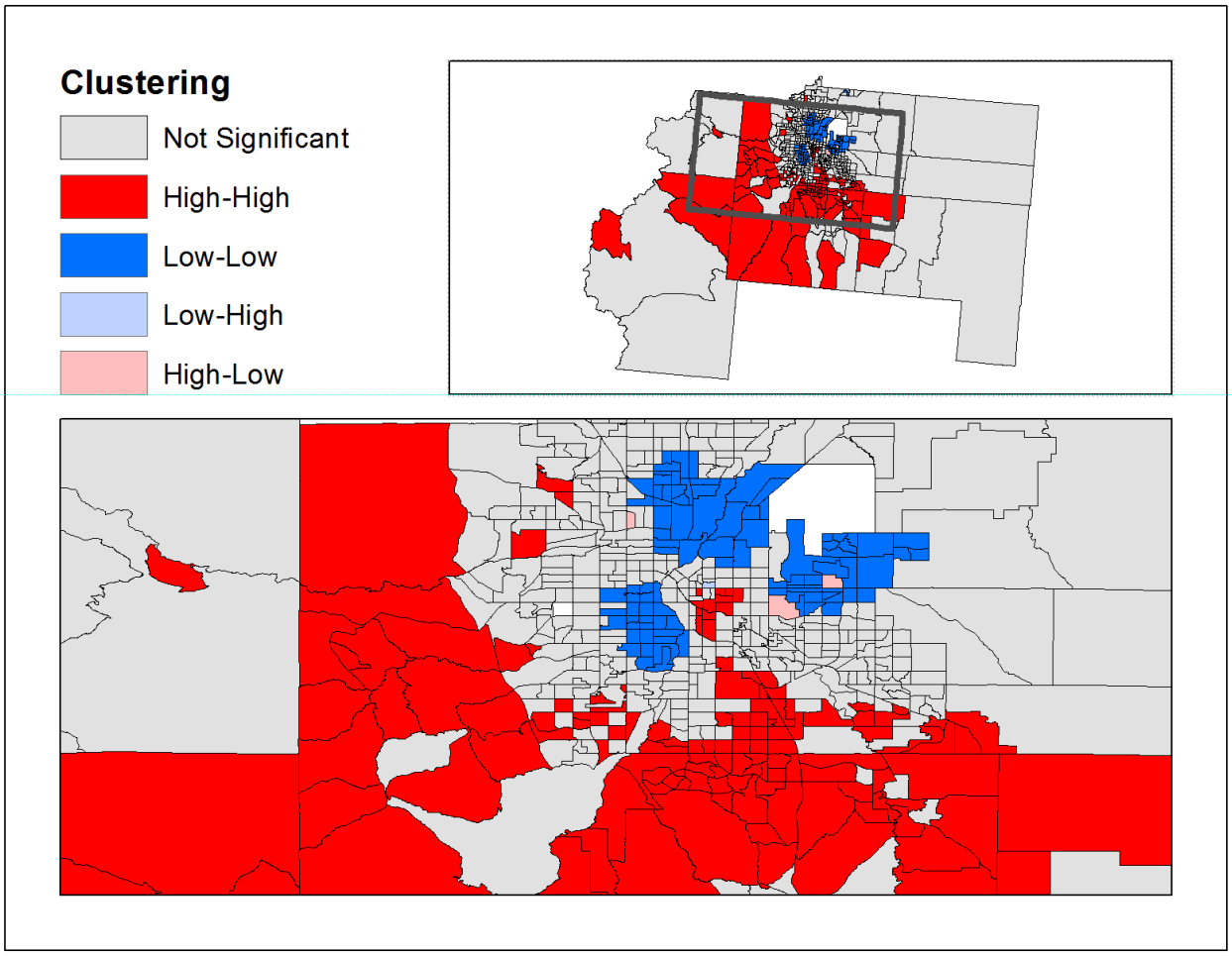

Figure 18. Univariate Local Moran's *I* cluster map for percent black

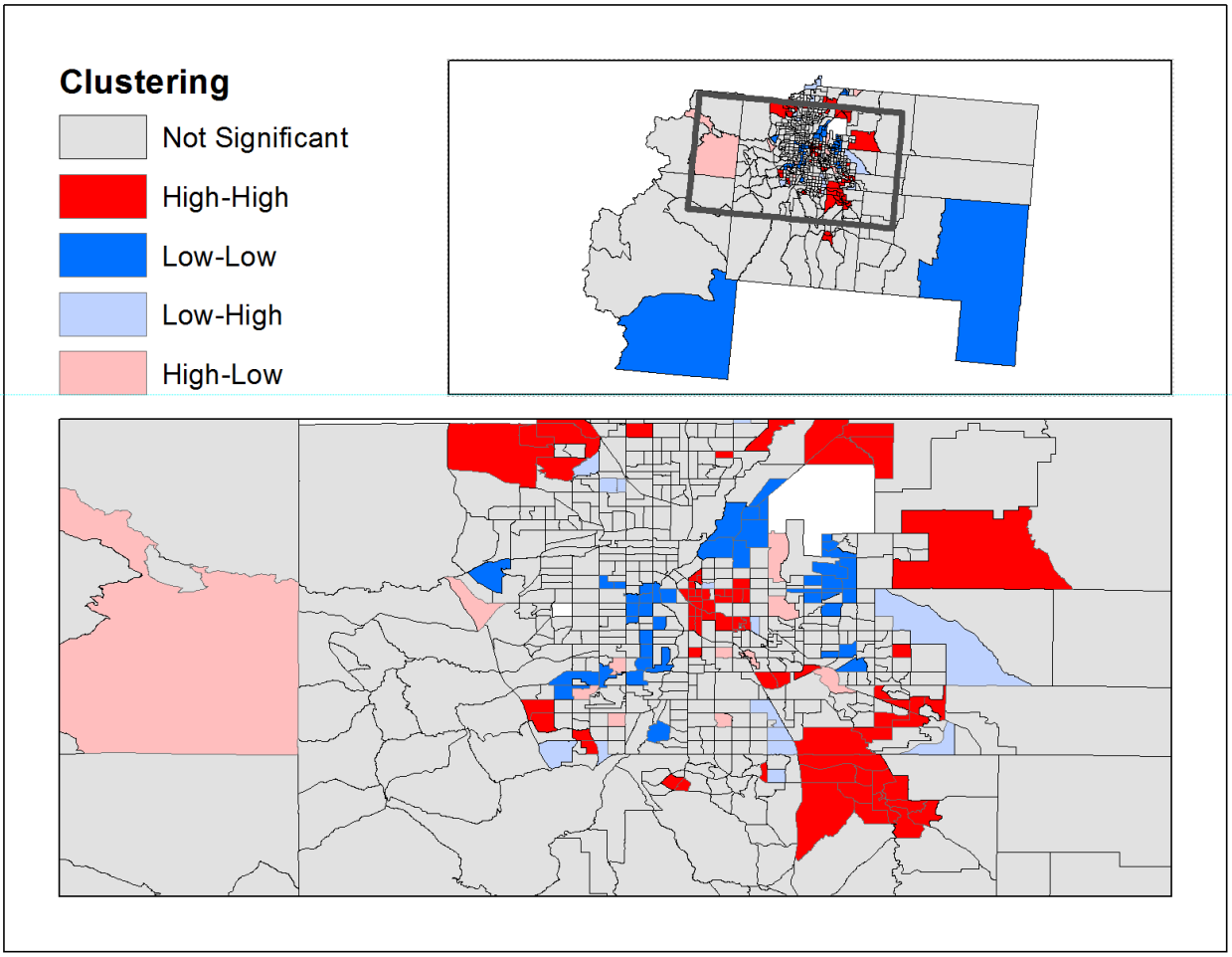

Figure 19. Univariate Local Moran's *I* cluster map for the percent who completed at least high school

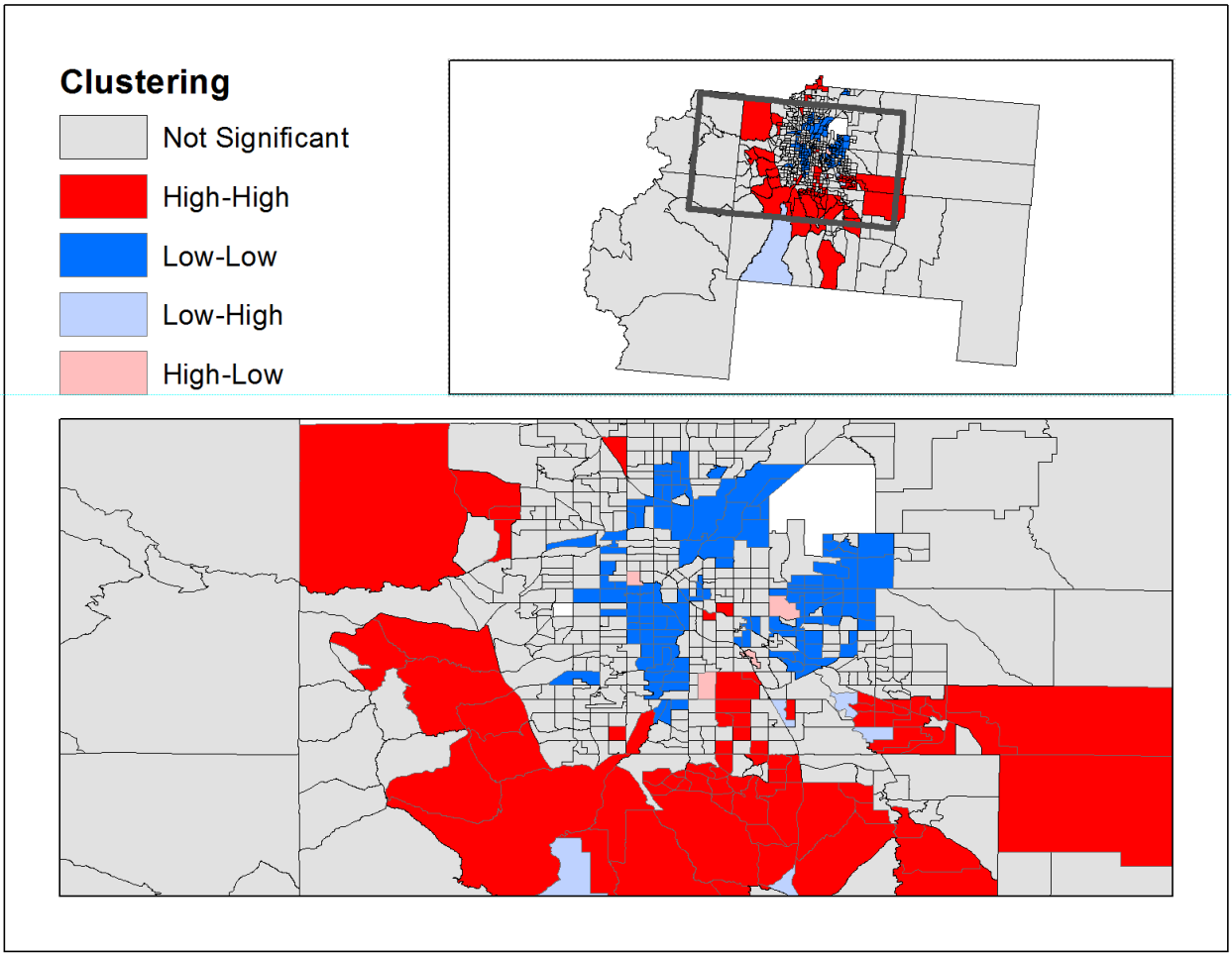

Figure 20. Univariate Local Moran's *I* cluster map for the percent employed

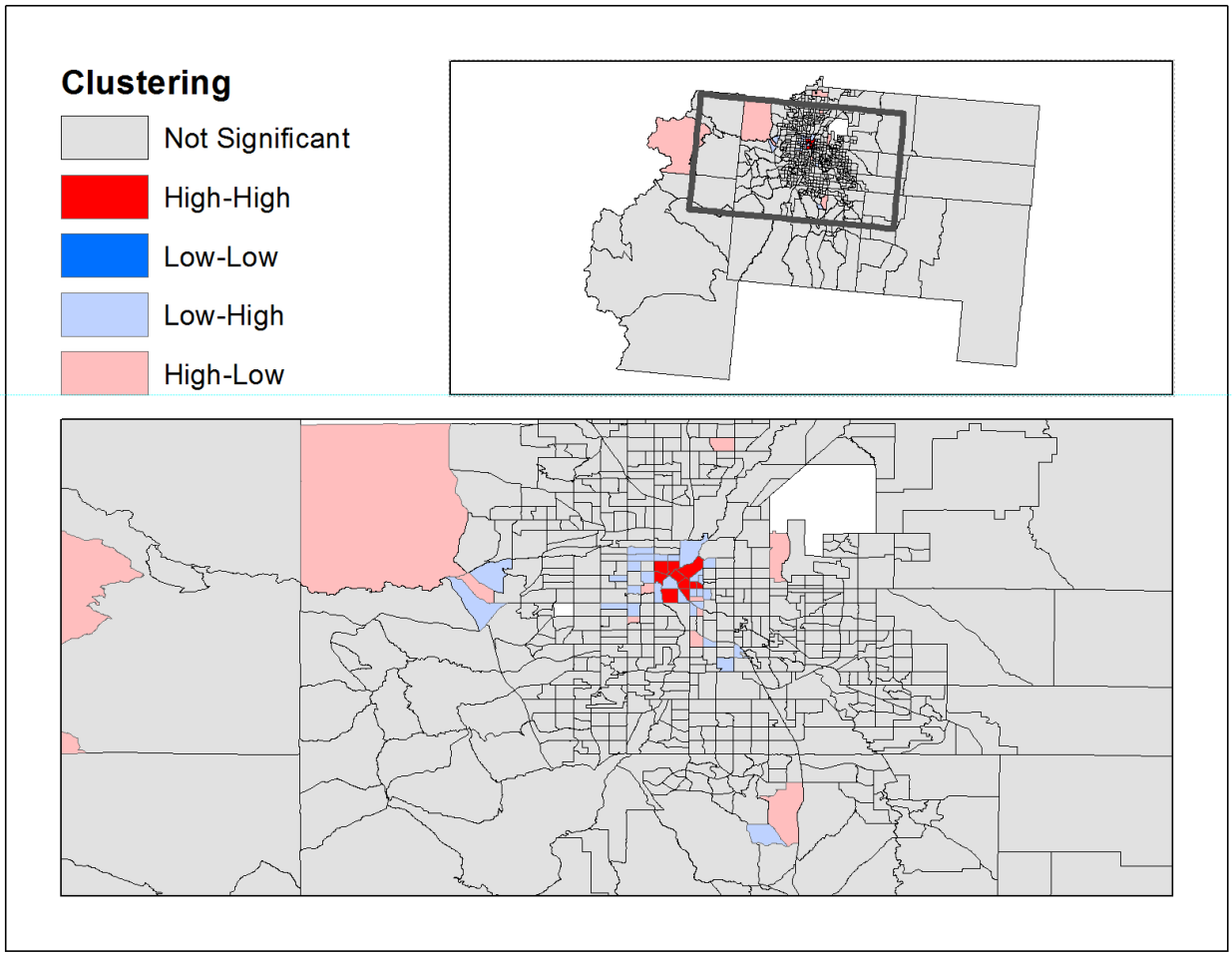

Figure 21. Univariate Local Moran's *I* cluster map for median household income

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Academic Vita

Blake Naito
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EDUCATION

Pennsylvania State University, University Park, PA, May 2016
Bachelor of Science in Geography, GIS Option
Environmental Inquiry Minor

- Awards and Honors – Schreyer Honors College Academic Excellence Award, President's Freshman Award, Geography Student Scholarship, John and Elizabeth Holmes Teas Scholarship, James W. Dunlop Memorial Scholarship, President Sparks Award, Class of 1922 Memorial Scholarship, Evan Pugh Junior Award

EXPERIENCE

US Department of Housing and Urban Development, Denver, CO May 2014 – August 2014
Pathways Student Intern
Assisted the Office of Fair Housing and Equal Opportunity in exploring the use of GIS to map population characteristics for potential discrimination. Performed clerical duties essential to the continued running of the office.

- Created maps to assist in determining evidence of discrimination in North Dakota
- Trained coworkers how to utilize the data and maps created to facilitate related, future projects
- Reorganized and inventoried more than twelve filing units with files up to forty years old to increase efficiency

Pennsylvania State University, University Park, PA August 2012 – Present
Teaching Intern for GEOG 361: Cartography – Maps and Map Construction, August 2014 – December 2014
Collected and organized data for use in labs and provided assistance to students with questions in my lab section
Undergraduate Research Opportunities Connection Assistant, August 2014 – May 2015
Assisted a doctoral student with geographic information retrieval research by collaborating to determine best approaches for coding documents and by coding a number of NSF abstracts
Assisted a doctoral student with a hurricane vulnerability analysis project by retrieving, modifying, and preparing census data as well as performing literature reviews and utilizing R code to map the data.
Assisted a masters student with an analysis of human perceptions of space by locating road data and performing spatial analysis on the data to better understand connectivity within cities around the world in relation to Twitter data.

PROFESSIONAL AFFILIATIONS

Student Member, Association of American Geographers
Student Member, American Society for Photogrammetry and Remote Sensing

COMMUNITY ENGAGEMENT AND ACTIVITIES

The Pennsylvania State University Blue Band and Blue Band THON August 2012 – Present
Officer/Manager, August 2013 to March 2016
Performed duties essential to the running of the marching band. Assisted staff with any building or band-related tasks.

- Assist with organization of transporting instruments and equipment for over 300 members to and from a variety of venues
- Collaborate with team to set up, clean up, and maintain practice fields for near-daily use

Penn State Blue Band THON Roadie, August 2013 – March 2016
Organized support for THON, the world's largest student-run philanthropic event raising funds and awareness for pediatric cancer. Coordinated logistics for fundraisers to maximize effectiveness

- Oversaw and coordinated event efforts for seven other Roadies
- Worked with fellow executive board members to improve group communication and overall organization function
- Year-round fundraising and support for pediatric cancer victims and their families and dance marathon support for 46 continuous hours

GIS Coalition August 2012 – Present
President, August 2013 – May 2015
Led bi-weekly meetings, organized speakers, coordinated mapping events, and fostered collaboration with the Department of Geography and other clubs on campus.

- Pioneered collaboration with ClubEM, Penn State's Emergency Management club as well as the Undergraduate Department of Geography Students organization
- Garnered attendance for national conferences including the Location Intelligence Summit and ASPRS Annual Conference
- Coordinated efforts with fellow officers to improve atmosphere of inclusiveness and participation for members