A Sustainability Assessment of St. Paul Using LEED-EN

Hanna Lee, Taylor Mayhall, Robert Olney

Senior Comprehensive Exercise

Advised by Tsegaye Nega & Aaron Swoboda

Environmental Studies

Carleton College

Wednesday, March 11, 2015

Hanna Lee

(sign here)

Taylor Mayhall

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Abstract

Today, 82 percent of North America's population lives in cities. To address the challenge of sustainable development in growing cities, a number of certifications have been created to ensure the living quality of urban areas. Leadership in Energy and Environmental Design (LEED) is one sustainable development certification in the U.S. with 1.85 million certified square feet as of January 2015. This study applies 12 criteria from LEED for Existing Neighborhoods (LEED-EN) to 40-acre samples in St. Paul, Minnesota to see how scores vary by a variety of factors, including location, income and building age variables. We show that variables measuring density and connectivity exhibit the greatest difference between high and low-scoring samples. We also find that proximity to city center and large transit networks appears positively correlated with sample scores, while the median age of the sample's buildings is negatively correlated.

Acknowledgements

Many thanks to Tsegaye Nega and Wei-Hsin Fu for helping us narrow down our study, implement GIS analysis, run the SANET program, and generally motivate us along the way. We also thank Aaron Swoboda for helping us see the forest for the trees. Finally, our gratitude to Eliot Allen, Chris Ulrich, Matt Koukol, Jake Reilly, Michelle Beaulieu and all of the St. Paul planning district councils for graciously answering our questions and providing us with GIS data.

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Introduction

Urban populations now exceed 54% of the world total, and this percentage is expected to grow at nearly two percent per year during the next decade (World Health Organization). As it is becoming increasingly necessary to understand the ecological and social implications of this expansion, a new field for sustainable development has emerged. The goal of sustainable development is "...to ensure that it meets the needs of the present population without compromising the ability of future generations to meet their own needs" (World Commision on Environment and Development). Accordingly, policy makers and advocacy groups in the United States have come up with various urban sustainability initiatives to guide cities towards more sustainable development (Maclaren, 1996).

Currently, the Leadership in Energy and Environmental Design (LEED) program is widely adopted as sustainability guidelines for green buildings in the U.S. with more than 250,000 total projects as of January, 2015 (USGBCc). While the scope of the majority of LEED certifications is at the scale of a single building, LEED for Neighborhood Development (ND), was developed in 2009 with the ideal in mind that "a building is only as green as its surroundings" (USGBCa). Thus, LEED-ND extends sustainability certifications beyond single buildings to encompass entire proposed neighborhood development projects (Talen et al., 2013).

Reports predicted that applying LEED-ND metrics to *existing* neighborhoods, rather than just proposed ones, would provide helpful planning insight by uncovering the relationships between unplanned elements in existing urban structures and sustainability (Lazar and Murtha, 2009). However, it is difficult to apply LEED-ND metrics to existing neighborhoods, since its metrics are standardized for future developments only. Following this realization, a new rating system, called LEED for Existing Neighborhoods (LEED-EN), was developed in 2011 with slight modifications from LEED-ND. In LEED-EN, some credits from LEED-ND are deleted, combined with other credits, or applied with different standard percentage for points.

Our paper analyzes sustainability in St. Paul, Minnesota by four major urban concepts used in seven credits of LEED-EN. Our research is motivated by the question: How do neighborhoods in St. Paul, Minnesota score differently according to LEED-EN criteria? To address this question, we calculated scores for seven out of 38 LEED-EN credits for 94 samples taken from St. Paul's 17 neighborhoods (Appendix A). Our samples received scores from 10-33

of a possible 46. We found that higher-scoring samples are located more centrally, whether around downtown or interstates, and the buildings within these samples are generally built earlier than lower-scoring samples.

Background on LEED-EN Certification

The LEED-EN proposed certification contains three categories: Smart Location & Linkage (SLL), Neighborhood Pattern & Design (NPD), and Green Infrastructure & Buildings (GIB). Each of these categories contains prerequisites and credits (Table 1). The credits grant qualifying neighborhoods with a range of points, depending on different criteria. Credits that allow for higher possible points are considered to be weighted more heavily. All total, the LEED-EN credits add up to a possible 109 points. In order to qualify for LEED-EN certification, a neighborhood must earn 40-49 points. Due to time constraints and limited information available, we chose to analyze St. Paul using the SLL prerequisites, three of the most heavily-weighted SLL credits, three of the most heavily-weighted NPD credits, and one of the GIB credits. These credits assess four of the main urban sustainability concepts: connectivity, density, land-use diversity, and resource conservation. The total possible score for the credits we analyzed is 46 points, just above the number of points needed to qualify for the LEED-EN certification (Appendix B).

Table 1. LEED-EN certification categories and points possible. Red highlights indicate the prerequisites and green highlights indicate the credits that we analyzed.

SLL	Smart Location and Linkage	26 possible
PR1	Smart Location	Required
PR2	Imperiled Species and Ecological Communities Protection	Required
PR3	Wetland and Water Body Protection	Required
PR5	Floodplain Avoidance	Required
CR1	Preferred Locations	10
CR2	Brownfields Redevelopment	2
CR3	Locations with Reduced Automobile Dependence	7
CR4	Bicycle Network and Storage	1
CR5	Housing and Jobs Proximity	3
CR6	Restoration & Management of Conservation Areas	3
NPD	**Neighborhood Pattern and Design**	**44 possible**
PR1	Walkable Streets	Required
PR2	Compact Development	Required
PR3	Connected and Open Community	Required
CR1	Walkable Streets	12
CR2	Compact Development	6
CR3	Mixed-Use Neighborhoods	4
CR4	Mixed Income Diverse Communities	7
CR5	Reduced Parking Footprint	1
CR6	Street Network	2
CR7	Transit Facilities	1
CR8	Transportation Demand Management	2
CR9	Access to Civic and Public Space	1
CR10	Access to Recreation Facilities	1
CR11	Visitability and Universal Design	1
CR12	Community Outreach and Involvement	2
CR13	Local Food Production	1
CR14	Tree-Lined and Shaded Streets	2
CR15	Neighborhood Schools	1
GIB	**Green Infrastructure and Buildings**	**29 possible**
PR1	Certified Green Building	Required
PR2	Minimum Building Energy Efficiency	Required
PR3	Minimum Building Water Efficiency	Required
CR1	Certified Green Buildings	5
CR2	Building Energy Efficiency	2
CR3	Building Water Efficiency	1
CR4	Water-Efficient Landscaping	1
CR5	Existing Building Reuse	1
CR6	Historic Resource Preservation and Adaptive Use	1
CR7	Tree Protection	1
CR8	Storm water Management	4
CR9	Heat Island Reduction	1
CR10	Solar Orientation	1
CR11	Renewable Energy Sources	3
CR12	District Heating and Cooling	2
CR13	Infrastructure Energy Efficiency	1
CR14	Wastewater Management	2
CR15	Recycled Content in Infrastructure	1
CR16	Solid Waste Management Infrastructure	1
CR17	Light Pollution Reduction	1
Others	IDP - Innovation and Design Process	6 possible
	RPC- Regional Priority Credit	4 possible

Literature Review

The seven credits used in our analysis assess several aspects of urban sustainability: connectivity, density, land-use diversity, and resource conservation (Appendix C). These are not new concepts in the field of sustainable development. In fact, they are accepted metrics for assessing the sustainability of urban environments. Studies have confirmed that these metrics are suitable to include in the LEED-EN certification.

Connectivity

Connectivity is a measurement of directness and availability of alternative routes from one location to another within a street network (Handy et al., 2002). As distance increases, vehicle miles travelled also increases (Handy et al., 2002). Better street connectivity in urban environments has been shown to improve health, as it is consistently associated with overall physical activity like biking and walking (Frank et al., 2012). Additionally, short, urban vehicle trips have relatively higher per mile emission rates due to cold engine starts and traffic congestion (De Nazelle et al., 2010). By reducing the number of miles travelled or allowing for substitution of motor vehicles with biking, walking, or public transit, well-connected cities can greatly decrease carbon emissions (Frank et al., 2012; Boarnet and Crane, 2001; Ewing and Cervero, 2001; Holtzclaw et al., 2002). LEED-EN measures for connectivity include the Smart Location and Linkage credits 1 and 3: Preferred Locations (maximum of ten points), Reduced Automobile Dependence (maximum of seven points), as well as Neighborhood Pattern and Design credit 1: Walkable Streets (maximum of twelve points).

Density

Density is a measurement of the amount of activity in an area, like population, employment, or building square footage (Handy et al., 2002). There is widespread support for including density as a measurement of sustainability because dense neighborhoods most efficiently use land (Dempsey et al., 2012; Jenks and Jones, 2010; Shin, 2010; Urban Task Force, 1999). High-density urban development is considered more cost effective than low-density in terms of "grey infrastructure provision" like roads and sanitation (Dempsey et al., 2012). Density has also been shown to increase social equity, because resources like key services and facilities, open space, and employment opportunities are equally available to all within walking distance (Barton, 2000; Burton, 2000; Llewelyn-Davis, 2000; Urban Task Force, 1999; Dempsey et al.,

2012). Services are claimed to be more economically viable when they exist within access of a larger population. Density is relatively easy and straightforward to measure (Handy et al., 2002). The LEED-ND and -EN certifications measure density under the Neighborhood Pattern & Design credit 2: Compact Development, which receives a maximum of six points.

Land Use Diversity

Land use diversity is a measurement of how many land uses exist within a given area, including residences, retail, offices, places of worship, supermarkets, and parks (Handy et al., 2002). The existence of different land uses in an area encourages people to increase their sense of community by interacting with others (Frank et al., 2012). Like connectivity, land use diversity reduces vehicle miles travelled because there are more desired locations within walking or biking distance (Handy et al., 2002; Frank et al., 2012). LEED-EN Neighborhood Pattern and Design credit 3: Mixed use neighborhoods (maximum of 4 points) addresses this urban concept.

Resource Conservation

Resource conservation is a measurement of a community's efforts to conserve resources like water, electricity, and even ecological composition. One way of measuring resource conservation in a community is by looking at the resource efficiency of its individual buildings. According to Eichholtz et al. (2010), "Buildings account for approximately 40 percent of the consumption of raw materials and energy" globally (2492). Some studies have drawn connections between green work spaces and increased worker productivity (Kats, 2003; Edwards and Naboni, 2013), though such connections remain tenuously understood (Miller et. al, 2009). Others have observed trends in greater building sustainability and higher economic rents (Eichholtz et. al, 2010). LEED-EN measures the resource conservation of buildings with the Green Infrastructure and Buildings credit 1: Certified Green Buildings (maximum of five points), whose intent is "to encourage the design, construction, and retrofit of buildings that utilize green building practices" (Criterion Planners, 2011).

Brownfields are closely linked to green building development. Defined as previously-industrial land that is now abandoned and contaminated or potentially contaminated with hazardous waste, brownfields are the focus of redevelopment efforts (Wedding and Crawford-

Brown, 2007).[1] They are often located in the center of metropolitan areas and are prime candidates for urban redevelopment and renewal (De Sousa, 2008). Construction of green buildings on brownfields has the potential to increase aforementioned urban concepts like connectivity and density, as well as create jobs and conserve resources. In 2003, a survey found that brownfields redevelopment in 148 cities could generate 576,373 new jobs and as much as $1.9 billion annually in additional tax revenues (US Conference of Mayors, 2003). Another study showed that brownfields redevelopment indirectly preserves up to 4.5 acres of green space for every acre redeveloped, through reduced requirements for new infrastructure and denser site plans (Deason et al., 2001). Brownfields redevelopment is the second credit in the Smart Location and Linkage category of the LEED-EN proposed certification, with a maximum of two points.

Urban Sprawl

Sustainability assessments of cities, like LEED-EN, have been designed to enhance the above urban concepts, all of which ultimately work to reduce urban sprawl. Urban sprawl describes rapid growth at the periphery of a city or metropolitan area with a simultaneous decline of population in the city's central region (Squires, 2002). Today, it is widely acknowledged among planners and urban researchers that sprawl is associated with greater segregation between income classes and poverty concentration (Margo, 1990; Mills and Lubuele, 1997; Glaesar et al., 2006; Lindeke, 2014). Jargowsky observed that this would not be a problem from an income inequality perspective if "new suburbs were built, replete with new schools, parks, and other amenities, and the benefits of these new places were equally accessible across the economic spectrum" (Jargowsky, 2001). But through zoning rules, construction of housing units that attract higher income families, and other devices, suburbs intentionally limit access to lower income families, allowing wealth to concentrate in certain favored sectors of the city (Jargowsky, 2001). Urban sprawl is also associated with higher environmental degradation (Squires, 2002). Loss of wildlife habitat from fragmentation and development, carbon emissions from increased vehicle miles travelled, and overconsumption of water due to landscaping are all factors that correspond to urban sprawl (Grabkowski; Johnson, 2001). Thus, minimization of urban sprawl is in the best environmental and social interest of cities.

[1] Severely contaminated land like Superfund sites do not fall under the brownfields category.

Why Use a Neighborhood Scale?

LEED-EN and -ND are designed to assess these urban concepts on a neighborhood scale. Benfield (2010) comes to the conclusion that neighborhoods are more appropriate scales than jurisdictions or cities, because the environment does not follow political boundaries, and neighborhoods reflect the "human scale" of real cities. Sharifi and Murayama (2013) acknowledge that neighborhoods are the level at which land development takes place. Assessments of urban sustainability at the neighborhood-scale are becoming more common, not just in the United States LEED system, but also for certifications in the UK, Japan, Malaysia, Australia, New Zealand, and Qatar (Sharifi & Murayama 2013). Talen et al. (2013) agree that neighborhood scales make sense, but note that the significant amount of time and money involved in building and certifying an -ND project acts as a strong deterrent to certification. They suggest that calculating scores at a jurisdictional, city-wide level would be more feasible. Talen et al. (2013) use geographic information systems (GIS) to look at the entire city of Phoenix, Arizona. Their goal is to determine which areas would qualify for the basic credits so that developers do not attempt to build -ND projects on ineligible areas. This study will add to the literature by using LEED-EN to assess the sustainability of existing neighborhoods.

Methodology

Study Area

Our study uses GIS to apply the 12 LEED-EN prerequisites and credits on samples taken from within existing neighborhoods of St. Paul, MN. We chose St. Paul because the city demonstrates high compliance to the principles of smart growth, one of the main design elements of both LEED-ND and LEED-EN. In 2003, St. Paul received a National Award for Smart Growth Achievement, with the title "Overall Excellence in Smart Growth" (EPA, 2003). Six years later, St. Paul adopted a Sustainable Building Policy with the goal of mandating the construction, renovation, and operation of buildings in a sustainable way that improves the living quality of the entire city (Saint Paul Sustainable Building Policy). In 2013, Minnesota ranked 10th in the United States for most LEED-certified projects (USGBCb). In particular, St. Paul, as part of the National League of Sustainable Cities, is known for its relatively long history with commitment to sustainable urban living (Sustainable Cities Institute).

Additionally, the City of St. Paul clearly defines its neighborhoods. In the United States, the concept of the "neighborhood" varies. Some cities formally establish neighborhoods, while others develop neighborhoods organically out of historical pathways. The Twin Cities are a stark example of this lack of uniformity: Minneapolis and St. Paul, though roughly equivalent in population and area, contain 70 and 17 neighborhoods, respectively (Minneapolis-Saint Paul Neighborhoods). These numbers can be disputed, depending on the conceptualization of a "neighborhood," because neighborhoods are defined in multiple spheres: legal, socio-cultural, economic, historic. The City of St. Paul formally defines neighborhoods by "planning districts," of which there are 17 (Figure 1). Planning districts were created in 1975 to encourage neighborhoods to be more active in their own governance and help spend the Community Development Block Grants (District Councils). The annually elected volunteer neighborhood boards are given tax funds from the City of St. Paul as well as grants and donations, based on the City District boundaries.

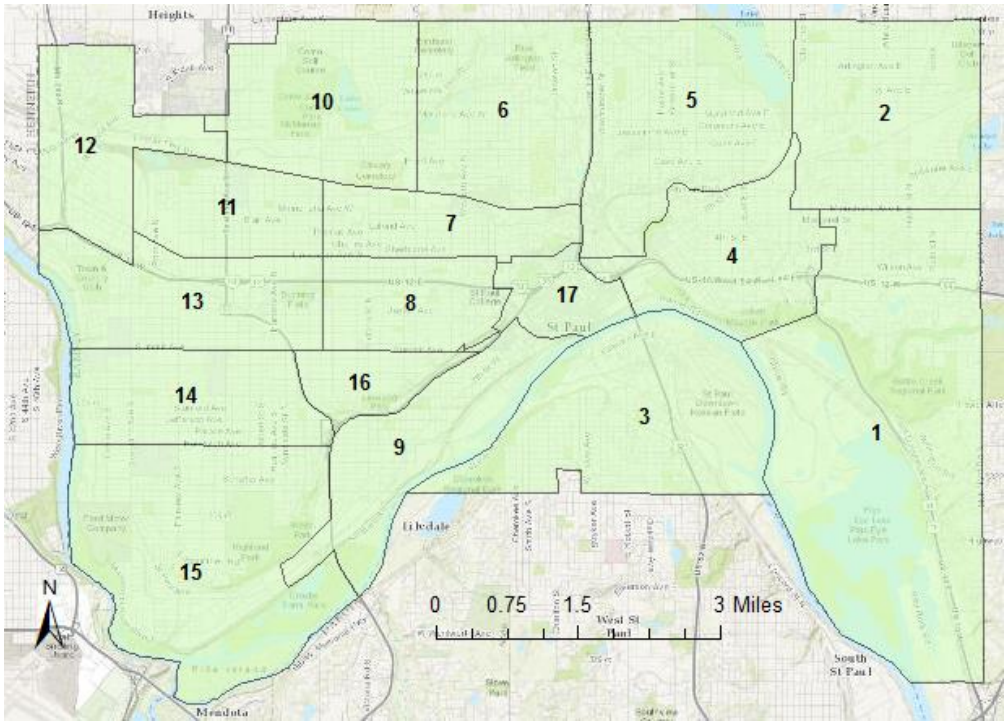


Figure 1. St. Paul planning districts labeled by number.

Data Collection

Our project employed GIS technology to map St. Paul. We started with an original October 2014 shapefile of the plat polygons in St. Paul, obtained from Datafinder.org. We created a layer of the 17 planning district boundaries. Our first step was to determine whether areas were eligible for study at all by analyzing them against the prerequisites of the first LEED-EN category, Smart Location and Linkage (SLL), following the method of Talen et al. (2013). Accordingly, we obtained data for these four prerequisites: Smart Location, Imperiled Species and Ecological Communities Protection, Wetland and Water Body Protection, and Floodplain Avoidance. Once we had all the necessary layers for the SLL category, we split the layers by planning district boundaries. Any land within the FEMA hazard areas, the buffers, and the undeveloped categories from SLL prerequisite 1 was *not* eligible for LEED-EN certification. These areas were eliminated from the study, and only eligible areas remained (Figure 2).

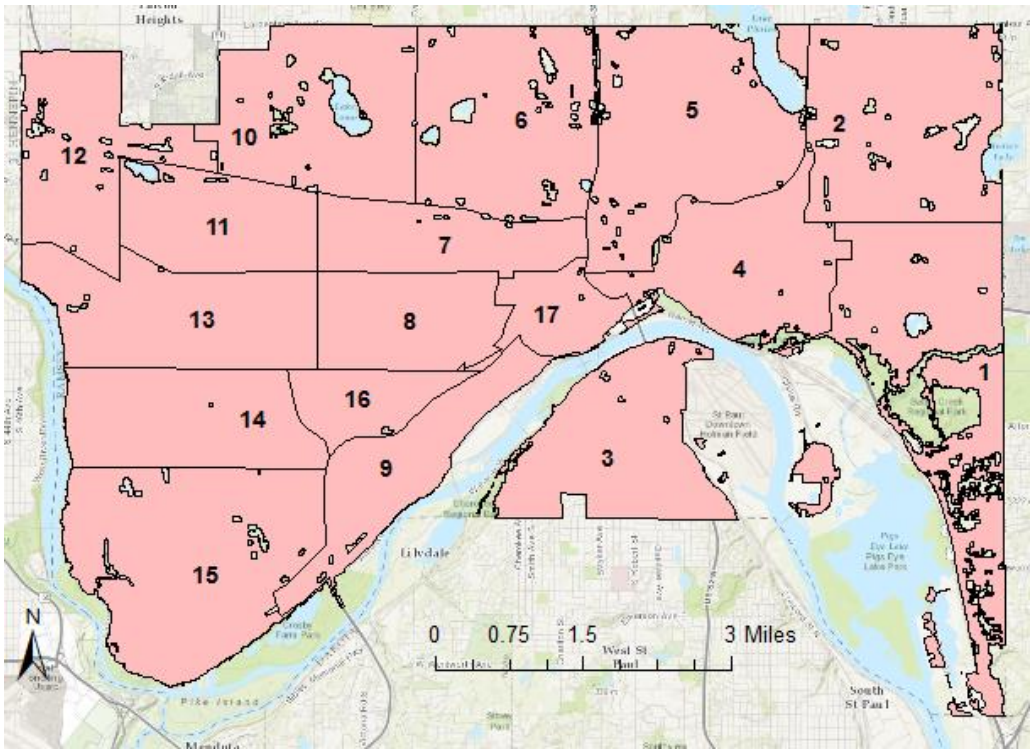


Figure 2. Planning district areas (labeled by number) eligible for our study after applying the SLL category prerequisites.

Sampling

Since LEED-EN defines the size of a neighborhood as an area containing at least two habitable buildings up to a maximum of 320 acres, we realized that we could not apply LEED-EN criteria to the entire planning districts. Instead, we selected 40-acre plots from within the eligible planning district areas, borrowing from the conventional legal requirement of choosing 40-acre parcels for zoning studies (Reilly, 2015). A zoning study is a review, evaluation, and amendment to the city's zoning code, specific to an area, initiated by the planning commission (Reilly, 2015). We overlaid a 40-acre square fishnet on a map of the planning districts. A number of samples was then taken from within each of the 17 planning districts, proportional to the area share of each planning district (Figure 3). For the neighborhood with smallest eligible area (591 acres), we picked two of the numbered plots using a random number generator tool. We took random samples of a number proportional to the eligible area identified in the rest of the planning districts. For example, in a larger neighborhood of 1,548 acres, we took five samples because that is proportionally accurate. In total, we selected 94 samples (Appendix A).

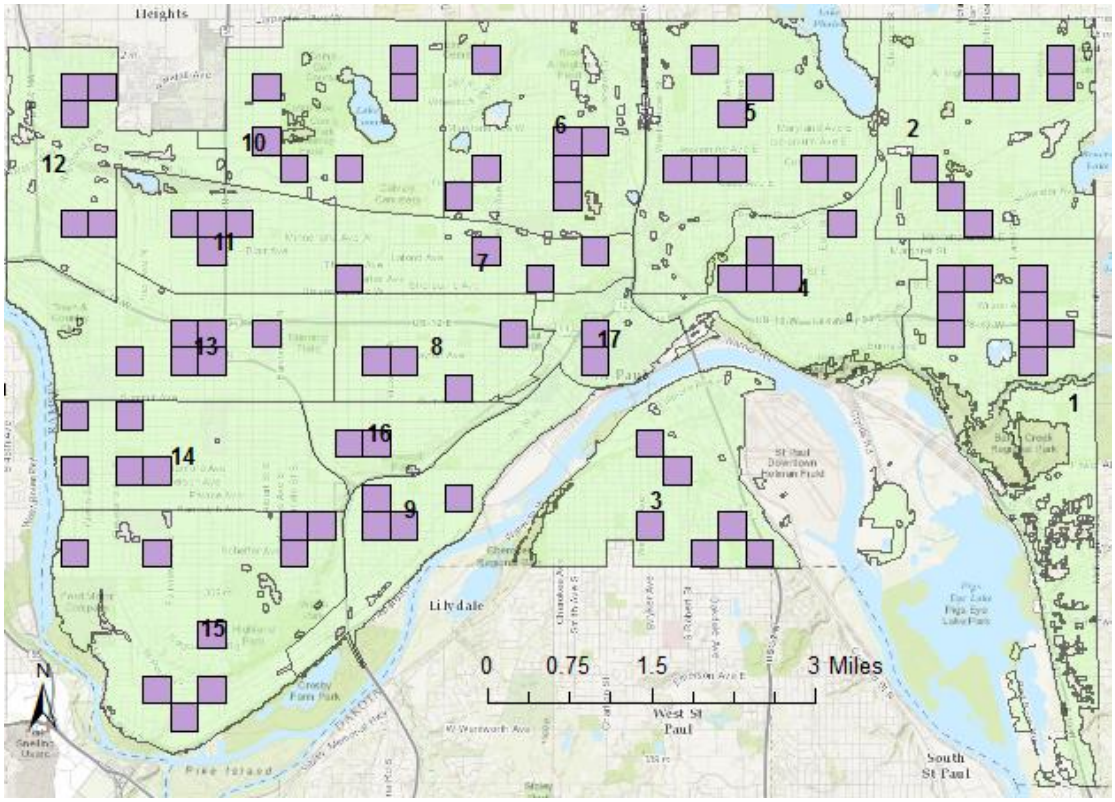


Figure 3. The 94 forty-acre samples randomly chosen from each St. Paul planning district.

Category 1: Smart Location and Linkage (26 possible points)

We used ArcMap World Imagery to identify building entrances and street intersections, creating separate layers for each. At this point, we began working on individual credits in the Smart Location and Linkage (SLL) category.

Preferred Locations: This credit is intended to encourage sustainable living and employment within existing cities. There are three criteria within this category by which a neighborhood can earn points. The first criterion asks whether the neighborhood is an infill site. The second criterion asks whether the neighborhoods have connectivity, measured by the number of intersections per square mile. Thus, we mapped all intersections for each sample. The final criterion asks whether any of the neighborhoods qualify under specific federal programs. We found maps of the locations of the specific federal programs for St. Paul, MN. We calculated a final total for each sample according to the score earned in each of the three options for this credit.

Brownfields Redevelopment: This credit rewards neighborhoods that are located on brownfields sites that have been at least partially remediated since 2000. An additional point is awarded if at least half of the neighborhood lies within a Preferred Location area. For this credit, the qualification from the Preferred Location credit was used (the Department of the Treasury Community Development Financial Institutions Fund Qualified Low-Income Community). We found a map of all national brownfields redevelopment sites on the EPA's website, downloaded the information, and clipped to the St. Paul, MN sites.

Locations with Reduced Automobile Dependence: This credit requires that 50% of the dwelling units and non-residential building entrances be located within either a ¼-mile walk of bus or streetcar stops or a ½-mile walk from other transit (light rail, ferry, etc.) stops. Furthermore, there are requirements for the number of total trips per week in each neighborhood. We used the program Spatial Analysis Along Networks (SANET) and schedules of stop times to calculate the number of points for each sample. SANET cannot easily run large file sizes so we had to decrease the size by eliminating some of the building entrances.

Category 2: Neighborhood Pattern and Design (44 possible points)

Walkable Streets: This category is intended to reduce total vehicle miles traveled, as well as provide a safe, appealing street environment. There are 12 elements of this credit, each

earning one point if a neighborhood qualifies. he elements are very involved and necessitate detailed, on-the-ground knowledge of the St. Paul streets. For example, one element asks whether ground-level retail, service, or trade windows are kept unshuttered at night, as stipulated in covenants. This level of detailed information is unavailable to us, so we decided to obtain outside data from Walkscore.com, like Talen et al. (2013) did in their study. Though Talen et al. ultimately concluded that Walkscores could not be used as a proxy for their particular analysis, they were using the LEED-ND classification, which focuses on vacant parcels in areas with lower market strength. We used a different metric with LEED-EN which looks at existing neighborhoods in populated areas of a city, and therefore we found Walkscore to be relevant to our study and this credit's goal of promoting transportation efficiency. Walkscore scored each of the St. Paul planning districts on a scale of 0-100 by analyzing walking routes to nearby amenities, pedestrian friendliness based on population density, and road metrics (Walkscore.com). All samples in the same planning district, therefore, received the same walkability score, which we converted to proportionally comparable LEED-EN scores (Appendix E).

Compact Development: This credit, with the goal of promoting the livability, walkability, and transportation efficiency of cities, assesses the density of buildings. Residential buildings are measured by dwelling unit per acre. Non-residential buildings are measured by floor-area ratio, or the square footage of the building divided by the total square footage of the lot. We already had a parcel layer for all lots in St. Paul, MN and one attribute in the layer is parcel use, broken down by residential and commercial uses. We created separate layers for residential and non-residential parcels. We calculated the dwelling unit per acre measurement for residential parcels. We measured the square footage of each building within a residential parcel, then divided that number by the total square footage of the parcel. Comparing our final answers with the table provided by the LEED-EN certification credit instructions, we were able to allocate the appropriate credit score for each sample.

Mixed Use Neighborhoods: A neighborhood receives a certain number of points by the number of diverse uses found within a ¼-mile walk from 50% of its dwelling units. These include food retail (supermarkets), services (banks, post offices, etc.), retail (department stores, hardware stores, etc.), and community (places of worship, parks, libraries, etc.). Using OpenStreets basemap and Google maps, we created a layer for diverse uses in St. Paul. For this

credit, we simply created a ¼ mile buffer around each of our samples to count the number of diverse uses within each buffer. For this, we eliminated the step of using SANET to calculate the walk distance from residential buildings to diverse uses since there is little difference between walk distance and 'distance on-the-fly' within the area as small as our samples (40-acre).

Category 3: Green Infrastructure & Buildings (29 possible points)

Certified Green Buildings: To qualify under the prerequisite, a neighborhood must have one building that has been certified by LEED or an equivalent sustainability certification[2] since January 1, 2000. Having more than one such building qualifies the neighborhood for the credit. Up to four points can be earned for each individual building that qualifies within a sample. We considered buildings certified under LEED, Energy Star, Green Globes, and B3 Minnesota[3]. Only Energy Star had buildings within any of our samples.

Results

We added all the credit scores for each sample to obtain a final score (Figure 4). The total possible score that each credit could earn was 46. Our samples earned scores between 10-33, with most samples earning about 17 points (Appendix D). The credits that we analyzed for this study account for about half of the total possible points available for LEED-EN certification. In order to certify for LEED-EN, a neighborhood must earn 40-49 points; none of our samples earned between 40-49 points. Only 17 samples scored above half (23) of the total possible points. A visual breakdown of these scores is provided in Figure 5.

[2] Suitable equivalent sustainability certifications are those that require review by independent, third-party certifying bodies as defined by ISO/IEC 17021.

[3] B3, which stands for Buildings, Benchmarks and Beyond, is a set of guidelines created by the state of Minnesota that is intended to be a compatible alternative to LEED.

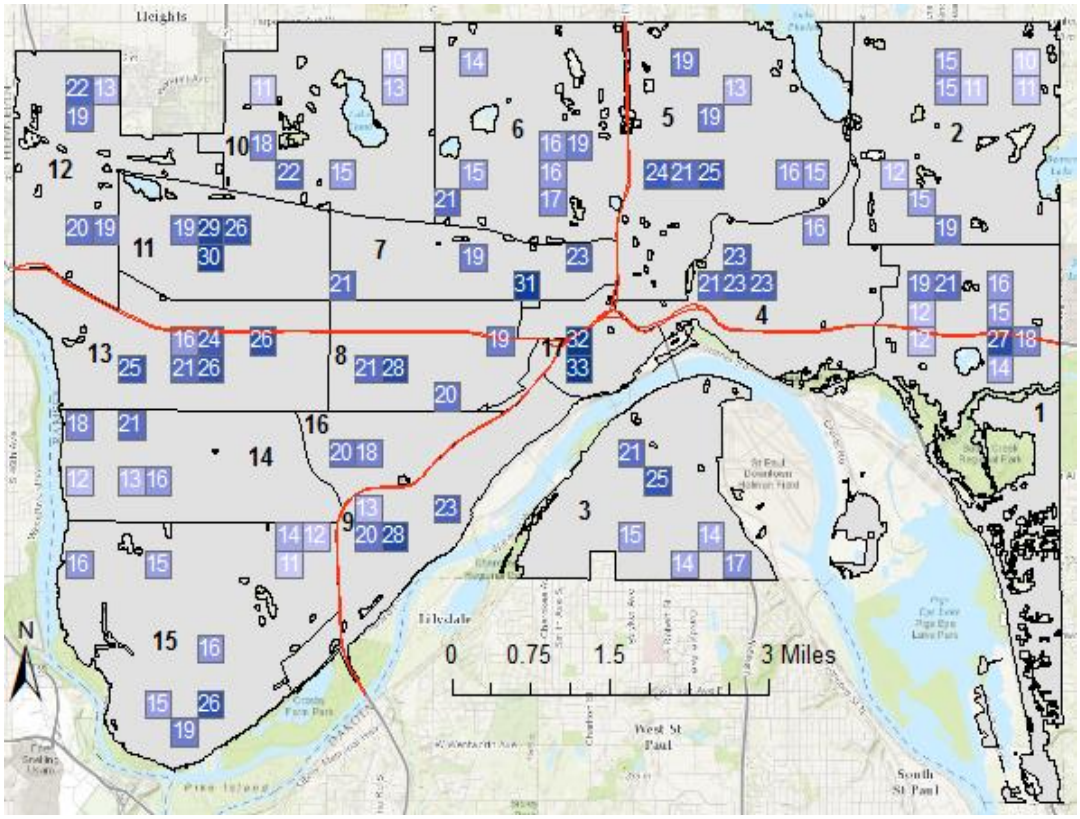
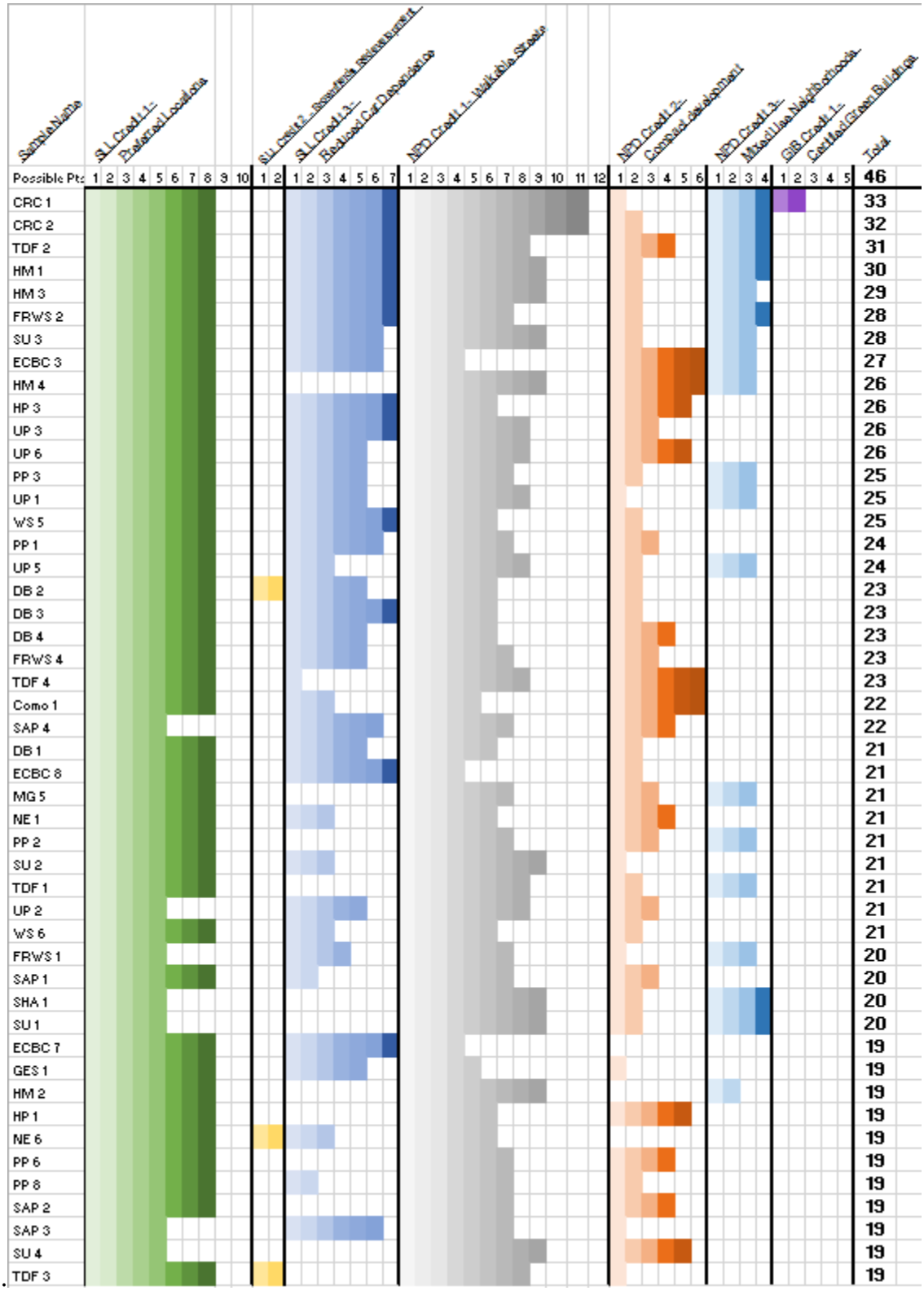


Figure 4: Total scores earned by each planning district sample within eligible areas, calculated as sum of scores for seven credits. Red lines represent interstates.

Unsurprisingly, the highest-scoring sample, one of the two in downtown St. Paul, was the only one with certified green buildings. Thus, even though LEED-EN attempts to look at the sustainability of entire neighborhoods, the sustainability of individual buildings remains important. Although it may be true that "a building is only as green as its surroundings," it is also the case that a neighborhood is only as green as the buildings from which it is comprised.

As seen in Figure 5, large variations exist in the scores for credits that measure compactness and density. High-scoring samples did well in the Reduced Automobile Dependence, Compact Development, and Mixed-Use Neighborhoods credits. Low-scoring samples did poorly in these, often scoring zero, and slightly less well in Preferred Locations and Walkable Streets (Appendix E).


Sample Name
SL Credit 1.1 - Preferred Locations
SU Credit 2 - Sensitive Site Development
SL Credit 1.3 - Reduced Car Dependence
NPD Credit 1 - Walkable Streets
NPD Credit 2 - Compact development
NPD Credit 3 - Mixed Use Neighborhoods
GB Credit 1 - Certified Green Buildings
Total
Possible Pts
46
CRC 1 33
CRC 2 32
TDF 2 31
HM 1 30
HM 3 29
FRWS 2 28
SU 3 28
ECBC 3 27
HM 4 26
HP 3 26
UP 3 26
UP 6 26
PP 3 25
UP 1 25
WS 5 25
PP 1 24
UP 5 24
DB 2 23
DB 3 23
DB 4 23
FRWS 4 23
TDF 4 23
Como 1 22
SAP 4 22
DB 1 21
ECBC 8 21
MG 5 21
NE 1 21
PP 2 21
SU 2 21
TDF 1 21
UP 2 21
WS 6 21
FRWS 1 20
SAP 1 20
SHA 1 20
SU 1 20
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PP 8 19
SAP 2 19
SAP 3 19
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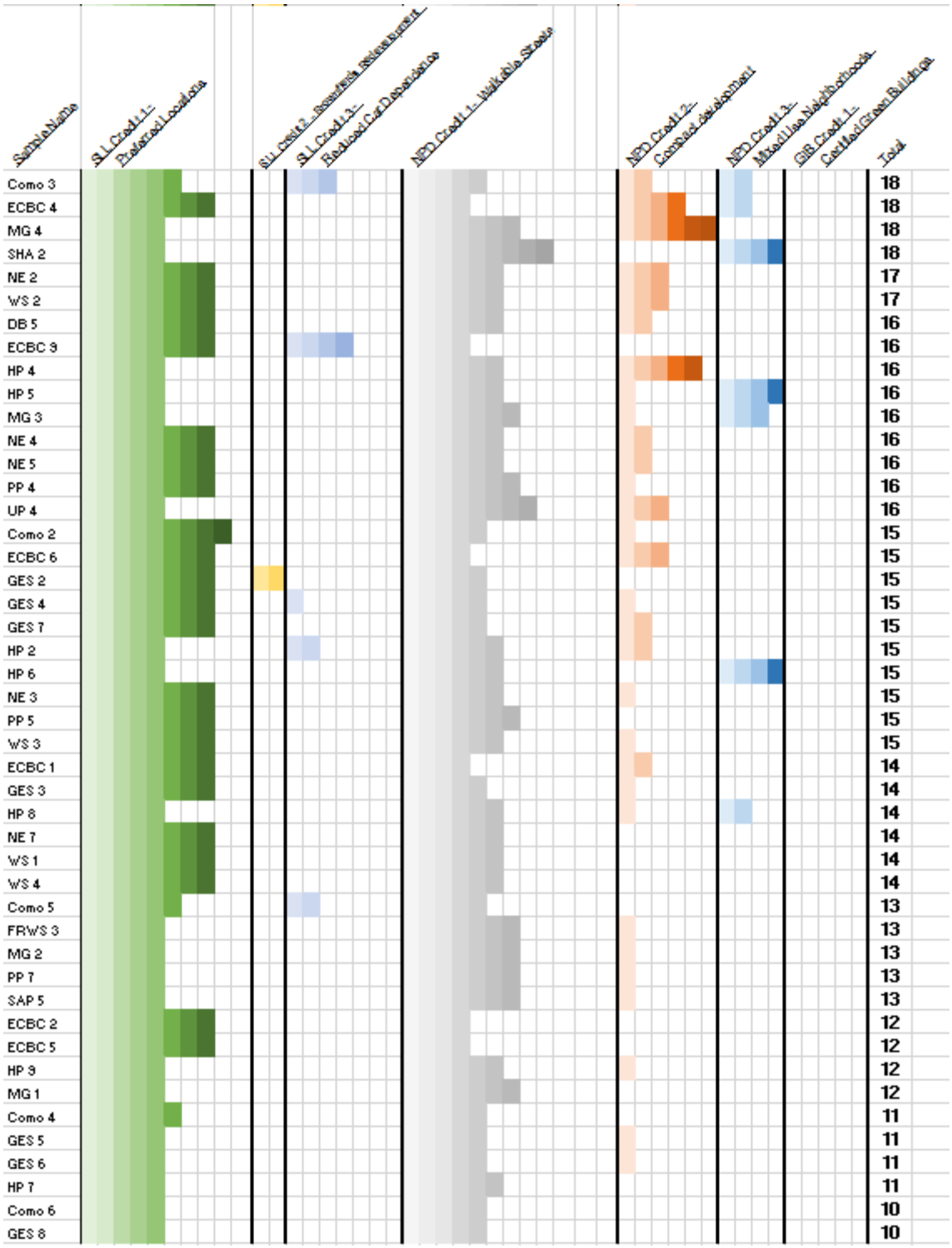


Figure 5: Breakdown of total LEED-EN scores by sample and credit.

We also analyzed the building age and median income of each sample. In a sense, the building age of a sample can be a proxy variable for urban sprawl: with the exception of downtown areas, buildings in the inner-city are generally older than those nearer the city limits (Figure 6). Observing the median income for each sample helped us begin to look at the relationship between sustainability and socio economic development. The relationships between these two variables and LEED-EN scores are shown in Figures 7 and 8.

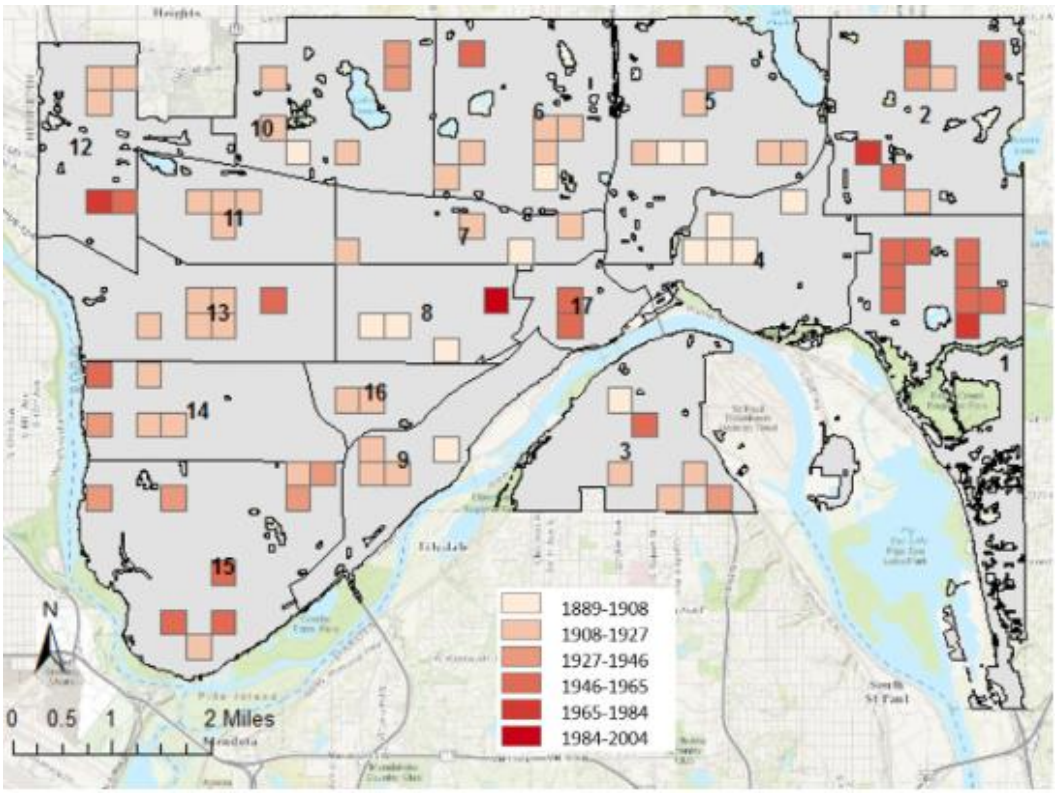


Figure 6. Planning district samples colored by median year built of the buildings within the sample. The sample with the newest buildings is located in District 8.

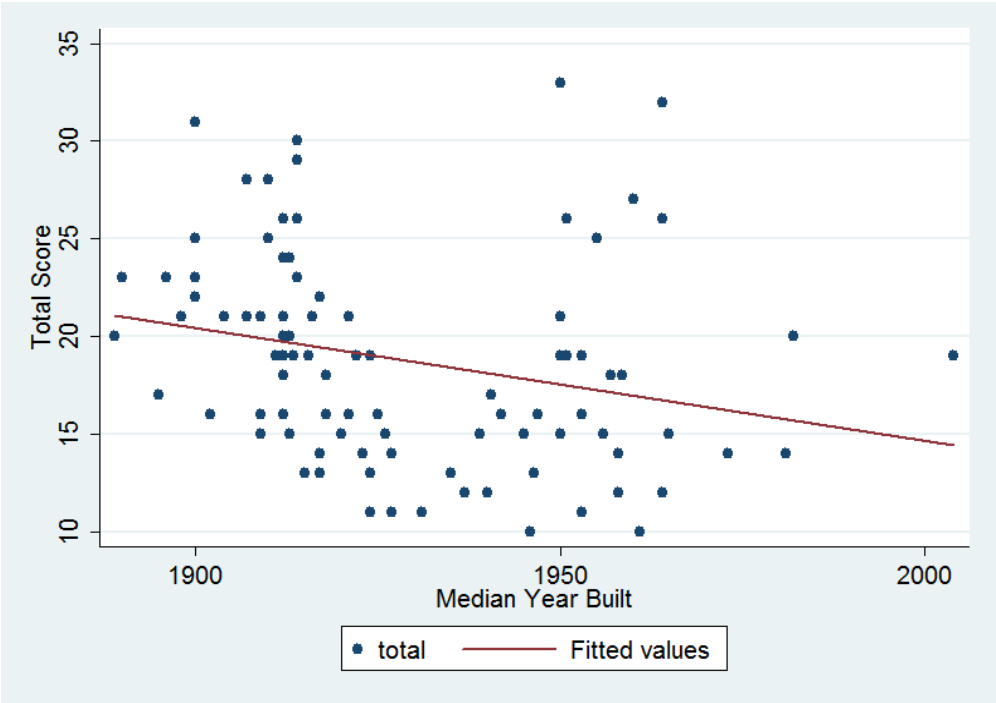


Figure 7: Relationship between total LEED-EN scores and median year-built of buildings.

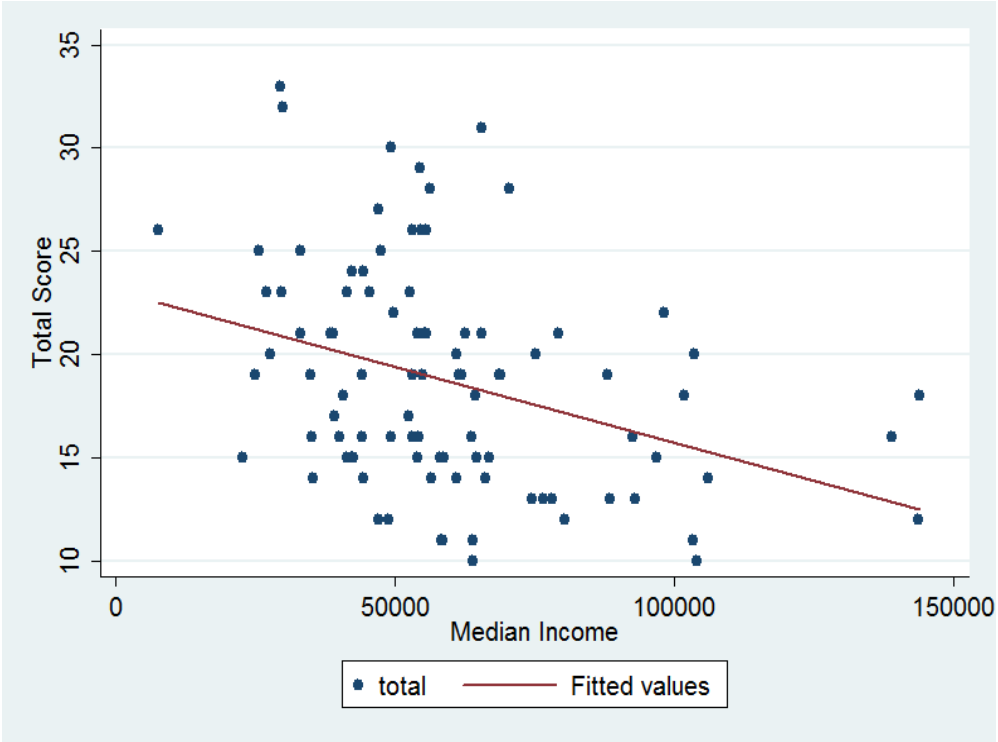


Figure 8: Relationship between total LEED-EN scores and median income.

Discussion

Our results show a variety of trends that may not be unique to St. Paul. Density and connectivity were the most important factors to achieve a high score in this study. This is hardly surprising, given that these credits are generally allotted the most points. Samples that scored well in these density and connectivity credits (preferred locations, reduced automobile dependence, walkable streets, and compact development) were located near busy streets and interstates, or in the center of downtown. The two samples that earned the very highest scores were located in downtown, close to interstates and the center of the city. On the other hand, two of the lowest-scoring samples were located next to a golf course on the outskirts of town in Planning District 2 (Figure 4).

Our results also show evidence of urban sprawl in St. Paul when we display the median year built of the buildings within our samples (Figure 6). Most of the samples with newer buildings are located in the outer districts, rather than the center of the city, showing that development grew towards the periphery of the city over just a few decades. Older neighborhoods, built when cars were not as heavily relied upon, are generally more compact and located in the center of the city. The very center of downtown is the outlier in this trend. Likely, downtown home to many skyscrapers and other modern constructions. In general, samples with older buildings receive a higher LEED-EN score. However, the age of a building is not explicitly counted in the scoring, so the age of the buildings in the sample did not cause the sample's calculated LEED-EN score; rather, it suggests that scores are correlated with the proximity of the sample to the city center and transit networks. The Pearson correlation coefficient for median year built and final score is -0.257. The p-value for this correlation coefficient is 0.0123, meaning it is statistically significant at the 5% level.

We also analyzed the median income of each sample. After comparing 2010 census block income data to final scores, we find that, as median income increases, the final score of the sample decreases. The Pearson correlation coefficient, statistically significant at the 1% level, is -0.354. This makes sense because studies have generally concluded that poverty tends to be concentrated in city centers (Margo, 1990; Mills and Lubuele, 1997; Glaesar et al., 2006; Lindeke, 2014). The Twin Cities, in particular, face a challenge with high concentrations of poverty in particular neighborhoods just outside of downtown, generally dominated by non-white

communities (Lindeke, 2014; MetroCouncil, 2014). From a sustainability perspective, these areas fare well because of their strong scores in connectivity and density credits.

It is tempting to conclude that neighborhoods containing the highest-scoring samples are on their way to LEED-EN certification should all credits be analyzed, but we cannot say this with certainty. Because some of the credits are dependent on the distance of certain desirable features from building entrances or intersections, we cannot extrapolate our scores to the entire planning district without actually measuring the entire planning district. Furthermore, many of the other LEED-EN credits that we did not consider deal with urban concepts vastly different from the ones in our study. For example, it is not possible to surmise how a sample might fare in terms of energy or water efficiency, when our study did not include credits related to these. However, we can say that our sample scores are representative of a likely score earned by the surrounding planning district.

Because our samples with high scores are indicative of more sustainable neighborhoods, our study could have implications for policy in St. Paul. Samples with high points could implement further testing to see if they do in fact qualify for LEED-EN certification when all credits are assessed. Samples with low scores could become target areas for improved environmental projects, road design, and residential practices that would allow for higher scores in the future. These samples scored low on credits like walkability and reduced automobile dependence, meaning that they are not pedestrian- or public transit-friendly. Such information might be useful to city transit planners when expanding routes and sidewalks.

Our study also has implications for the future of the LEED-EN certification, which is only a proposed certification at this time. First, we found some limitations of the criteria used by the certification. Perhaps most importantly, the certification's required size limit of "neighborhoods" is too small to apply to the City of St. Paul's neighborhoods, defined as planning districts. This might easily be true for many major cities around the country. We think that this should be changed in the certification, so that neighborhoods defined by city governments aren't automatically excluded. Additionally, we discovered that some of the criteria are not applicable to the city of St. Paul. For example, SLL prerequisite 2 (Conservation of Imperiled Species and Ecological Communities) has requirements that are too strict for any neighborhood to qualify. We recommend that it not be included in the final LEED-EN certification criteria, or else neighborhoods that may otherwise qualify will be eliminated for lack

of available information. The obstacles that we faced when applying LEED-EN criteria to St. Paul neighborhood samples can inform future edits that may help improve the proposed certification.

Limitations and Future Research

Due to a variety of factors such as time constraints and finite resources, our analysis has many limitations, four of which warrant mention here. First, we did not assess every credit in the LEED-EN certification. Following the methodology of Talen et al. (2013), we assessed the prerequisites for which we could obtain data from the most important scoring category, Smart Location and Linkage (SLL), with the idea that neighborhoods which do not meet these prerequisites would not be able to obtain LEED-EN certification at all. Then we chose the two or three most heavily-weighted credits from all three categories for which we could find accessible data, ensuring that the important urban concepts would be measured. By limiting ourselves to SLL prerequisites and seven credits, we necessarily limited the power of our scores to represent the LEED-EN scores for the St. Paul neighborhoods. As such, further studies that include the criteria eliminated from this study will be required to develop a more accurate LEED-EN assessment of St. Paul.

Second, as mentioned several times, LEED-EN is a proposed certification that has not yet been officially approved. Therefore, the calculation of LEED-EN scores is currently not immediately useful for neighborhoods. However, an understanding of LEED-EN's accuracy will be necessary for any discussions of whether to formalize the certification. Additionally, if these scores are found to be accurate sustainability assessments, they can still guide neighborhood policies and developments towards a greener living area. Further studies of LEED-EN on other cities will allow the certification to gain popularity and eventually official status.

Third, we operated under a unique definition of "neighborhood" in this analysis. St. Paul's neighborhoods correspond to the City's official planning districts. These areas are much larger than the samples assessed in our analysis. LEED-EN certification caps the size of its units of analysis to 320 acres. For our analysis, we chose a number of smaller (40 acre) plots to represent each planning district. Therefore, extrapolating our results to entire planning districts for policy purposes would require a few extra steps. For example, policymakers might overlay

our smaller plot data with a map of St. Paul's official neighborhoods, revealing sustainability trends throughout the city. In doing so, policymakers may be able to ascertain which official neighborhoods are relatively advanced in this area, and which ones could be targeted for specialized development.

Fourth, for two of our credits we created building entrance layers and then used the SANET program to calculate distance from building entrance to transit stop or diverse uses. Due to the processing limitations of SANET and our time constraints, we could not calculate the distance from all building entrances or the program would have run for weeks. Therefore, we randomly eliminated building entrances to pare down the data that would be run through the program. For SLL Credit 3, we eliminated all of the building entrances that were not at the center of the sample. For NPD Credit 3, we randomly eliminated the entrances that were right next to each other so that we would have a more even distribution throughout the sample. Further analysis of these credits would require more time and a stronger program that could process larger amounts of data.

Conclusion

We conducted an assessment of five prerequisites and seven credits from the LEED-EN proposed certification on samples within St. Paul neighborhoods and found that density and connectivity of samples correlated to higher scores. In other words, samples with older buildings located closer to the center of the city or large transit networks (like interstates) scored higher than samples with newer buildings located on the outskirts of the city. Furthermore, we found that median year built and median income are both negatively correlated with total scores. We also found that the LEED-EN certification is not immediately applicable to cities like St. Paul due to limitations like maximum neighborhood size requirements and availability of obscure data. We recommend that further research be conducted to calculate the complete LEED-EN scores of more samples in St. Paul. With more time and access to planning district data, all of the credits could be examined for the samples we already tested or new samples of the larger districts could be analyzed. We also suggest that the LEED-EN certification be adapted or edited to accommodate different types of cities before becoming official.

Appendix

Appendix A. Districts by name and sample number

Planning District	District Number	Number of Samples
ECBC/Sunray	1	9
Greater East Side	2	8
West Side	3	6
Dayton's Bluff	4	5
Payne-Phalen	5	8
North End	6	7
Thomas-Dale/Frogtown	7	4
Summit-University	8	4
Fort Road-West 7th	9	4
Como	10	6
Hamline-Midway	11	4
St. Anthony Park	12	5
Union Park/Merriam	13	6
Macalester-Groveland	14	5
Highland Park	15	9
Summit Hill	16	2
CapitolRiver Council	17	2

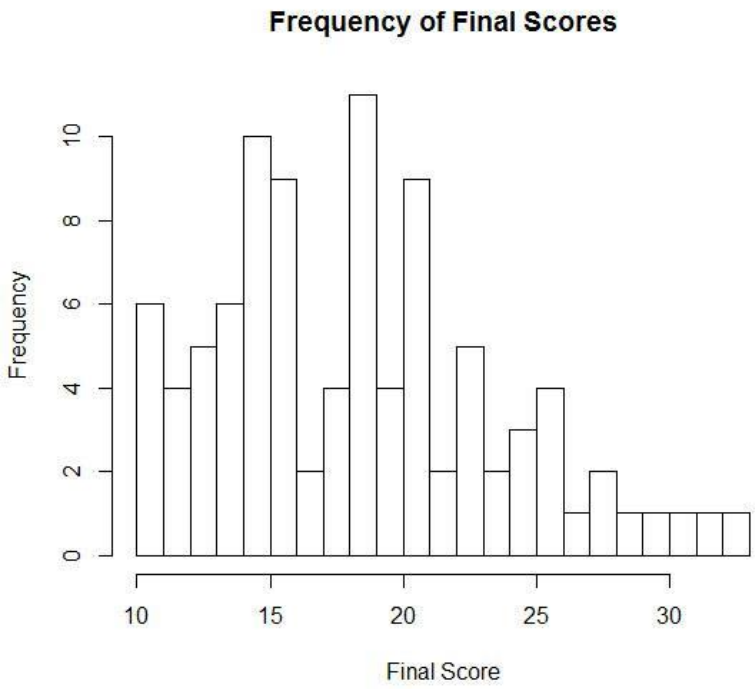
Appendix B. Credit Scores

Credit Name	**Possible Points**
Preferred Locations	10
Brownfields Redevelopment	2
Locations with Reduced Automobile Dependence	7
Walkable Streets	12
Compact Development	6
Mixed-Use Neighborhoods	4
Certified Green Buildings	5
Total	46

Appendix C. Urban concepts measured by our seven LEED-EN credits

Urban Concept	**LEED-EN Credits**
Connectivity	SLL credits 1 and 3; NPD credit 1
Density	NPD credit 2
Land use diversity	NPD credit 3
Resource conservation	SLL credit 2; GIB credit 1

Appendix D. Histogram of final scores for all samples



Appendix E. Walkability Scores

Planning District	WalkScore.com score	LEED-EN score
ECBC/Sunray	35	4
Greater East Side	43	5
West Side Comm.	51	6
Dayton's Bluff	54	6
Payne-Phalen	58	7
North End	49	6
TD-Frogtown	70	8
Summit-University	76	9
FR-West 7th	60	7
Como	40	5
Hamline-Midway	71	9
St. Anthony Park	60	7
Union Park/Merriam	64	8
Mac-Groveland	62	7
Highland Park	49	6
Summit Hill Assoc.	71	9
Capitol River Council	91	11

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