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Edited by Gregory K. Ingram and Yu-Hung Hong

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Prediction of Transportation Outcomes for LEED-ND Pilot Projects

Reid Ewing, Colin Quinn-Hurst, Lauren Brown, Meghan Bogaerts, Michael Greenwald, Ming Zhang, and Lawrence Frank

At this point, there's no one—at least no one in urban planning—who doesn't know that the initials LEED stand for Leadership in Energy and Environmental Design. The green building certification system developed by the U.S. Green Building Council (USGBC) has become a global phenomenon. Since LEED was launched in 2000 as a single rating system for new construction, it has expanded to encompass more than 65,000 projects in all 50 states and in 106 countries. There are now eight rating systems covering various types of development, from commercial interiors to homes to schools, with more systems to come. In the United States, as of May 2010, LEED initiatives in government—including legislation, ordinances, policies, and more—were found in 142 cities, 36 counties, 28 towns, 34 states, 14 federal agencies, 17 public school districts, and 41 institutions of higher education.

The USGBC's mission is a sweeping one: "to transform the way buildings and communities are designed, built, and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life." There is no question that LEED has been a success in the marketplace (see table 9.1). But is it leading to higher-quality development? That is the question addressed in this chapter, in the specific context of the LEED for Neighborhood Development (LEED-ND) pilot program. To answer the question, we

Table 9.1
Number of Registered LEED Projects for Each Rating System, May 2010

Rating System	Approximate Number
New construction (NC)	16,051
Core and shell (CS)	2,871
Commercial interiors (CI)	2,797
Retail (NC and CI)	152
Existing buildings: Operations and maintenance	4,356
Schools	1,173
Homes	25,588
Neighborhood development	238

Source: U.S. Green Building Council.

analyze the potential reduction in vehicle miles of travel (VMT) and the energy and carbon dioxide (CO_2) savings of the LEED-ND certified projects relative to a regional average baseline. Energy and CO_2 savings are a direct result of VMT reductions.

A Brief History of LEED

The U.S. Green Building Council was founded as a nonprofit organization in 1993 by a small group of professionals with experience in multiple sectors of the building industry. They saw promise in the fledgling green building movement, but recognized the need for a focused effort at the national level to bring about the level of change they sought. The mission of the first USGBC volunteer committee was to go beyond policy statements and case studies to actually define a green building and to create a tool based on that definition. In 2000 the LEED Green Building Rating System Version 2.0 was released after the completion of a pilot program involving a small number of commercial buildings.

The first LEED rating system and all subsequent systems have included both a set of prerequisites, which are mandatory, and a set of credits, from which projects can pick and choose in order to amass enough points to qualify for certification. These rating systems touch on a variety of issues related to sustainability, including energy savings, water efficiency, land use and transportation choices, and stewardship of natural resources and features. Projects are certified at one of four levels (Certified, Silver, Gold, Platinum) via submission of documentation to a third-party reviewer, the Green Building Certification Institute.

In recent years, LEED has become more a market force than an experiment. As of May 2010, 5,642 commercial/institutional and 6,318 residential projects have achieved certification. There are 155,000 credentialed LEED professionals—individuals who demonstrate LEED mastery via an exam and ongoing education requirements—a number that has shown exponential growth similar to that of the number of LEED projects.[1]

Expansion to Neighborhoods

In 2003 the USGBC, the Congress for the New Urbanism, and the Natural Resources Defense Council began to discuss the potential for expanding LEED beyond single buildings to neighborhoods. The LEED-ND pilot rating system was developed over the next several years and launched in 2007. The pilot program was open to all interested parties, and 238 projects ultimately registered to participate. Because a main purpose of the pilot program was to assess the applicability of the rating system to a variety of real-world scenarios, no restrictions were placed on project size, mix of uses, or country. Pilot projects in all phases of development were accepted and grouped into three stages. Stage 1 was available to projects at the conceptual plan phase, Stage 2 was for approved plans that had received most of their land use entitlements, and Stage 3 was for completed neighborhood developments. As of May 2010, 75 pilot projects had achieved at least one stage of certification.

The pilot projects provided regular feedback on how the pilot rating system functioned on the ground, which informed the revisions subsequently adopted as LEED 2009 for Neighborhood Development. Registration for new projects opened in April 2010, and full certification followed in November 2010. As of January 2011, 60 projects have registered to pursue LEED 2009 for Neighborhood Development. The LEED-ND rating system defines criteria in key issue areas of sustainability and awards certification to green neighborhood development projects that can document achievement in those areas. Elements of Smart Growth, New Urbanism, and green building form the foundation of LEED-ND, producing a rating system that values compact, connected neighborhoods located near existing developed areas and containing green buildings and infrastructure. For the first time under a LEED program, the location, context, and pattern of land development matters as much as the design of individual buildings. The USGBC's stated goal is to encourage development practices that are supportive of public health, protect fragile natural resources, reduce greenhouse gas emissions, and provide a range of other benefits to residents and workers in or near each LEED-ND project.

1. The number of LEED-certified projects has grown at an annual rate of 115 percent since 2000. The number of LEED professionals has grown at an annual rate of 88 percent since 2001.

Granted, the system is a bit complicated, with 9 prerequisites and 49 credits under which points can be accumulated (in the pilot rating system). Sure, the credits also are a bit arbitrary. Why does a developer get only seven points for limiting drive-alone trips to/from the development to 30 percent or less of all trips (which is almost impossible to achieve), but can earn up to eight points for having walkable streets? Sure, you have to trust the applicant to audit his project accurately. But if all this leads to better development outcomes, who cares? That is the issue to which we now turn.

More Emphasis on Outcomes

In the 1970s, planning curricula included courses in evaluation research, which unfortunately have been dropped in recent years. Planning students learned that input evaluation (a bus stop is on the property) is less useful than output evaluation (buses come with reasonable frequency), and that in turn is less useful than outcome evaluation (bus ridership is up, and auto use is down).

The lead author of this chapter was hired to conduct an outcome-oriented traffic study of the Napa Pipe project, a brownfield redevelopment project in Napa, California (see figures 9.1 and 9.2). It was one of the first certified projects under the LEED-ND pilot program. The developer wanted the study to credit Napa Pipe for trips that stay within the development or for those that leave the development but are environmentally benign because they use alternative modes of transportation. Our traffic impact assessment suggested that about 7 percent of all trips generated by the Napa Pipe development would not congest the external street network or add VMT in the region, either because they would remain within the mixed-use development (MXD) or because they would involve transit or walking to external destinations.

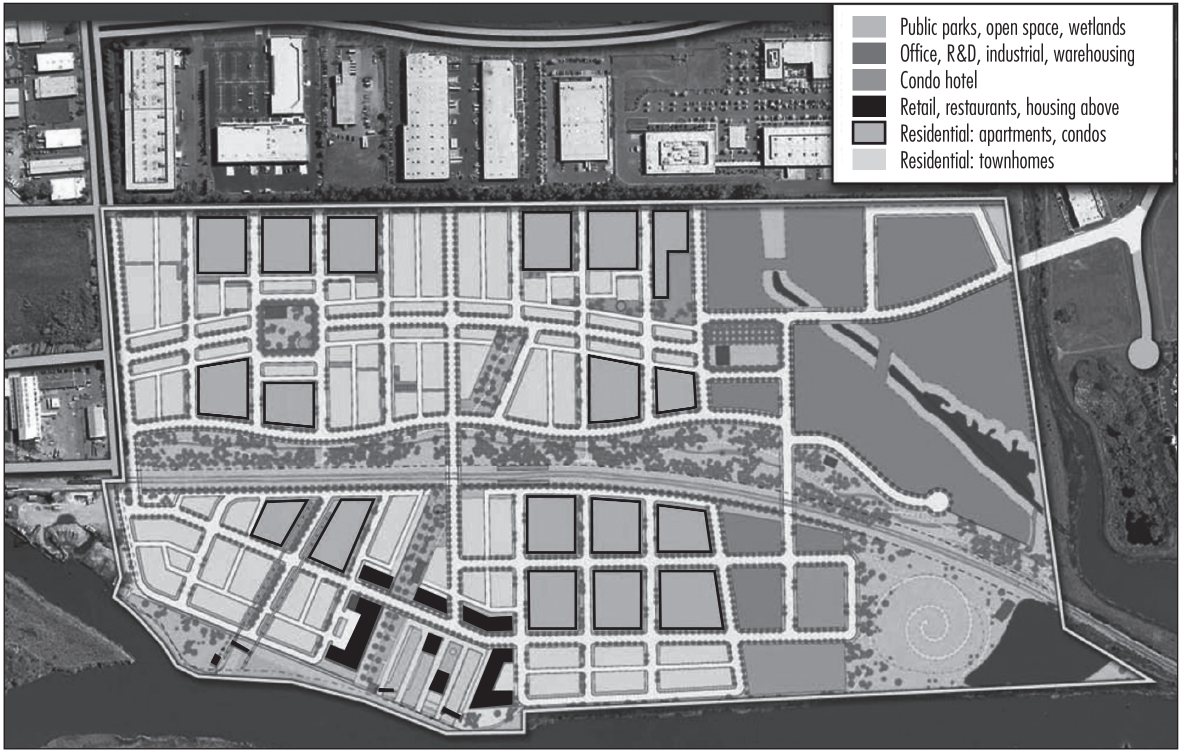
This is the kind of outcome evaluation that should become central to the LEED certification process. How much stronger the program would be if it was built on good outcomes. This study is a step in that direction.

Conceptual Framework

The theory of rational consumer choice underlies this study. That theory is well articulated elsewhere (Boarnet and Crane 2001; Cao, Mokhtarian, and Handy 2009; Cervero 2002; Crane 1996; Zhang 2004). Travel to/from developments is conceived as a series of choices that depend on the "D variables" (see figure 9.3).

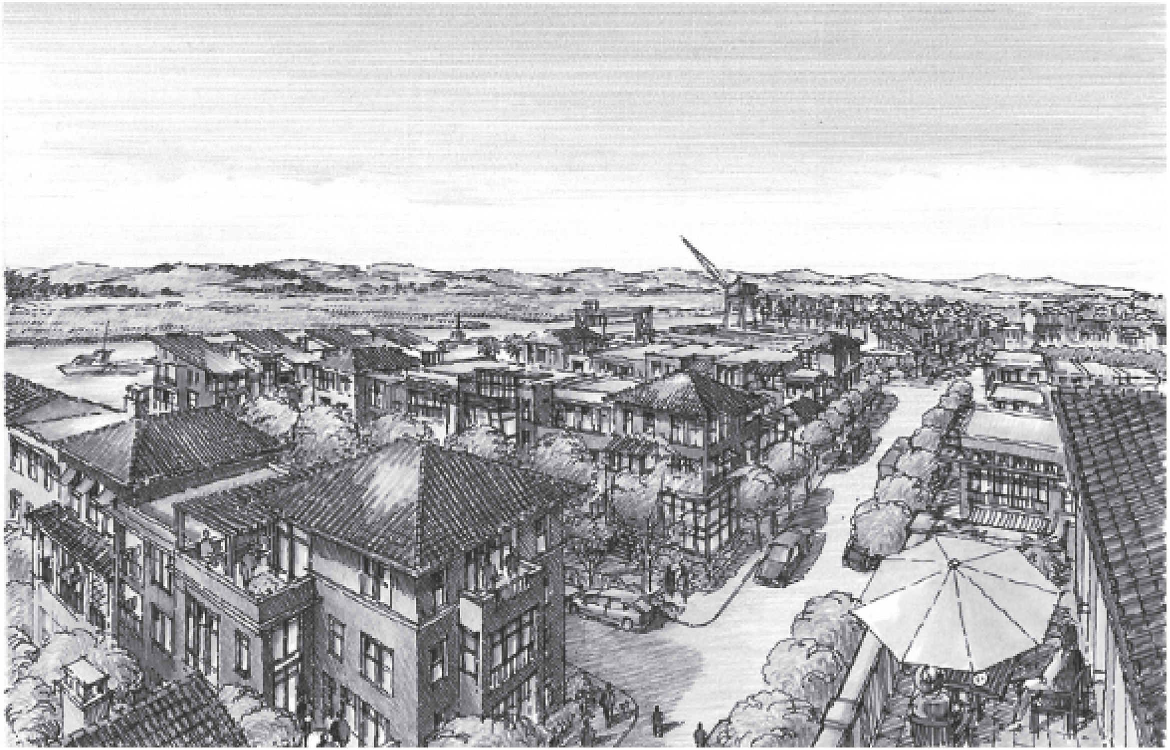
The original three Ds, coined by Cervero and Kockelman (1997), are density, diversity, and design. They were followed by destination accessibility and distance to transit (Ewing and Cervero 2001, 2010). Development scale is a sixth D, relevant to analyses where the unit of analysis is a development project. Though not part of the environment, demographics are the seventh D, controlled as confounding influences in travel studies.

Figure 9.1
Napa Pipe Project Site Plan



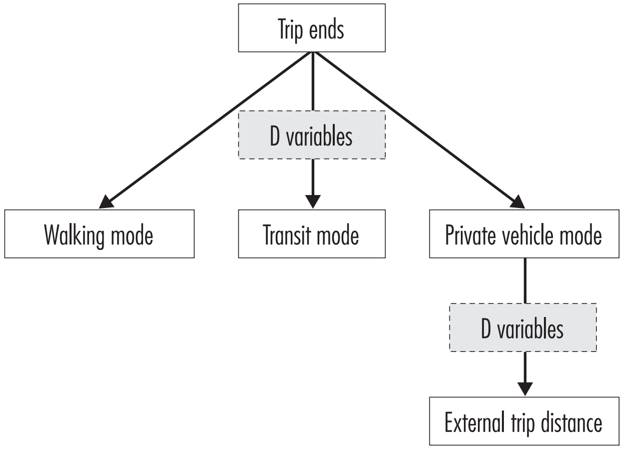
Source: Napa Redevelopment Partners. Reprinted with permission.

Figure 9.2
Artist's Rendering of the Napa Pipe Project



Source: Napa Redevelopment Partners. Reprinted with permission.

Figure 9.3
Conceptual Framework of Study



Mode choices are conceived as dichotomous. A traveler may choose to walk or not. Likewise, the traveler may choose to use transit or not. For private vehicle trips, the traveler chooses a destination, which may be near or far. This outcome variable is continuous rather than dichotomous.

The D variables in figure 9.3 are characteristics of travelers, MXDs, and regions, as defined in the next section. The D variables determine, moderate, mediate, and confound travel decisions.

Modeling Outcomes

A recent study for the U.S. Environmental Protection Agency (EPA) developed new methodology for more accurately predicting the traffic-related impacts of MXDs (Ewing et al., forthcoming). Standard protocols were used to identify and generate data sets for 239 MXDs in six large and diverse metropolitan regions—Atlanta; Boston; Houston; Portland, Oregon; Sacramento; and Seattle.

Data from household travel surveys and geographic information systems (GIS) databases were pooled for these MXDs, and travel and built environmental variables were consistently defined across regions. Hierarchical modeling was used to estimate models for internal capture of trips within MXDs, walking and transit use for external trips, and trip length for external automobile trips.

MXDs with diverse activities on-site were shown to capture a large share of trips internally, reducing their traffic impacts relative to conventional suburban developments. Smaller MXDs in walkable areas with good transit access were found to generate significant shares of walking and transit trips, thus also mitigating traffic impacts. Centrally located MXDs, both small and large, were shown to generate shorter private vehicle trips, which reduces their impacts relative to outlying developments.

Final Samples

The 239 MXDs form our data set for the current study. They range from compact infill sites near the regional core to low-rise freeway-oriented developments. The 239 survey sites range in size from less than 5 acres to more than 2,000 acres, and fewer than 10 to more than 15,000 residents and employees. They vary in population and employment densities, mix of jobs, mix of housing and retail, presence or absence of transit, and centrality within the region.

RiverPlace, a classic MXD just south of downtown Portland, Oregon, is one of the 239 (see figures 9.4 and 9.5). Of the sampled trips, 40 percent are by walking and 5 percent by transit, well above the regional averages. The development's

Figure 9.4
RiverPlace in Context

Source: Google Maps. © 2011 Google – Imagery, © 2011 TerraMetrics Map data, © 2011 Google – Terms of Use.

Figure 9.5
RiverPlace at Eye Level

auto trips average 7.15 miles, well below the regional average. On balance, the traffic impact of RiverPlace is a fraction of that generated by single-use suburban developments of comparable composition and size.[2]

Outcome Variables

Because the purpose of the present study is different from that of the earlier study (Ewing et al., forthcoming)—it is not about the internal capture of trips within MXDs—we went back to the original database of 35,877 trip ends to/from/within the 239 MXDs in the six regions. Using these data, we modeled three outcomes: odds of trips being by walking, odds of trips being by transit, and length of trips by private vehicle (see table 9.2). These three variables together allow us to predict the average VMT per trip for the LEED-ND pilot projects and compare it to the baseline VMT of conventional developments.

2. According to the National Household Travel Survey of 2009, 14 percent of Portland's trips are by walking, and 2 percent are by transit. The average vehicle trip length in the Portland consolidated metropolitan statistical area is 8.9 miles.

Table 9.2
Variable Definitions

Outcome Variables	
WALK	Dummy variable indicating that the travel mode is walking (1 = walking mode; 0 = other).
TRANSIT	Dummy variable indicating that the travel mode is public bus or rail (1 = transit; 0 = other).
TDIST	Network trip distance between origin and destination locations for an external private vehicle trip, in miles.
Explanatory Variables	
Level 1: Traveler/Household	
HHSIZE	Number of members of the household.
VEHCAP	Number of motorized vehicles per person in the household.
BUSSTOP	Dummy variable indicating that the household is within one-quarter mile of a bus stop (1 = yes; 0 = no).
Level 2: Mixed-Use Development (MXD)	
AREA	Gross land area of the MXD, in square miles.
POP, EMP, ACT	Resident population, employment, and activity (population + employment) within the MXD.
ACTDEN	Activity density per square mile within the MXD. Sum of population and employment within the MXD, divided by gross land area.
JOBPOP	Index that measures balance between employment and resident population within the MXD. Index ranges from 0, where only jobs or residents (not both) are present in an MXD, to 1, where the ratio of jobs to residents is optimal from the standpoint of trip generation. Value is intermediate when the MXD has both jobs and residents, but one predominates.[a]
LANDMIX	Another diversity index that captures the variety of land uses within the MXD. Entropy calculation based on net acreage in land use categories likely to exchange trips. For Portland, the land uses were residential, commercial, industrial, and public or semipublic.[b] For other regions, the categories were slightly different.[c] The entropy index varies in value from 0, where all developed land is in one of these categories, to 1, where developed land is evenly divided among these categories.

(continued)

Table 9.2
(continued)

INTDEN	Number of intersections per square mile of gross land area within the MXD.
POP1MI, EMP1MI, ACT1MI	Population, employment, and activity (population + employment) within one mile of the MXD centroid. Weighted average for all traffic analysis zones (TAZs) intersecting the MXD. Weighting was done by proportion of each TAZ within the MXD boundary relative to an entire TAZ area (i.e., "clipping" the block group with the MXD polygon).
POP5MI, EMP5MI, ACT5MI	Proportion of regional population, employment, and activity (population + employment) within five miles of the MXD centroid.
POP10MI, EMP10MI, ACT10MI	Proportion of regional population, employment, and activity (population + employment) within 10 miles of the MXD centroid.
EMP10A, EMP20A, EMP30A	Proportion of regional employment accessible within 10-, 20-, and 30-minute drive times of the MXD using an automobile at midday.
EMP30T	Proportion of regional employment accessible within 30-minute travel time of the MXD using transit.
STOPDEN	Number of transit stops within the MXD per square mile of land area. Uses 25-foot buffer to catch bus stops on periphery.
RAILSTOP	Rail station located within the MXD (1 = yes; 0 = no). Commuter, metro, and light-rail systems are all considered.
Level 3: Region	
REGPOP, REGEMP, REGACT	Population, employment, and activity (population + employment) within the region.
SPRAWL	Measure of regional sprawl developed by Ewing, Pendall, and Chen (2003). Index derived by extracting the common variance from multiple measures through principal components analysis.

[a] JOBPOP = 1 – [ABS (employment – 0.2 × population)/(employment + 0.2 × population)].
[b] The entropy calculation is: LANDMIX = – [single-family share × LN (single-family share) + multifamily share × LN (multifamily share) + commercial share × LN (commercial share) + industrial share × LN (industrial share) + public share × LN (public share)]/LN (5), where LN is the natural logarithm of the value in parentheses.
[c] For Houston, the land uses were residential, commercial, industrial, and institutional; a "mixed residential and commercial" class of land uses was included with commercial. For Boston, the land uses were residential, commercial, industrial, and recreational. For Seattle, Atlanta, and Sacramento, detailed land uses were aggregated into four categories: residential, commercial, industrial, and institutional; a mixed class of land uses was included with commercial.

Models were estimated separately by trip purpose—home-based work, home-based other, and non-home-based. We presume that different factors might be at play, or that the same factors might be more or less important, when people travel for different purposes.

Explanatory Variables

Density is always measured as the variable of interest per unit of area. The area can be gross or net, and the variable of interest can be population, dwelling units, employment, building floor area, or something else. Population and employment are sometimes summed to compute an overall activity density per areal unit.

Diversity measures pertain to the number of different land uses in a given area and the degree to which they are represented in land area, floor area, or employment. Entropy measures of diversity, wherein low values indicate single-use environments and higher values more varied land uses, are widely used in travel studies. Jobs-to-housing or jobs-to-population ratios are less frequently used.

Design includes street network characteristics within an area. Street networks vary from dense urban grids of highly interconnected, straight streets to sparse suburban networks of curving streets forming loops and lollipops. Measures include average block size, proportion of four-way intersections, and number of intersections per square mile. Design is also occasionally measured as sidewalk coverage (share of block faces with sidewalks); average building setback; average street width; or number of pedestrian crossings, street trees, or other physical variables that differentiate pedestrian-oriented environments from auto-oriented ones.

Destination accessibility measures ease of access to trip attractions. It may be regional or local (Handy 1993). In some studies, regional accessibility is simply distance to the central business district. In others, it is the number of jobs or other attractions reachable within a given travel time, which tends to be highest at central locations and lowest at peripheral ones. The gravity model of trip attraction measures destination accessibility. Local accessibility is a different animal. Handy (1993) defines local accessibility as distance from home to the closest store.

Distance to transit is usually measured as an average of the shortest street routes from the residences or workplaces in an area to the nearest rail station or bus stop. Alternatively, it may be measured as transit route density, distance between transit stops, or number of stations per unit area.

Development scale may be measured in terms of land area, number of residents, number of jobs, or the sum of residents and jobs, referred to as the "activity level." Development scale was the most significant influence on internal capture rates in a study of South Florida MXDs, and more than half of all trips were found to be internalized by community-scale MXDs (Ewing, Dumbaugh, and Brown 2001).

The independent variables available in this study are shown in table 9.2. These variables are at three different levels of aggregation: level 1 = traveler/

household; level 2 = MXD; and level 3 = region. They are consistently defined across regions.

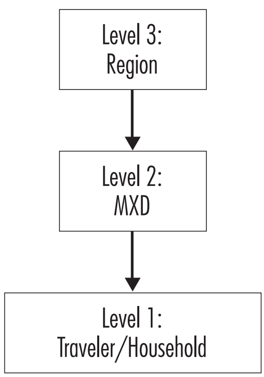
Analysis

For walking and transit trips, our dependent variable is the log of the odds of an individual making a trip by these modes. For these outcomes, models were estimated with both linear and logarithmic values of the independent variables. The logarithmic models, which express the odds as a power function of the independent variables, outperform the linear models in terms of their pseudo-R^2s, sensitivity to changes in values of independent variables, and validation results (Ewing et al., forthcoming). Thus, only the logarithmic models are presented in this chapter. Coefficient values are arc elasticities of odds with respect to the independent variables.

For estimating the trip distance by automobile, the models took three forms: linear, semilogarithmic (linear-log), and log-log. The semilogarithmic models, which express trip distance as a linear sum of logged variables, outperform the other models in terms of their pseudo-R^2s and sensitivity to changes in values of independent variables. Only the semilogarithmic models are presented in this chapter.

Our data and model structure are hierarchical (see figure 9.6). Hierarchical modeling is required to account for dependence among observations, in this case the dependence of trips to/from a given MXD and the dependence of MXDs within a given region. All the trips to/from a given MXD share the characteristics of the MXD—that is, they are dependent on these characteristics. This dependence violates the independence assumption of ordinary least squares (OLS)

Figure 9.6
Data and Model Structure of Study



regression. Standard errors of regression coefficients based on OLS will consequently be underestimated. Moreover, OLS coefficient estimates will be inefficient. Hierarchical (multilevel) modeling overcomes these limitations, accounting for the dependence among observations and producing more accurate coefficient and standard error estimates (Raudenbush and Bryk 2002).

Models were estimated with HLM 6 (Hierarchical Linear and Nonlinear Modeling) software. Hierarchical linear models were estimated for the continuous outcome (trip distance), while hierarchical nonlinear models were estimated for the dichotomous outcomes (walking versus other, and transit versus other). Within a hierarchical model, each level in the data structure is formally represented by its own submodel. The submodels are statistically linked.

Results

Results of three model estimations are presented in tables 9.3–9.5. Each table includes model coefficient estimates, asymptotic t-ratios, and probability values (p-values) for the t-ratios.

ODDS OF WALKING

For home-based work trips, the odds of walking decline with household size and vehicle ownership per capita, and increase with job-population balance within the MXD and number of residents + jobs within one mile of the MXD (see table 9.3). Walking is thus related to three types of D variables—diversity, destination accessibility, and demographics. Large households achieve economies through carpooling and trip chaining, and thus are less likely to walk. Households with more cars have a lower generalized cost of auto use, making them less likely to walk. On-site balance of jobs and housing creates opportunities for matching origins and destinations, producing short trips that are amenable to walking. The presence of off-site jobs and housing within one mile likewise creates opportunities for matching origins and destinations, still within walking distance. The pseudo-R^2 of this model is a relatively low 0.12.

For home-based other trips, the odds of walking decline with household size and vehicle ownership, and increase with job-population balance within the MXD and number of residents + jobs within one mile of the MXD. In addition, the odds of walking increase with intersection density within the MXD.[3] Walking is thus related to four types of D variables—diversity, design, destination accessibility, and demographics. High intersection density increases routing options, makes routes more direct, creates frequent street-crossing opportunities, and makes trips seem more eventful. The pseudo-R^2 of this model is a respectable 0.39.

---

3. For projects falling within a single block, the intersection density of the quarter-mile buffer was used instead.

Table 9.3
Odds of Walking (log-log)

	Home-Based Work			Home-Based Other			Nonhome-Based		
	Coeff.	t-ratio	p-value	Coeff.	t-ratio	p-value	Coeff.	t-ratio	p-value
Constant	–10.26			–11.84			–12.45		
JOBPOP	0.283	2.84	0.005	0.153	2.60	0.01			
INTDEN				0.440	2.77	0.006	0.815	5.28	<0.001
EMP1MI							0.570	6.84	<0.001
ACT1MI	0.719	4.01	<0.001	0.674	6.23	<0.001			
HHSIZE	–1.50	–7.22	<0.001	–0.805	–11.4	<0.001	–0.221	–3.47	0.001
VEHCAP	–1.93	–8.61	<0.001	–0.862	–11.1	<0.001	–0.220	–3.27	0.001
Pseudo-R^2	0.12			0.39			0.45		

For nonhome-based trips (neither trip end is at home), the odds of walking decline with household size and vehicle ownership, and increase with intersection density within the MXD and number of jobs within a mile of the MXD. The relationship to employment results from the greater probability of matching origins to destinations where jobs are concentrated near one another. Walking is related to three types of D variables—design, destination accessibility, and demographics. Possible explanations for these relationships were provided earlier. The pseudo-R^2 of this model is 0.45, the highest of any model estimated.

Although there is significant variance of walking from region to region, it is not explained by the variables in our data set. None of the level 3 variables proved significant, which is not surprising with only six regions. Regional variance is, however, captured in the random effects term of the level 3 equation.

ODDS OF TRANSIT USE

In our earlier study (Ewing et al., forthcoming), we modeled transit use in terms of number of jobs that can be reached within 30 minutes by transit. This indicator was derived from regional travel models for the six regions and was available for the 239 MXDs in our sample.

In this study, we requested the same indicator from the LEED-ND pilot projects being evaluated. None was able to provide transit accessibility data. Therefore, we selected a proxy for transit accessibility that, for the 239 MXDs, is highly correlated with the number of jobs reachable within 30 minutes by transit. That proxy is the number of jobs within 10 miles of a site. It implies an average transit travel speed of 20 mph, with stops for passengers. This became our measure of destination accessibility.

For home-based work trips, the odds of transit use decline with household size and vehicle ownership per capita; increase with intersection density within the MXD and number of jobs within 10 miles of the site; and are higher for MXDs with rail stations within them (see table 9.4). The odds of transit use are significantly higher for households within one-quarter mile of a bus stop than for those farther away. Transit use is thus related to four types of D variables—design, destination accessibility, distance to transit, and demographics. A higher intersection density translates into a more direct walk to and from transit stops, and also possibly more efficient routing of transit vehicles. A higher proportion of jobs within 10 miles increases the likelihood of a particular job being within easy commuting distance for residents. And residence within the standard quarter-mile walking distance of a bus stop or proximate to a rail station shortens access trips. The pseudo-R^2 of this model is 0.37.

For home-based other trips, the odds of transit use decline with household size and vehicle ownership per capita, and increase with the activity density within the MXD. The odds of transit use are significantly higher for households within one-quarter mile of a bus stop than for those farther away. This is a weak model. The pseudo-R^2 of this model is a negative number, since the combined variance at levels 1 through 3 is greater for the estimated model than the null model with only an intercept and no explanatory variables.

For nonhome-based trips, the odds of transit use decline with vehicle ownership per capita and increase with the proportion of jobs within 10 miles of the MXD. This is the weakest model estimated. The pseudo-R^2 of this model also is a negative number.

Regarding these negative pseudo-R^2s, a pseudo-R^2 is not entirely analogous to R^2 in linear regression, which can assume only positive values. One standard text

Table 9.4
Odds of Transit Use (log-log)

	Home-Based Work			Home-Based Other			Nonhome-Based		
	Coeff.	t-ratio	p-value	Coeff.	t-ratio	p-value	Coeff.	t-ratio	p-value
Constant	–8.04			–6.46			–3.67		
ACTDEN				0.249	2.09	0.037			
INTDEN	0.989	3.63	0.001						
EMP10MI	1.02	2.22	0.027				0.532	2.86	0.005
RAILSTOP	0.759	1.95	0.052						
HHSIZE	–1.09	–6.04	<0.001	–0.837	–7.53	<0.001			
VEHCAP	–1.62	–8.25	<0.001	–1.07	–8.83	<0.001	–0.299	–3.33	0.001
BUSSTOP	0.356	1.99	0.046	0.396	3.44	0.001			
Pseudo-R^2	0.37			n.a.			n.a.		

on multilevel modeling notes that the variance can increase when variables are added to the null model (Kreft and de Leeuw 1998, 119). It goes on to say: "This is counter-intuitive, because we have learned to expect that adding a variable will decrease the error variance, or at least keep it at its current level. . . . In general, we suggest not setting too much store by the calculation of [pseudo-R^2s]." For more discussion of negative pseudo-R^2s, see Snijders and Bosker (1999).

While there is significant variance in transit use from region to region, it is not explained by the variables in our data set. Again, none of the level 3 variables proved significant. Regional variance is, however, captured in the random effects term of the level 3 equation.

LENGTH OF PRIVATE VEHICLE TRIPS

For home-based work trips by private vehicle, trip distance increases with household size and vehicle ownership per capita, and declines with intersection density and proportion of jobs reachable within 30 minutes by private vehicle (automobile) (see table 9.5). Trip distance is thus related to three types of D variables—design, destination accessibility, and demographics. Larger households have more complex activity patterns, which lengthens trips. More vehicles per household frees up family cars for trips to more distant destinations. MXDs with high intersection density provide more direct routing to destinations. MXDs with good auto accessibility to regional jobs generate shorter trips because more trip attractions are within easy commuting distance. These relationships match expectations. We note, however, that the model fit is relatively weak, with a pseudo-R^2 of just 0.08.

For home-based other trips by private vehicle, trip distance increases with household size and vehicle ownership per capita, and declines with job-population

Table 9.5
Length of Private Vehicle Trips (semilog)

	Home-Based Work			Home-Based Other			Nonhome-Based		
	Coeff.	t-ratio	p-value	Coeff.	t-ratio	p-value	Coeff.	t-ratio	p-value
Constant	11.40			3.69			8.19		
JOBPOP				–0.475	–3.26	0.002			
LANDMIX							–1.09	–3.84	<0.001
INTDEN	–1.09	–2.29	0.023				–0.912	–2.36	0.019
EMP20A				–0.702	–4.99	<0.001	–0.804	–5.72	<0.001
EMP30A	–0.811	–4.39	<0.001						
HHSIZE	2.95	8.79	<0.001	0.937	6.44	<0.001	0.628	3.53	0.001
VEHCAP	2.78	7.38	<0.001	1.50	9.71	<0.001	0.968	5.33	<0.001
Pseudo-R^2	0.08			0.04			0.09		

balance and proportion of jobs reachable within 20 minutes by automobile. Trip distance is thus related to three types of D variables—diversity, destination accessibility, and demographics. MXDs with good job-population balance capture some nonwork trips internally, and those with good auto accessibility generate shorter external trips. All relationships are highly significant, but the pseudo-R^2 is only 0.04.

For nonhome-based trips by private vehicle, trip distance increases with household size and vehicle ownership per capita, and declines with land use entropy, intersection density, and proportion of jobs reachable within 20 minutes by automobile. Trip distance is thus related to four types of D variables—diversity, design, destination accessibility, and demographics. The new variable, land use entropy, measures the mix of land uses within the site. Greater mix is associated with shorter nonhome-based trips. Other relationships are as described above. The pseudo-R^2 is 0.09.

Although there is significant variance in private vehicle trip length from region to region, it is not explained by the variables in our data set. Again, none of the level 3 variables proved significant. Regional variance is, however, captured in the random effects term of the level 3 equation.

Evaluating LEED-ND Pilot Projects

This section applies the models derived in the preceding section to a set of LEED-ND pilot projects. We begin by describing how these particular projects were recruited to participate in the evaluation and how data were collected from and for them. Then we profile each project in qualitative terms. Finally, we use the project data to predict travel outcomes.

PROJECT RECRUITMENT AND DATA COLLECTION

USGBC staff first contacted the project teams of certified LEED-ND projects in early December 2009. On that date, 56 projects had completed the full review process at one of the three certification stages: Stage 1, preapproval; Stage 2, certified plan; and Stage 3, certified completed neighborhood development. In that correspondence, staff explained that the authors of this chapter intended to analyze the potential reduction in VMT and the energy and CO_2 savings of the certified projects relative to a regional average baseline. The project teams were told that the authors would need input data on population density, land use mix, intersection density, and other planning parameters in order to evaluate the projects with a traffic impact analysis method previously developed for the EPA.

Ultimately, teams from 19 projects agreed to supply the authors with this information. In February 2010, we contacted the project teams with a standard e-mail request for a project narrative, a LEED scorecard, and project data to implement the models described in the previous section. We received responses from six projects. After a second e-mail reminder two weeks later, we received an additional seven responses, resulting in a 68 percent response rate among those agreeing to participate.[4]

After sorting the data, we identified missing or inaccurate information. In some cases, the project did not have data for the requested element. In other cases, a request had been misinterpreted, and the data provided were unusable. In these cases, follow-up efforts were made to clarify the request and obtain the relevant data. For projects currently under development, follow-up requests frequently sought to clarify the number of employees expected for different business uses (office, retail, etc.) on the site. These data proved difficult to obtain, as forecasts were not always available in a consistent format.

Project representatives provided most of the data after either the initial or the follow-up request, but few could provide data for a number of variables, such as vehicle ownership per capita in the project area, total employment within one mile of the project, and total employment within certain automobile and transit travel times. For these variables, we used other sources to obtain the relevant values. To estimate the number of vehicles per person in each project area, we consulted U.S. Census 2000, Form 3, Imputation of Vehicles Available, utilizing data for the census tracts most closely corresponding to the project site's boundaries. For each tract, we divided the number of vehicles by population to obtain vehicle ownership per capita for the area.

For employment and population within time and distance bands, we went to an outside contractor, the Environmental Systems Research Institute (Esri). Through the Esri Business Analyst Online service, we obtained employment and population numbers for the desired buffers. A buffer in GIS is a zone around a map feature measured in units of distance or time. This service proved highly functional for our purposes, as it offers the option to create buffers around a given location based on either mileage or drive time. First, we identified the number of employees and residents within one mile of each project. To do so, we set a boundary with a one-mile radius around the site, ordering a Business Summary report for the area within the boundary. This report provided population, employment, and number of businesses within various business categories.

Next, we created buffers based on 10-, 20-, and 30-minute drive times from the center of each project. Business Analyst Online offers drive-time buffers as an option when defining the geographic area of analysis. We ordered a Business Summary report for the area, and then used the report to identify the number of employees within each buffer, as well as the population.

Finally, we created a boundary with a 10-mile radius around each site, again ordering a Business Summary report for the area thus defined. We used the number of employees within 10 miles to approximate the number of employees within

4. One project is located in Canada and could not be included for lack of complete input data. Hence the final sample consisted of 12 U.S. projects.

30 minutes by transit. We had previously determined that the two variables are correlated.

PROJECT PROFILES

Following are brief descriptions of the 12 U.S. projects that volunteered to participate in this evaluation.

Constitution Square is located in NoMa (north of Massachusetts Avenue), a rapidly developing neighborhood of Washington, DC. The first phase of construction, totaling 1.6 million square feet over 4.4 acres, was completed in 2010. The mixed-use project will have offices, a grocery store and additional retail space, 440 apartment units, and a Hilton Garden Inn hotel. Located next to the New York Avenue Metro station, it will meet the growing need for office space in the area.

Easy access from downtown Washington, DC, makes *Crystal City* a prime location for residential and commercial development. This area of Arlington, Virginia, is undergoing revitalization after the relocation of thousands of Department of Defense jobs. The Crystal City Vision Plan outlines a 260-acre MXD that will increase density and sustainability and create connections with the local transportation system. The plan includes redeveloped buildings, a new surface transitway, parks, plazas, street improvements, and street-front retail space to enhance Crystal City's neighborhoods.

Decker Walk is a 0.4-acre development in an urban neighborhood of Baltimore consisting of 19 contiguous two- and three-story row houses. The central location will allow residents to take advantage of the existing infrastructure, services, and amenities of the surrounding area. Most notably, the site is just a few blocks from Patterson Park, a popular 155-acre park east of downtown. Innovative row house design will lower utility costs through efficient heating, cooling, water, and electrical systems. Unlike standard new construction, these homes take advantage of existing masonry walls (built in 1920), thereby reducing the cost of materials and increasing the building's thermal performance. The walls that originally divided the backyards have been removed to create an expansive communal space.

Hercules Bayfront is a 40-acre infill urban development in Hercules, California. It is located adjacent to San Francisco Bay on the site of an old dynamite factory and incorporates multiple historical buildings. When complete, the project will be a pedestrian- and transit-oriented neighborhood, where water ferry, commuter and regional rail, and bus service will be available to residents and the surrounding community at a single Intermodal Transit Station. The new development will include approximately 1,392 new residential units; 115,000 square feet of office space; 90,000 square feet of retail space; and 134,000 square feet of flex space. The project calls for a traditional town center, with shops, galleries, cafés, and arcades along Bayfront Boulevard, as well a mixed residential and commercial area known as The Village. It also will involve major rehabilitation of a creek and riparian area running through the site and the creation of multiple new parks, plazas, and access points to the adjacent San Francisco Bay Trail.

The *MacArthur BART Transit Village* is an 8.2-acre redevelopment of the property adjacent to the MacArthur BART (Bay Area Rapid Transit) Station in Oakland, California. The station is located at the geographic center of the San Francisco Bay Area, serving as a major transportation hub within Alameda County. Once complete, the village will provide 624 new housing units, including market-rate home ownership and first-time buyer opportunities; 90 affordable apartments for families; a child-care center; 40,000 square feet of ground-floor commercial space; and a new BART parking garage. The project also will include a redevelopment of the existing BART Plaza and improved streets with new sidewalks, streetscapes, and traffic signals.

Mueller is located on 711 acres previously occupied by the Austin, Texas, airport. Upon completion, the mixed-use urban village will accommodate approximately 10,000 residents; 10,000 permanent employees; more than 1,100 affordable homes; and approximately 140 acres of public open space and greenways. The town center will have cafés, shops, and plazas; at least 30 percent of the businesses will be locally owned. The first phase of construction began in 2006, and the second phase of construction began in the summer of 2008. Located three miles from downtown Austin and two miles from the University of Texas at Austin, Mueller has become a popular location for diverse and affordable residential development. A number of large research facilities and businesses also have relocated to Mueller. Twenty percent of the project site is reserved for parks and open space, including a trail system; each residence will be located within 600 feet of open space.

The *Napa Pipe* redevelopment is a mixed-use neighborhood on a former World War II industrial site located three miles from downtown Napa, California. The 150-acre site includes 50 acres of residential land, 50 acres of open space, and additional nonresidential space for light-industrial, research-and-development, and commercial use (local artisans, restaurants, and office space). Community facilities will include a boathouse, a transit center, a school, a hospital, senior housing, a café, a theater, and an area reserved for parks and wetlands.

The *SALT District* project is a 156-acre neighborhood retrofit effort situated in the Near Westside neighborhood of Syracuse, New York. It is the first neighborhood retrofit effort in the United States to achieve any stage of LEED-ND certification. The LEED-ND process was used to inform an evaluation and plan for an existing area. The study area began with many attributes that are rewarded in the LEED-ND rating system, such as an infill location and a diversity of uses, but it was missing many other important characteristics, such as green infrastructure and full street-network connectivity. The initial assessment of the study area found that it was five credit points short of receiving basic certification. Plans, therefore, were changed to provide improved connectivity (new pedestrian paths, bike lanes, and streets), green building strategies, more transit facilities, and open space. With these changes, the SALT District moved from noncertifiable to gold certification in the LEED system.

Solea is a 0.36-acre mixed-use, mixed-income project in Washington, DC, with for-sale living and work space above 5,000 square feet of retail and commercial space. It will serve as a gateway connecting Shaw, a historically significant neighborhood, and Columbia Heights, the most ethnically diverse neighborhood in Washington. Affordable residential units will be dispersed throughout the building in a range of unit sizes to accommodate low- and moderate-income individuals, families, and seniors in the rapidly gentrifying area.

Station Park Green is a transit-oriented MXD in San Mateo, California. The 12-acre site will accommodate nearly 600 households; 60,000 square feet of retail space; and 10,000 square feet of office space. Consultants, city planning staff, and the community of San Mateo relied on extensive public workshops and meetings to create the development plan. As a result, Station Park Green will include parks and greenways, community facilities, and a walkable street grid connecting public spaces. Furthermore, the community's building massing and articulation emphasize public safety while furthering solar access and climate goals.

Symphony Park, a new 61-acre development destined to become the cultural and artistic center of southern Nevada, is located just a few miles north of downtown Las Vegas. Transforming a brownfield site into a vibrant, sustainable urban neighborhood, the redevelopment project is planned as a pedestrian-oriented, mixed-use urban center with 1.8 million square feet of office/medical space; 4.5 million square feet of residential space; two new nongaming hotels; one casino/hotel/retail center; 475,000 square feet of street-level retail space; and a new 379,000-square-foot performing arts center. All of the buildings, including the Smith Center for the Performing Arts, will be required to achieve LEED certification. The David Schwarz–designed Smith Center is now under construction and aims to be the first performing arts center of its size to achieve silver LEED certification. Upon completion, Symphony Park will provide an estimated 14,110 jobs and generate $1.8 billion in annual spending.

Tassafaronga, situated on 7.5 acres on the south side of Oakland, California, is a new pedestrian- and transit-oriented neighborhood with 179 affordable housing units near green pathways, pocket parks, and open spaces. All of the buildings in this redevelopment of an industrial area have been designed to LEED's highest level of green standards, platinum, incorporating solar power for on-site generation of electricity and hot water. A defunct pasta factory and parcel of unused industrial land will be reclaimed to create small, affordable apartments and a medical facility including an AIDS clinic. Many of the existing structures will be refurbished, and much of the demolished building material will be recycled into the new structures.

TRANSPORTATION BENEFITS

A singular and somewhat controversial feature of LEED-ND projects is that they must be in a "smart location." The stated intent of this prerequisite is

- to encourage development within and near existing communities or public transportation infrastructure; and
- to reduce vehicle trips and VMT and support walking as a transportation choice.

Smart location options defined in the pilot version of the LEED-ND rating system are as follows:

- Locate the project on an infill site.
- Locate the project near existing or planned adequate transit service so that at least 50 percent of dwelling units and business entrances within the project are within one-quarter mile walking distance of a bus or streetcar stop or within one-half mile walking distance of a rapid bus stop, light- or heavy-rail station, or ferry terminal.
- Locate the project near existing neighborhood shops, services, and facilities so that the project boundary is within one-quarter mile walking distance of at least four diverse uses or within one-half mile walking distance of at least six diverse uses.
- Locate the project within a region served by a metropolitan planning organization (MPO) and within a transportation analysis zone for which MPO research demonstrates that the average annual home-based and/or nonhome-based rate of VMT per capita is lower than the average annual rate of the metropolitan region as a whole.
- Locate the project within a region served by an MPO and demonstrate through peer-reviewed analysis that the average annual home-based and/or nonhome-based rate of VMT per capita of the project will be lower than the average annual rate shown by MPO research for the metropolitan region as a whole.

LEED-ND also provides credits for neighborhood pattern and design, green building, and innovation and design. Good neighborhood design requires walkable streets, compact development, and a connected and open community. Thus, LEED-ND certification could be expected to result in lower VMT per trip than the regional average, plus higher walking and transit shares of trips.

PREDICTIONS OF TRAVEL OUTCOMES FOR PILOT PROJECTS

To predict travel outcomes, we simply substituted values of the relevant independent variables into the model equations in tables 9.3–9.5.

Results of our calculations are shown in tables 9.6–9.8. The last column in each table provides weighted average values, with weights based on the proportion of metropolitan VMT for different trip purposes. The weights are 21 percent for home-based work travel, 47 percent for home-based other travel, and 32 percent for nonhome-based travel.

As shown in table 9.6, Constitution Square, Decker Walk, and Solea have

Table 9.6
Predicted Walking Share of Trips for LEED-ND Pilot Projects (%)

	Home-Based Work	Home-Based Other	Nonhome-Based	Weighted Avg.
Constitution Square	34.7	18.5	11.6	19.7
Crystal City	3.9	4.6	4.9	4.6
Decker Walk	14.9	15.6	14.5	15.1
Hercules Bayfront	2.5	3.3	2.8	3.0
MacArthur BART	6.8	10.7	11.3	10.1
Mueller	3.1	3.4	2.5	3.1
Napa Pipe	3.1	2.9	4.5	3.5
SALT District	10.7	12.6	18.0	13.9
Solea	13.3	16.8	18.6	16.6
Station Park Green	12.0	16.3	18.7	16.2
Symphony Park	8.5	9.7	12.6	10.4
Tassafaronga	12.7	14.1	10.0	12.5

predicted walking shares greater than 15 percent. These shares are a result of relatively low household size and auto ownership in the vicinity, and relatively high activity density (residents + jobs) within a mile of the site. Station Park Green also has a high predicted walking share, mostly due to high job-population balance and intersection density. At the low end of the scale, Hercules Bayfront, Mueller, and Napa Pipe have predicted walking shares of approximately 3 percent. These low values (compared to other projects) stem mostly from low employment and activity densities within a mile of the site.

Regarding predicted transit shares, displayed in table 9.7, Constitution Square (12.3 percent) and Decker Walk (10 percent) score the highest among the LEED-ND projects. This is a product of relatively low auto ownership in the vicinity, relatively high accessibility to employment, and all residents living within a quarter mile of a bus stop. At the other extreme, Crystal City, Hercules Bayfront, MacArthur BART, Mueller, and Napa Pipe are under 5 percent. These low transit shares result from a combination of relatively high auto ownership, low activity density, low intersection density, and/or low accessibility to employment.

The relatively low predicted transit shares for Crystal City, Hercules Bayfront, and MacArthur BART are a function of model parameters and input values. However, as these developments have rail stations within them, the actual transit shares are likely to be much higher. Recall that while the models estimated for EPA used an exact measure of transit accessibility (jobs reachable within 30 minutes by transit), the models estimated in this study use a proxy measure correlated with transit accessibility (jobs within 10 miles of the project site). Had

Table 9.7
Predicted Transit Share of Trips for LEED-ND Pilot Projects (%)

	Home-Based Work	Home-Based Other	Nonhome-Based	Weighted Avg.
Constitution Square	14.1	18.1	2.5	12.3
Crystal City	4.4	4.5	1.8	3.6
Decker Walk	25.4	8.2	2.4	10.0
Hercules Bayfront	1.8	5.3	0.8	3.1
MacArthur BART	9.2	3.7	1.9	4.3
Mueller	4.3	2.3	2.5	2.8
Napa Pipe	1.2	5.5	0.6	3.1
SALT District	16.0	6.9	2.8	7.5
Solea	12.0	7.9	2.2	7.0
Station Park Green	12.6	5.2	1.2	5.5
Symphony Park	13.7	6.1	2.0	6.4
Tassafaronga	13.0	6.3	1.6	6.2

we had data on transit accessibility for these three sites, predicted transit shares would doubtless have been much higher.

For all projects, we predict relatively low average length of private vehicle trips, at least compared to regional averages (see table 9.8). In general, home-based work trips represent the longest trips, while home-based other trips appear somewhat shorter, followed by nonhome-based trips. It appears that the more urban, centrally located projects exhibit lower average trip lengths. Among the projects, Constitution Square has the shortest weighted average trip length at 3.55 miles, a result of a relatively small average household size, low average auto ownership, and high employment accessibility by automobile. Napa Pipe has the longest weighted average trip length at 5.67 miles, a result of the lowest employment accessibility by automobile.

Table 9.9 shows the predicted VMT per trip for the LEED-ND projects. An approximation of the average VMT per trip was calculated with the following formula:

avg. VMT per trip = (1 – avg. walking share – avg. transit share)
× (avg. private vehicle trip length)

This is not a precise formula, since it doesn't account for bike trips or private vehicle occupancies. Still, it allows a precise comparison of the LEED-ND projects with regional averages computed the same way with National Household Travel Survey (NHTS) data (see table 9.10 in the next section).

Table 9.8
Predicted Average Length of Private Vehicle Trips for LEED-ND Pilot Projects (miles)

	Home-Based Work	Home-Based Other	Nonhome-Based	Weighted Avg.
Constitution Square	3.59	3.71	3.28	3.55
Crystal City	6.92	4.85	4.57	5.19
Decker Walk	2.93	4.83	7.42	5.26
Hercules Bayfront	5.95	5.55	4.65	5.35
MacArthur BART	6.56	4.37	4.04	4.72
Mueller	6.43	4.08	3.87	4.51
Napa Pipe	6.39	5.35	5.66	5.67
SALT District	4.65	4.71	2.87	4.11
Solea	4.51	5.38	3.97	4.74
Station Park Green	4.85	3.69	3.43	3.85
Symphony Park	5.84	4.45	3.54	4.45
Tassafaronga	3.57	4.34	7.69	5.25

Table 9.9
Predicted VMT per Trip for LEED-ND Pilot Projects

	Walking Share (%)	Transit Share (%)	Avg. Private Vehicle Trip Length (miles)	Project VMT per Trip
Constitution Square	19.7	12.3	3.55	2.41
Crystal City	4.6	3.6	5.19	4.77
Decker Walk	15.1	10.0	5.26	3.94
Hercules Bayfront	3.0	3.1	5.35	5.02
MacArthur BART	10.1	4.3	4.72	4.04
Mueller	3.1	2.8	4.51	4.24
Napa Pipe	3.5	3.1	5.67	5.29
SALT District	13.9	7.5	4.11	3.23
Solea	16.6	7.0	4.74	3.62
Station Park Green	16.2	5.5	3.85	3.02
Symphony Park	10.4	6.4	4.45	3.70
Tassafaronga	12.5	6.2	5.25	4.27

In table 9.9, Constitution Square once again stands out, with an exceedingly low approximate VMT per trip of 2.41 miles. Napa Pipe has the highest VMT per trip at 5.29 miles, but even this value is low by the standards of conventional sprawl development. Taken together, the LEED-ND pilot projects appear to generate relatively low VMT per trip.

COMPARISON WITH REGIONAL AVERAGE VALUES

To draw conclusions about the environmental and climate friendliness of the LEED-ND pilot projects, we needed a baseline against which to compare them. An obvious baseline is the regional average VMT per trip. If walking and transit shares in the pilot projects are higher than the regional averages, and if the private vehicle trip lengths are shorter, the average VMT per trip will be lower in the LEED-ND projects than the regional averages. We can then infer that the environmental footprint of the LEED-ND projects will be smaller than the regional average, at least with regard to transportation energy use.

To obtain average walking share and average transit share for each region, we used the Online Analysis Tools feature of the NHTS. Using the Table Designer tool, we accessed the 2009 data and looked at the “Annual person trips (Travel Day PT)” variable. Using this variable, we categorized results for “Transportation mode on travel day trip (TRPTRANS)” based on the variable “MSA/CMSA code for HH (HHC_MSA).”

To obtain average private vehicle trip length, we again used the Table Designer tool for the 2009 data, based on the variable “Average vehicle trip length — Travel Day.” Results for this variable were categorized by the variable “MSA/CMSA code for HH (HHC_MSA).”

Finally, an approximation of the average VMT per trip was calculated with the formula in the previous section.

When comparing VMT per trip for each LEED-ND pilot project with the regional average, the range is from 28 percent of the regional average for Constitution Square to 70 percent for Napa Pipe (see table 9.10). The best explanation that we can propose for these impressive results is that the LEED-ND pilot projects are so urban and so central to their respective regions (with the exception of Napa Pipe) that VMT relative to the regional average is greatly depressed.

COMPARISON WITH LEED-ND CREDIT VALUES

With predicted VMT per trip in hand, we made one final comparison. There is some variance in VMT per trip across the LEED-ND pilot projects and also some variance in LEED-ND credit scores. LEED-ND has four categories within which projects can score points for individual features: smart location and linkage, neighborhood pattern and design, green construction and technology, and innovation and design process. We reasoned that points for features in the first two categories would most directly translate into reductions in vehicular travel. Indeed, when we plotted VMT per trip against credit scores in these two categories, we found a relationship, albeit a weak one, in the expected direction (see

Table 9.10
2009 NHTS Average Transportation Outcomes, by Region

Development	Metropolitan Statistical Area (MSA)	Walking Share (%)	Transit Share (%)	Avg. Private Vehicle Trip Length (miles)	Regional VMT per Trip	Project/ Regional VMT per Trip (%)
Constitution Square	Washington–Baltimore, DC–MD–VA–WV	14.4	5.8	10.98	8.76	27.5
Crystal City	Washington–Baltimore, DC–MD–VA–WV	14.4	5.8	10.98	8.76	54.5
Decker Walk	Washington–Baltimore, DC–MD–VA–WV	14.4	5.8	10.98	8.76	45.0
Hercules Bayfront	San Francisco–Oakland–San Jose, CA	14.2	4.1	9.30	7.59	66.1
MacArthur BART	San Francisco–Oakland–San Jose, CA	14.2	4.1	9.30	7.59	53.2
Mueller[a]	Austin–San Marcos, TX	3.8	3.9	6.47	5.97	n.a.
Napa Pipe	San Francisco–Oakland–San Jose, CA	14.2	4.1	9.30	7.59	69.7
SALT District	Syracuse, NY	n.a.	n.a.	n.a.	n.a.	n.a.
Solea	Washington–Baltimore, DC–MD–VA–WV	14.4	5.8	10.98	8.76	41.3
Station Park Green	San Francisco–Oakland–San Jose, CA	14.2	4.1	9.3	7.59	39.8
Symphony Park	Las Vegas, NV–AZ	n.a.	n.a.	n.a.	n.a.	n.a.
Tassafaronga	San Francisco–Oakland–San Jose, CA	14.2	4.1	9.3	7.59	56.3

[a] Regional averages from the 2005 Austin Activity Travel Survey.

Figure 9.7
VMT per Trip Versus LEED-ND Credit Score

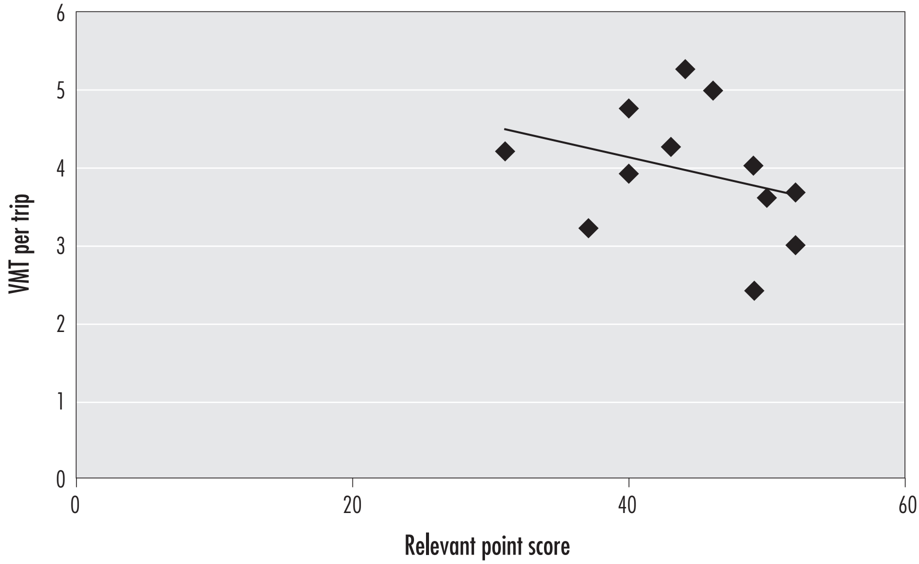


figure 9.7). With the lead author of this chapter sitting on a LEED technical advisory group, and with one of the coauthors working for the U.S. Green Building Council, we certainly have the opportunity to push for changes in the LEED-ND rating system. It seems, however, that the subjectively derived rating criteria are somehow capturing the variance in objectively estimated VMT per trip, at least for this small sample of projects. We would urge that the sample be expanded as the program moves from the pilot phase to full-blown operation.

Conclusions

In summary, we applied models derived from 239 MXDs to 12 LEED-ND pilot projects and found values for walking shares ranging from 3.0 to 19.7 percent of trips; for transit shares from 2.8 to 12.3 percent of trips; and for private vehicle trip lengths from 3.55 to 5.67 miles. In all three metrics, the most urban and centrally located projects tend to perform the best.

We also calculated average VMT per trip. This metric provides a useful measure for comparison with regional values, as projects with walking and transit shares higher than the regional average and private vehicle trip lengths shorter than the regional average can expect lower VMT per trip than the regional average. As such, this metric allows us to infer whether the environmental footprint of LEED-ND projects will be smaller than the regional average with regard to transportation, energy, and carbon emissions. We found that the VMT per trip for all the LEED-ND pilot projects was a fraction of the regional average.

A number of caveats may apply to these surprisingly favorable results. First, this study examined only a small number of self-selected projects. These projects may represent the best of the best, atypical of MXDs generally or even other LEED-ND projects. Second, the study includes several very small projects and two that are essentially single use, whereas the models applied to these projects were developed from a database of larger mixed-use projects. Third, the study lacked precise data for key variables such as auto ownership and employment accessibility by transit. We used general measures of auto ownership from the 2000 census for households in the vicinity of the projects. The census figures used in this study may differ considerably when compared to actual future auto ownership for these projects. Similarly, lack of exact data forced the use of very general measures for employment accessibility. Finally, the low pseudo-R^2 values in the study create an additional potential source of error, reducing accuracy in modeling.

Acknowledging these caveats, this study paves the way for future evaluation of LEED-ND candidate projects. This kind of outcome evaluation should become central to the LEED-ND certification process. When built on a quantifiable expectation of good outcomes, the LEED-ND program will become even stronger.

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