Building Green: The Emerging Geography of LEED-Certified Buildings and Professionals

Julie Cidell, University of Illinois

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Abstract: One of the most important attempts to reduce the environmental impacts of the built environment is through the construction of green buildings. This paper examines the geography of the emerging green building industry through a study of the spatial distribution of two different elements of that industry. The first element is the location and diffusion of green buildings themselves as certified by the U.S. Green Building Council (USGBC) through their Leadership in Energy and Environmental Design (LEED) standards. There is a clear shift from an original concentration in major coastal cities to a more even distribution across the country, with broad representation across commercial, public, and non-profit owners. The second area of study is the spatial distribution of LEED-accredited professionals, who are accredited by the USGBC to oversee the certification process. The distribution of these professionals matches existing concentrations of population, suggesting two different geographies of building green.

Keywords: urban sustainability, buildings, energy, spatial distribution, standards

Introduction

Amid concerns about energy usage, greenhouse gas emissions, and other aspects of urban sustainability, the design and building professions have begun to establish and promote standards and practices to lower the environmental impact of buildings[i]. Buildings in the U.S. account for 70 percent of electricity consumption, 39 percent of energy usage, and 12 percent of potable water usage, while generating 39 percent of greenhouse gas emissions, exclusive of any goods or services produced inside (USGBC 2008c). Reducing energy consumption and greenhouse emissions in buildings is therefore an important step to reducing them overall. One means of doing so has been through the development of standards designed to produce “green buildings.” In the U.S., these standards are known as LEED (Leadership in Energy and Environmental Design), promulgated by the USGBC (U.S. Green Building Council)[ii] and implemented by designers and builders. The LEED standards are designed to help designers and builders reduce the environmental footprint of a building and make it easier for its inhabitants to do so as well. They work on a point-based system, allowing building owners and designers to choose which level of "greenness" they want to achieve and which points or credits to earn.

Beyond the environmental benefits of building green, firms and individuals increasingly advertise their expertise to gain market share or create new markets. Since LEED has been in operation, owners of approximately 3 percent of all new buildings have sought certification for a total of 3.6 billion square feet, and this figure is expected to rise to 10 percent by 2010 (USGBC 2003, 2008). As of August 2007, there were nearly one thousand certified projects and over 7,300 registered (meaning certification will likely be achieved once construction is completed) (USGBC 2007). Furthermore, there are over 40,000 LEED Accredited Professionals (APs) who have passed the USGBC test and are accredited to complete the LEED checklist for a building to verify that it is, in fact, green. While APs can be from any economic sector, 86 percent self-identify as engineers or architects (USGBC 2007), which means they are working in the sectors which LEED is intended to change.

If the LEED standards are going to transform "business as usual" in the building industry, it is important to know where these standards are being implemented. This paper answers this question through an investigation of the spatial distribution of LEED-certified buildings and LEED-accredited professionals as of October 1, 2007 in the case of buildings and December 15, 2007 in the case of APs. The paper begins by explaining the history and implementation of LEED. The second section reviews the existing literature on green buildings and LEED, followed by a discussion of the methodology and data used in this analysis. The fourth section describes the results of the analysis, and the conclusion lays out some of the implications for green buildings and urban sustainability.

Leadership in Energy and Environmental Design

The LEED standards were developed not only to improve the profiles of individual buildings, but to encourage the design and construction industries to develop innovative solutions that could be used on other projects, thus changing the face of the entire building industry (USGBC 2003). The U.S. Green Building Council was founded in 1993 by three environmental consultants as a non-profit organization with the express purpose of creating a system of nationwide standards to stimulate interest in building more sustainably. The LEED program began in 1998. Since then, it has been used by public and non-profit agencies as well as private developers for buildings ranging from houses to skyscrapers. The Government Services Administration (GSA) requires all new federal building projects or renovations to meet LEED standards, and private corporations such as Ford, Sprint, Steelcase, PNC Bank, and Toyota have made the standards part of their building process as well. Similar standards exist around the world, including BREEAM in the UK and the Green Star program in New Zealand and

Australia. The LEED standards have been adopted and/or modified for use in over forty countries, including Brazil, Canada, China, India, South Korea, and the United Arab Emirates (USGBC 2007).

Some of the benefits of green buildings are purely economic. For example, studies show energy savings of up to 30 percent, occupancy rates that are 3 percent higher, or up to a 40 percent increase in sales for stores using natural light (Heschong Mahone Group 1999, Van Schyndel 2007). Additionally, there may be health and social benefits: student test scores improve when classrooms have daylight or are located within green buildings (Heschong Mahone Group 2003a, Turner Construction 2005), and employee absenteeism goes down and productivity goes up when more workers have access to natural light (Heschong Mahone Group 2003b). On the other hand, the average extra cost of 2 to 9 percent to achieve LEED certification has led to criticisms that building green is only for those who can afford it (Sinha 2008). Still, improving the practices of building construction has important implications for water conservation, energy usage, and global warming.

The LEED standards work on a point-based system, where building owners can choose which requirements they want to meet above a few mandatory credits. The system is designed to reduce the total environmental impact of a typical building by 30 percent for Certified buildings, 40 percent for Silver, 50 percent for Gold, and 70 percent or more for Platinum[iii]. Points are earned from six different categories: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation and design. The New Construction variation is the most commonly sought type of certification at over 80 percent of all projects, but other categories include Existing Buildings, Commercial Interiors, Homes, and Neighborhood Development (the latter is still in the pilot stage). Table 1 illustrates the rapid growth in certified and registered buildings throughout the life of the program.

These standards are applied to buildings, not the firms that design and build them. An architecture or engineering firm cannot be designated as a "green builder" no matter how many LEED projects they are part of. However, individuals can become LEED-accredited professionals. Over 40,000 people have passed the test and received accreditation, which enables them to consult on projects and advise developers and builders how to best meet the standards (USGBC 2007). While the use of a LEED-accredited professional is not a requirement for certification, it is one of the easiest points to earn, which explains why virtually all projects utilize this “low-hanging fruit” (Cassidy et al. 2003). The American Institute of Architects found that 13 percent of the architecture firms it surveyed had a LEED-accredited professional on staff (DesignIntelligence 2007).

While the LEED standards are relatively new, the larger fields of sustainable architecture and urban sustainability have been around for years. The following section outlines how the LEED standards fit into these broader perspectives and the existing research on green buildings.

Building sustainably

On the one hand, “green buildings” are nothing new, if the definition includes structures built to take into account local climates and building materials. Studies of vernacular architecture from around the world have demonstrated how local people take into account available materials, temperature, and moisture (Cañas and Martín 2004, Ozay 2005, Renping 2006). On a larger scale, buildings such as the Crystal Palace in London (1851) and the Galleria Vittorio Emaneule II in Milan (1877) used what are today considered green techniques in their construction, namely passive heating and cooling systems (Cassidy et al. 2003). The energy crisis of the 1970s provoked interest in solar panels and other forms of alternative energy. However, the contemporary wave of green or sustainable architecture developed in the 1990s over concerns about energy usage, greenhouse gas emissions, habitat preservation, and a host of other environmental issues (*ibid.*).

A growing number of studies evaluate contemporary certified green buildings to determine the actual costs and benefits of implementation (von Paumgartten 2003, Edwards 2006). These studies uniformly show an overall benefit to following LEED standards, not only in the realm of reduced energy costs, but in terms of decreasing employee absenteeism and increasing productivity as well as higher building occupancy and sales and rental prices (CoStar 2008, Eichholtz et al. 2008). Other work has looked at why certain states have implemented LEED guidelines (May and Koski 2007), how different meanings of "green" allow building and design companies to find their own niches in this emerging market (Stenberg and Räisänen 2006), and how specific projects have come to be implemented (Johnston 2005, Stromberg 2005, Bedi 2006).

On the other hand, there is more to green buildings than technology and economics. First, inhabitants of green buildings often use them in ways their designers did not intend. For example, one "inefficiency" in the operation of green apartment buildings in Austria has been the occupants' preference for opening the windows, which plays havoc with the finely-tuned HVAC systems (Rohracher and Ornetzeder 2002). The people who are to make use of efficiently-designed buildings have their practices that need to be taken into account during the design process (such as opening windows for fresh air). Following on from this, improving the energy efficiency of buildings is almost always conceptualized in a limited way that does not take into account "the changing pressures and priorities that [govern] the strategies of different actors…technical strategies mesh with commercial tactics, [and] the plans of one practitioner often [clash] with the designs of another" (Guy and Shove 2000, p. 138). These pressures and priorities include real estate trends, government funding priorities, and consumer preferences, all of which influence the types of structures that are built and occupied.

Green buildings fit into the context of the larger debate on urban sustainability, even if that debate is not always made explicit. In particular, green buildings exemplify the position that the local is the appropriate scale for implementing sustainability. For example, Krueger and Agyeman (2006) look at what they call "already existing sustainabilities" to make the point that instead of looking for how localities are following guidelines that explicitly reference sustainability, we should be looking for other ways that city planning practices are changing in order to improve energy efficiency, use of resources, human development, and other components of traditional definitions of "sustainability". Other authors also start from the point of view that "the local" is the most appropriate level for implementing sustainability, using case studies to explore the mechanisms by which cities are attempting to implement sustainable practices (Santa Monica, CA and Austin, TX in Theaker and Cole (2001), Manchester and Leeds in While et al. (2004). The fact that over 180 units of local government in the U.S. require new construction to meet LEED standards indicates that green buildings are an important component of urban sustainability[iv] (USGBC 2008b).

The LEED standards are one set among many that have been developed since the mid-twentieth century in areas from food to electronics. A significant body of work exists on the geography of standards (e.g., Dunn 2003, Hebb and Wójcik 2005, Neumayer and Perkins 2005, Thompson 2005) and the ways in which standards shape the production of goods and services (Guthman 2004, Mutersbaugh 2005). In particular, the recent shift to firm-based standards rather than state-based regulation is thought to benefit firms by making it easier to keep operations consistent over multiple locations and by improving the firm's reputation (Angel and Rock 2005). On the other hand, firm-based standards exemplify the pressures and contradictions of neoliberalism by shifting responsibility from the state to individuals and relying on the market as the ultimate arbiter (McCarthy and Prudham 2004, Mutersbaugh 2005, Brown and Getz 2008). In this respect, LEED may be viewed as a compromise, with the flexible nature of the standards meaning that even if the state requires their implementation, building owners and designers can choose which elements they want to incorporate.

Because of the need to be responsive to regional and even micro-climates, the importance of place in designing and maintaining green buildings is crucial. The USGBC is currently revising its standards to take these geographic differences into account (Fournier 2007). However, no study has examined the spatial distribution of LEED buildings and professionals and how those distributions have changed over time, which is important to understanding how green building practices are spreading across space. While a description of the spatial distribution of a complex phenomenon like green buildings may seem overly simple, it is an important first step in analyzing such a phenomenon (Grubesic and O'Kelly 2002, Oppong et al. 2007). The next section explains the methodology and is followed by the results of the analysis in this first step towards understanding the geography of green buildings.

Data and methodology

Data for this study were obtained from the USGBC, which maintains a database of all registered and certified LEED buildings on its website (USGBC 2007). Information is self-reported, meaning that project administrators who apply for LEED certification are responsible for keeping their information up-to-date. As of October 1, 2007, there were 941 certified buildings across the country; forty-seven states plus the District of Columbia had at least one certified green building.

The USGBC also maintains a database of all of its Accredited Professionals, including name, address, company or organization, and occupation. Data were requested with only the company name, city and state, and profession, in order to retain the anonymity and privacy of the APs listed in the database. There were 40,499 entries in the AP database as of December 15, 2007. The APs were initially mapped at the level of a Census place[v] using city and state and then aggregated to the Core-Based Statistical Area (CBSA) level, the Census's designation for metropolitan areas. Information on certified LEED buildings was obtained from the USGBC's online database, which includes the city, state and ZIP code for each building. These data were also aggregated at the CBSA level (mapped at ZIP code centroids when not part of a CBSA). All data were mapped using ArcMap 9.2.

To further explain the spatial distributions that were found, correlations were run between the metropolitan areas and various likely explanatory variables: average household income, percentage of jobs in the service sector, and percentage of college graduates, all obtained from the U.S. Census or Economic Census; and the number of Fortune 500 company headquarters, obtained from Fortune magazine's website. ANOVA analyses were carried out for a series of nominal variables to see if being a state capital or in one of five different regions (East Coast, South, Central, Rocky Mountains, or West Coast) had a significant impact. The results are explained in the next section.

The spatial distribution of green buildings and builders

Given general perceptions of the West Coast as more environmentally friendly, the South as less so, and the rest of the country as in between, the geographic findings here are hardly surprising. What is unexpected is the extent to which a variety of sources of leadership for building green can be seen across locations, from government-sponsored to the private sector to universities or non-profit organizations. Additionally, the designers and builders of green buildings appear to be much more spatially concentrated than the buildings they produce, suggesting that green building practices may not have infiltrated the industry to the extent that the presence of green buildings would suggest.

Figure 1 shows the distribution of certified buildings and the number of green buildings per capita (displayed as population per building to make the numbers more meaningful), mapped in quartiles[vi]. The CBSAs that fall into the highest quartile are concentrated in the Pacific Northwest, the Rocky Mountains, the Upper Midwest, and scattered East Coast locations. Areas with relatively few green buildings per capita include Southern

California, the Great Plains, the Ohio River Valley, and most of the South. Miami, New Orleans, and Nashville are the largest metropolitan areas with no certified green buildings (as of 2007). Table 2 ranks the top twenty CBSAs by total green buildings and by green buildings per capita. The perennially "green" cities of Seattle-Tacoma and Portland, OR score quite well in both rankings, with Pittsburgh, Salt Lake City, and Austin holding their own. The per capita rankings include a number of smaller cities that are state capitals or university towns such as Corvallis, OR, Burlington, VT, or Madison, WI. One significant anomaly in both lists is Grand Rapids, MI, located in one of the most politically conservative regions of the Midwest and not known for its environmental leanings.

Of course, all green buildings are not created equal. There are four levels of LEED, and when buildings are weighted according to their level of certification, a slightly different picture emerges. Table 2 also shows the top twenty CBSAs ranked by the number of buildings weighted for their level of "greenness". (Only CBSAs with a minimum of three buildings were included to reduce the effects of a single one.) The cities at the top may not have as many green buildings, but the "greenness" of those buildings is significantly higher, as in Eugene, OR, Honolulu, and Rochester, NY. On the other hand, some cities that scored well in terms of the number of buildings or buildings per capita fall out of the top twenty here, including Grand Rapids, Salt Lake City, and Austin, indicating that their green buildings are largely meeting only the minimum standard.

A basic statistical analysis shows that high population, a well-educated and well-paid populace, and certain geographic factors make a metropolitan area more likely to have green buildings (Table 3). For the absolute number of buildings, population had the highest correlation, followed by the number of Fortune 500 companies (which is itself highly correlated with population), and then income, educational attainment, and percentage of jobs in the service sector (which are correlated with each other as well). Turning to buildings per capita, all of these variables become less significant and lower in magnitude, suggesting that other factors such as a highly-motivated local government or the presence of a university matter here[vii]. When buildings are weighted according to their level of certification, all variables are again significant, although here income and education matter more than population. It is therefore not necessarily the largest cities that are the greenest, but those with more highly-educated and well-off residents.

The table also shows the results of ANOVA analysis for nominal variables, which here tests the difference between types of metropolitan areas. State capitals (including Washington, DC) are significantly different from non-capitals: they are more likely to have green buildings, indicating that requirements for government buildings are making an impact on the landscape. Cities in the South and the West Coast are significantly different from the rest of the country; in the case of the former, it means they are *less* likely to have green buildings, while the latter are *more* likely. To some extent, these regional differences echo the above findings about income and service-sector jobs, but they also reinforce existing perceptions about the "greenness" of the West Coast.

The picture is quite different for LEED Accredited Professionals. In Figure 2, we see the corresponding distribution of APs by metropolitan area, also in quartiles, and per 100,000 residents. The cities in the highest quartile are quite varied in terms of size and geographic location, with the Pacific Northwest, Rocky Mountains, and large cities in the Midwest and East Coast holding the highest concentrations. As Table 4 indicates, a ranking of CBSAs by sheer number of APs produces predictable results, with large metropolitan areas dominating the list—which was not the case for green buildings themselves. This suggests that firms concentrated in large cities are carrying out green building activity in more distant locations. However, when the ranking is normalized by population, the results favor smaller metropolitan areas such as Fort Collins, CO, Charlottesville, VA, and Savannah, GA; only eight of the top twenty have a population of over a million. Many of these small cities are home to either major universities or corporate headquarters for engineering firms. Only seven cities appear on both lists (San Francisco, Washington, DC, Seattle, Boston, Denver, Portland, OR, and Kansas City), suggesting that they house particularly significant clusters of green builders *and* green buildings.

The same set of variables was tested against the location of APs (Table 5). As suggested above, population is by far the most strongly correlated with APs, though the other variables are all significant as well. For APs per capita, all variables were significant with roughly equal coefficients. Capital cities have significantly more APs as well as more APs per capita. This is interesting because in most U.S. states, the capital is neither the largest city nor the economic center, suggesting that state requirements for greener buildings have boosted the corresponding sector of the metropolitan economy. For example, multinational Turner Construction chose to locate its Green Building office in Sacramento, CA. In terms of regional differences, the West Coast is slightly more likely to have higher total APs than the rest of the country; the West Coast and Rocky Mountains have significantly more APs per capita compared to the rest of the country, while the South has significantly fewer.

The distribution of green buildings can be explained in part by the widely varying reasons for a building owner to go green. With that in mind, the USGBC tracks whether a building is owned by a for-profit, non-profit, or governmental organization (or individual). Figure 3 compares the distribution of LEED-certified buildings depending on whether their owners are profit-making institutions or individuals; local, state, or federal government; institutions of higher education; or non-profit institutions[viii]. There are some definite differences, indicating different leaders in implementing green building across the country. Figure 3a shows that for-profit buildings are more strongly concentrated in New Jersey and Pennsylvania (largely due to PNC Bank, one of the larger companies committed to building all of its new facilities to LEED standards), as well as Ohio and Texas. Figure 3b reveals that most non-metropolitan buildings are government-related, such as the Escalante Science Center in southern Utah or the Caribou Weather Forecast Office in northern Maine. Higher education, shown in Figure 3c, accounts for a significant percentage of the green buildings in New England, with additional concentrations in Gainesville, FL, and Phoenix. Finally, non-profit institutions are highly concentrated in the mid-Atlantic and New England regions as shown in Figure 3d.

Table 6 ranks metropolitan areas by the total number of green buildings (for those with at least ten buildings) and shows their distribution among the four categories. Over half of the cities have at least one building in all four categories, indicating a dispersed presence throughout the community and its institutions. Approximately two-thirds of the cities have two sectors with more than thirty percent each, indicating that multiple sectors are contributing to the total. In other words, green building practices in most regions have spread beyond the initial adopter, whether that was a university, corporation, or unit of government, to encompass multiple sectors.

It is not only the current distribution of green buildings that matters, but how that distribution has changed. Figure 4 shows the distribution of LEED-certified buildings over time based on the year in which they applied for certification. The nine squares indicate the initial pilot projects, with the darker circles in each map indicating the buildings were certified in the two-year time period in question, and the lighter symbols indicating buildings from previous years. Figure 4a shows that of the pilot projects, only those in the larger cities of Los Angeles, Chicago, Pittsburgh, and Milwaukee appeared to encourage other green buildings, while projects in Salt Lake City, Aspen, CO, St. Louis, and Harrisburg, PA remained in isolation. The time period to 2003 shows the greatest increase in registration, with new activity apparent across dozens of other new metropolitan areas. From 2003 to 2005, many of the non-metropolitan projects remained in isolation, while new regions were limited to Ohio and eastern Washington and Oregon. The most recent registrations break almost no new ground; nearly all of the projects which have been completed as of 2007 that were registered in the past two years are located in places that already have at least one green building. This might indicate a narrowing of the market (which is unlikely given the overall growth in LEED-certified buildings), or it might simply be the case that these buildings could be built more quickly because they were in areas with previous experience. An analysis of all projects registered within the same time frame would be necessary to know if, in fact, new green buildings are being built more quickly in areas with existing expertise.

Finally, in order to compare the different geographies of LEED-certified buildings and LEED-accredited professionals, Figure 5 shows the number of APs per green building by metropolitan area. The darker areas indicate those with a "surplus" of APs, suggesting that either they export a significant amount of their work or that they are anticipating a local market that has not yet developed[ix]. Generally speaking, these are large metropolitan areas, reiterating that even when total population is taken into account, LEED APs are still concentrated in larger cities. Table 7 ranks the top twenty CBSAs by this measure. These are the most likely places for clusters to be developing within the green building industry, even if the buildings they produce are not located in the same metropolitan area. Comparing this list with Table 3 shows that half of the cities with a "surplus" of APs also score high in terms of the total number of green buildings, indicating a lot of local expertise and experience in terms of building green (e.g., San Francisco and Washington, DC). On the other hand, half of the cities with a surplus do not appear in Table 3, indicating that they have a considerable number of green builders ready and waiting, but local conditions are not conducive to actually building green (e.g., Charlotte, NC, and Minneapolis-St. Paul).

Conversely, the lighter areas in Figure 5 suggest that expertise has been imported and that a local green building sector has not subsequently developed. Most of these are small metropolitan areas, many in the shadow of larger cities: Salem and Corvallis, OR; Holland and Grand Rapids, MI; and Boulder, CO. Table 7 also shows the lowest twenty cities in terms of APs per green building, corresponding to these locations where a local green building industry has not yet developed. Eight of these cities are also in the top twenty in terms of green buildings per capita, suggesting that green building expertise has been imported from a nearby, larger city. Significant importation of AP expertise seems to be taking place in Pittsburgh, PA, Grand Rapids, MI, and Salt Lake City, UT, who are in the top twenty in terms of the total number of green buildings, but the bottom twenty in terms of APs per green building. On the other hand, there may simply be a small number of accredited professionals who are working very hard to meet the demand in these three cities, or the APs may work for the company that owns the building, rather than being architects or engineers.

Though not shown in a table, correlations between the number of APs per green building and population, income, education, service-sector employment, and Fortune 500 companies were all significant and within a narrow range of 0.347 to 0.388. Neither region nor capital status mattered for this portion of the analysis. Across regions, there is therefore little discrepancy between the ratio of green builders to green buildings; however, within regions and across city sizes, APs are much more concentrated than buildings, with capital cities as an exception.

These results suggest that there are two different geographies of green buildings: one of the buildings themselves, which are concentrated in Western cities, college towns, and state capitals; and one of the APs who certify those buildings, who are concentrated in major metropolitan areas. So while LEED-certified buildings may be an example of already existing sustainabilities in a wide variety of places, the people who design, build, and certify them are working for firms that operate at a national or even international scale. On the one hand, this indicates that a national market exists for green building practices, which is encouraging from a sustainability point of view. On the other hand, it suggests that green building professionals may or may not be taking local conditions into account; since the LEED standards are flexible, an architect designing a building in another region might opt to focus on placeless criteria like heating systems or paint emissions rather than place-based criteria like connectivity to transit or habitat preservation. Future research will explore to what extent this is the case.

Conclusion

The rapid growth of LEED-certified buildings across the United States has not occurred evenly across space. There are some expected hot spots of green buildings, such as the Pacific Northwest, university towns, and government centers. There are also stark differences between cities in close proximity, such as high concentrations in Philadelphia and Boston with the low concentration of New York City in between, indicating the importance of local factors. Generally speaking, the West scores well (except for Southern California), the Midwest and South score medium to low, and the East Coast is split. Increases in income, educational attainment, and percentage of service-sector employment all correlate with more green buildings, suggesting that criticisms of them as being only for the rich may well be valid (Sinha 2008). Although different sectors have led the way in different regions, green buildings can be found in most locations under multiple types of ownership, indicating diffusion beyond the original type of project in a metropolitan area. Looking at LEED-certified buildings over time indicates that after an initial branching out from the pilot locations, no new ground has been broken in the past few years. It remains to be seen whether the existing spatial pattern will continue, or if builders and developers will push LEED certification into new territories. In particular, as the new category of LEED-certified homes begins to be implemented, green buildings are expected to appear in more suburban locations. Future research should incorporate additional information such as cost of heating and electricity, presence of state or local incentives or regulations regarding green buildings, and volume of new construction activity.

With regard to LEED-accredited professionals, the results are less clear. The distribution of LEED APs across the country shows that clusters of green building activity may be developing in the Pacific Northwest and in government centers such as Baltimore-Washington and Denver. What is most significant, however, is that green buildings and green builders are not generally concentrated in the same locations; in particular, smaller metropolitan areas are experiencing a shadow effect from larger nearby cities where expertise is being developed and exported. One important exception is state capitals, where legislative requirements for LEED-certified buildings appear to be enhancing the job prospects for LEED-accredited professionals, a further indication of the impact of product standards on economic landscapes. Further investigation is needed to see to what extent green building services are being exported, to what extent APs are able to develop the market for green buildings in their home metropolitan regions, and how this makes a difference to how green buildings are built, particularly given the local environmental knowledge required by many of the standards.

From an urban sustainability point of view, this study has two implications. First, the potential contributors to sustainability vary across economic sectors and scales. In most cases, these multiple kinds of institutions can be found in the same place, indicating that as builders and developers in a region adopt green building practices to meet the needs of one type of building owner, they are likely to maintain those practices on other projects. Nevertheless, future research should explore these different institutions and organizations to demonstrate how green building practices have diffused through multiple routes. Secondly, there is evidence for small but significant green building clusters, concentrated in certain large metropolitan areas and based in part on a pre-existing propensity for environmental practices but also on the demand coming from public, private, and non-profit sectors for green buildings. It is heartening to see that LEED APs can be found in all fifty states and in over 2,400 cities, indicating a strong interest on the part of architects and engineers in building sustainably across the country.

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Table 1. Growth in registered and certified LEED projects. Source: USGBC and author's calculations.

Year	Registered projects	Certified projects	Certified square feet
2000	50	12	1.2 million
2001	262	17	2.9 million
2002	597	38	5.1 million
2003	1106	84	12.5 million
2004	1913	200	25.2 million
2005	3338	398	49.2 million
2006	5030	718	85.7 million
2007 (August)	8600	997	113.7 million

Table 2. Green buildings by CBSA, total and per capita (for CBSAs with at least three green buildings). Buildings received a weight of 1 for Certified, 2 for Silver, 3 for Gold, and 4 for Platinum.
Source: USGBC and author's calculations.

Rank by Total Buildings	Rank by Buildings Per Cap.	Rank by Ave. Score
Seattle-Tacoma, WA	Corvallis, OR	Boulder, CO
Portland, OR	Burlington, VT	Eugene, OR
Chicago, IL	Portland, OR	Honolulu, HI
Los Angeles, CA	Fort Collins, CO	Rochester, NY
Washington, DC	Boulder, CO	Albuquerque, NM
Boston, MA	Grand Rapids, MI	Santa Barbara, CA
Pittsburgh, PA	State College, PA	Philadelphia, PA
Atlanta, GA	Gainesville, FL	Portland, OR
New York, NY	Seattle-Tacoma, WA	Fort Collins, CO
Philadelphia, PA	Bremerton, WA	Bremerton, WA
San Francisco-Oakland, CA	Pittsburgh, PA	Sacramento, CA
Grand Rapids, MI	Madison, WI	Olympia, WA
Denver, CO	Savannah, GA	San Francisco-Oakland, CA
Phoenix, AZ	Boise, ID	State College, PA
San Diego, CA	Austin, TX	Savannah, GA
Salt Lake City, UT	Charleston, SC	Sarasota, FL
Baltimore, MD	Holland, MI	Pittsburgh, PA
Sacramento, CA	Durham, NC	New Haven, CT
Austin, TX	Salt Lake City, UT	Riverside-San Bern., CA
St. Louis, MO	Olympia, WA	Atlanta, GA

Table 3. Correlations and ANOVA results for total green buildings and green buildings per capita. Source: U.S. Census (Economic Census and American Community Survey), Fortune Magazine, calculations by author.

Correlations					
	Pop'n	Income	Education	Service	Fortune 500
Total Buildings					
Correlation	0.676	0.368	0.362	0.321	0.564
Significance	0.000**	0.000**	0.000**	0.000**	0.000**
Buildings per capita					
Correlation	0.119	0.312	0.126	0.108	0.058
Significance	0.023*	0.000*	0.016*	0.040*	0.268
Level of LEED certification					
Correlation	0.302	0.434	0.454	0.280	0.242
Significance	0.000**	0.000**	0.000**	0.000**	0.000**
ANOVA					
Capital	East Coast	South	Midwest	Mtn. West	Pacific Coast
Total Buildings					
0.000**	0.084	0.004**	0.249	0.794	0.001**
Buildings per capita					
0.993	0.400	0.014*	0.556	0.849	0.000**
Level of certification					
0.000**	0.258	0.000**	0.997	0.064	0.007**

** Significant at the 0.01 level

* Significant at the 0.05 level

Table 4. LEED APs by CBSA, total and per capita (architects and engineers), for CBSAs with at least 25 APs.
Source: USGBC, author's calculations, and 2002 Economic Census.

Rank	By Total APs	By APs per capita
1	New York City, NY	Trenton, NJ
2	San Francisco-Oakland, CA	Fort Collins, CO
3	Washington, DC	Seattle-Tacoma,WA
4	Los Angeles, CA	San Francisco-Oakland, CA
5	Seattle-Tacoma, WA	Corvallis, OR
6	Chicago, IL	Charlottesville, VA
7	Boston, MA	Denver, CO
8	Denver, CO	Portland, OR
9	Portland, OR	Boulder, CO
10	Dallas-Ft. Worth, TX	Washington, DC
11	Philadelphia, PA	Ithaca, NY
12	Phoenix, PA	Boston, MA
13	Houston, TX	Lawrence, KS
14	Minneapolis-St. Paul, MN	Burlington, VT
15	Kansas City, MO	Savannah, GA
16	Sacramento, CA	Madison, WI
17	Baltimore, MD	Grand Rapids, MI
18	San Diego, CA	Iowa City, IA
19	St. Louis, MO	Gainesville, FL
20	Charlotte, NC	Kansas City, KS

Table 5. Correlations and ANOVA results for LEED-accredited professionals and APs per green building. Source: U.S. Census (Economic Census and American Community Survey), Fortune Magazine, calculations by author.

Correlations					
	Pop'n	Income	College	Service	Fortune 500
Total APs					
Correlation	0.843	0.387	0.355	0.322	0.779
Significance	0.000**	0.000**	0.000**	0.000**	0.000**
APs per capita					
Correlation	0.245	0.457	0.690	0.388	0.223
Significance	0.000**	0.000**	0.000**	0.000**	0.000**
ANOVA					
Capital	East Coast	South	Midwest	Mtn. West	Pacific Coast
Total APs					
0.001**	0.098	0.022	0.386	0.945	0.015*
APs per capita					
0.000**	0.061	0.000**	0.923	0.020*	0.011*

** Significant at the 0.01 level

* Significant at the 0.05 level

Table 6: Green buildings by CBSA by type of building owner. Source: USGBC and author's calculations.

	Total	Higher Education	Profit	Non-Profit	Government
Seattle	52	8	16	9	19
Portland	50	5	21	14	10
Chicago	38	2	17	5	14
Los Angeles	38	5	15	8	10
Washington, DC	36	0	16	10	10
Boston	33	4	15	12	2
Pittsburgh	33	2	12	15	2
Atlanta	31	3	10	6	12
Grand Rapids	29	3	11	9	6
Philadelphia	26	3	19	0	4
New York	26	0	21	2	3
San Francisco	25	1	14	6	4
Denver	22	2	9	3	8
Phoenix	15	5	5	2	3
San Diego	14	0	8	3	3
Sacramento	12	0	4	1	7
Baltimore	12	0	5	2	5
Austin	12	0	0	6	6
Salt Lake City	12	1	6	1	4
San Jose	11	2	5	1	3
St. Louis	11	1	6	4	0
Raleigh-Durham	11	6	1	0	4
Dallas-Ft. Worth	10	0	5	0	5

Table 7. Highest and lowest cities in terms of LEED APs per certified green building. Source: USGBC and author's calculations.

Top twenty	Bottom twenty
Charlotte, NC	Spartanburg, SC
Minneapolis-St. Paul, MN	Salem, OR
Columbus, OH	State College, PA
New York, NY	York, PA
San Francisco-Oakland, CA	Olympia, WA
Dallas-Ft. Worth, TX	Holland, MI
Houston, TX	Knoxville, TN
Kansas City, KS	Corvallis, OR
Washington, DC	Pittsburgh, PA
Phoenix, AZ	Allentown, PA
Boston, MA	Worcester, MA
Richmond, VA	Gainesville, FL
Los Angeles, CA	Grand Rapids, MI
Denver, CO	Harrisburg, PA
Chicago, IL	Atlanta, GA
Detroit, MI	Durham, NC
Colorado Springs, CO	Bremerton, WA
Sacramento, CA	Santa Barbara, CA
Cincinnati, OH	Salt Lake City, UT
Baltimore, MD	Boulder, CO

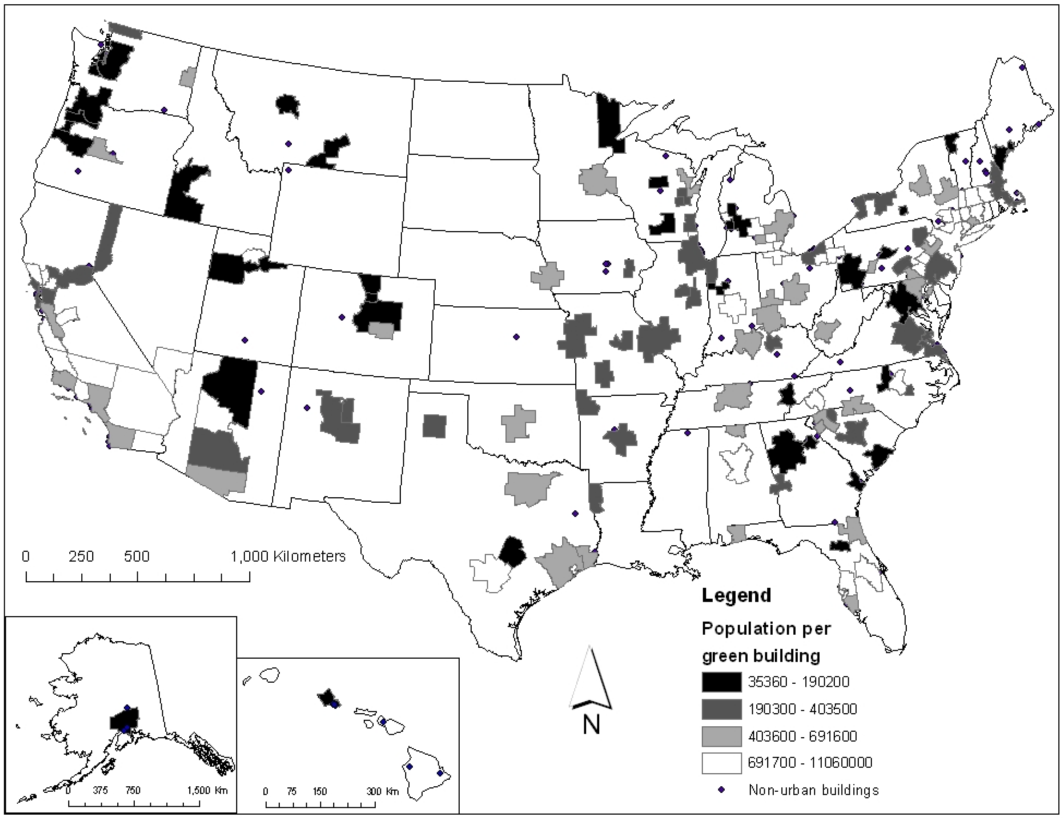

Figure 1. LEED-Certified Buildings Per Capita. Source: USGBC and author's calculations.

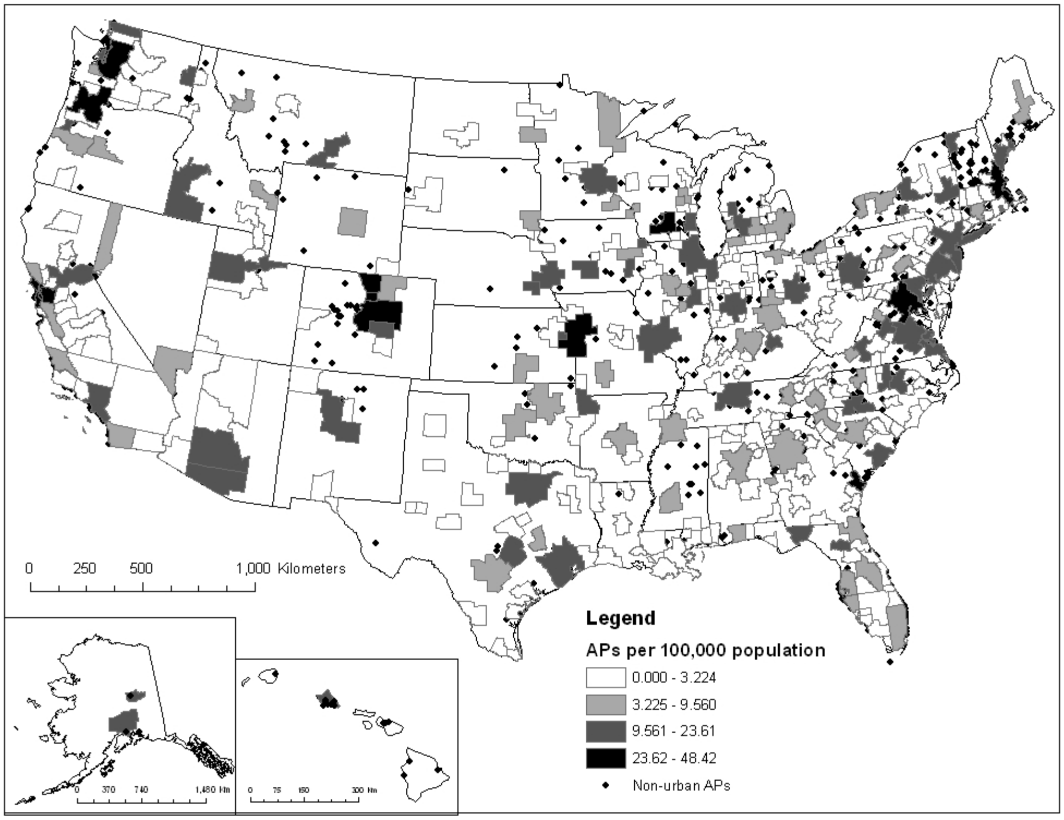

Figure 2. LEED APs as a percentage of all architects and engineers. Source: USBGC, Economic Census, and author's calculations.

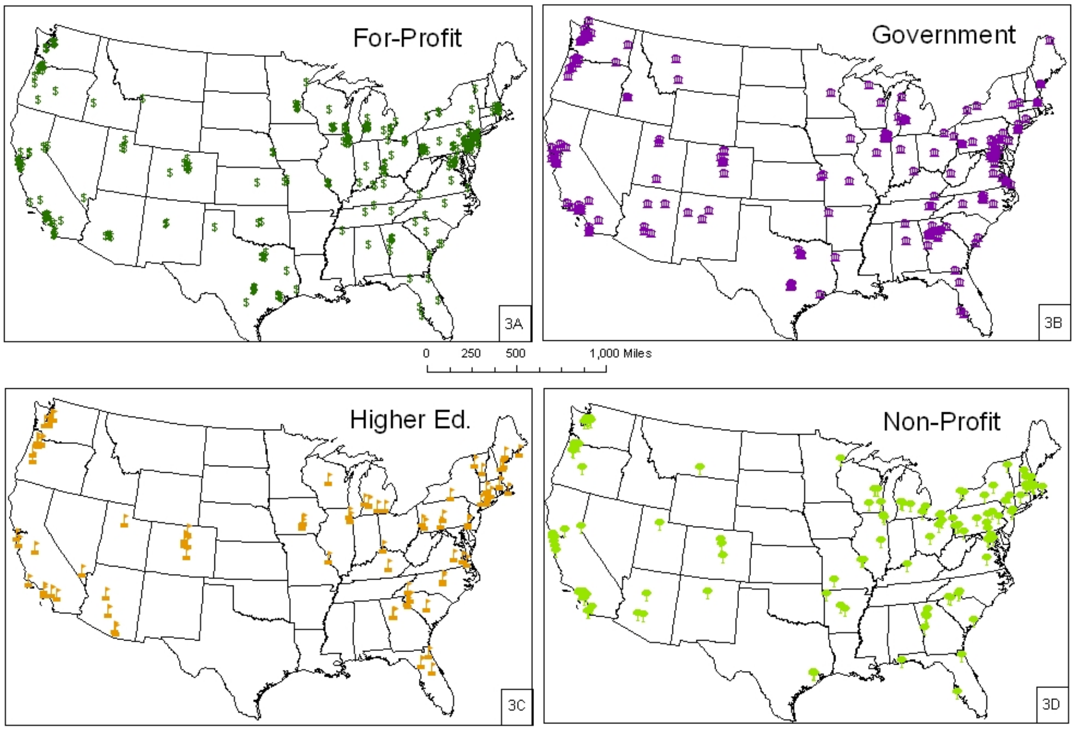

Figure 3. Distribution of Green Buildings Owned by For-Profit, Governmental, Higher Education, and Non-Profit Organizations. One symbol equals one building. Source: USGBC and author's calculations.

Figure 4. Distribution of LEED-Certified Buildings by Two-Year Time Periods, 1999-2007. Source: USGBC and author's calculations.

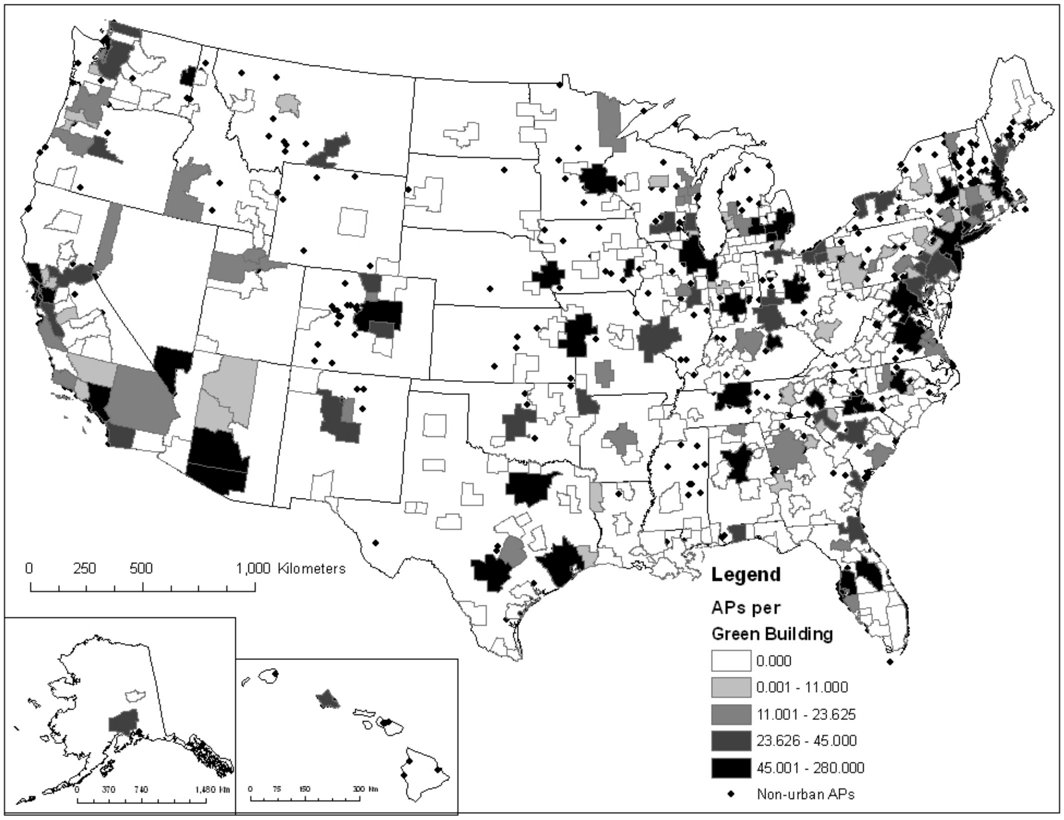

Figure 5. LEED APs per green building by metropolitan area. Source: USGBC and author's calculations.

JULIE CIDELL is an Assistant Professor in the Department of Geography at University of Illinois, Urbana, IL 61801. E-mail: jcidell@illinois.edu. Her research interests include urban environments and sustainability, the discourses and practices around green buildings, and critical transportation geography of airports and freight/logistics.

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[i] There is not sufficient space here to fully explore the contested concept of "urban sustainability"; readers are referred to Whitehead 2003.

[ii] Because the LEED standards have become the de facto standard for green buildings in the U.S., the terms "LEED-certified building" and "green building" are used interchangeably here, although there are many potential definitions of green buildings that do not match up with LEED certification.

[iii] For example, a recent study found that energy usage in LEED buildings is 25-30% lower across all types of certification, in keeping with expectations (NBI 2008); however, energy usage is only one of the environmental impacts the LEED standards are designed to reduce.

[iv] For example, all public buildings in Portland, OR, must achieve Gold certification; all commercial buildings in Baltimore larger than 10,000 square feet must certify at the Silver level; all private developments larger than 50,000 square feet in Los Angeles must achieve the Certified level; and all state-funded buildings in Arizona must achieve Silver certification. Additionally, all federal capital building projects must earn Silver certification (USGBC 2008a).

[v] For towns that are not officially Census places, the nearest place was used instead.

[vi] At the time of the analysis, all certified buildings were commercial or institutional rather than residential; now that the LEED for Houses program has come online, there are likely to be cities with significantly larger numbers of buildings because of developments consisting of dozens of green houses that would skew the results if included.

[vii] Correlations were not tested for the presence of a university, since this is likely to be a distinguishing factor only for smaller cities and would probably not be significant across the board; additionally, most small towns with significant numbers of green buildings are university towns, but not all university towns have large numbers of green buildings.

[viii] Because of the high number of university buildings in the list of certified buildings, and because they were split between the government and non-profit categories depending on whether they are public or private institutions, higher education was set up as a separate category.

[ix] Since achieving AP status as an individual is a much faster process than achieving LEED status for a building, it may also be the case that mapping buildings that are registered, not just certified, would result in a different picture.