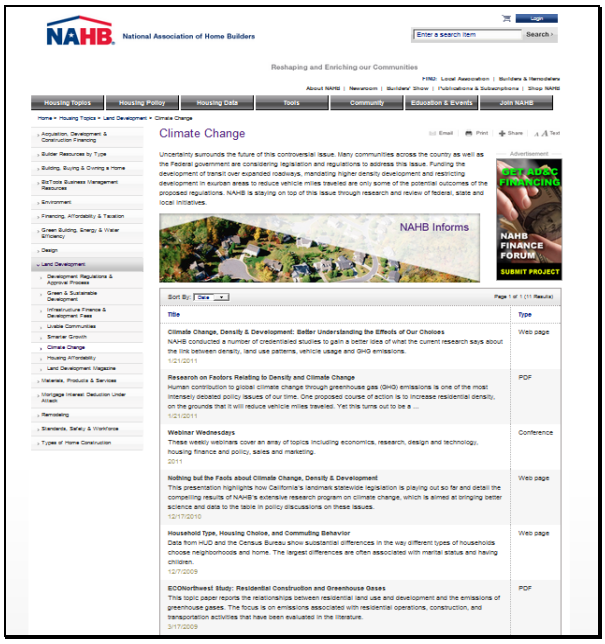
VICTORIA Transport Policy INSTITUTE
EFFICIENCY • EQUITY • CLARITY

www.vtpi.org
Info@vtpi.org
Phone & Fax: 250-360-1560

Critique of the National Association of Home Builders' Research On Land Use Emission Reduction Impacts

5 March 2019

By Todd Litman
Victoria Transport Policy Institute



This screenshot shows the National Association of Home Builders (NAHB) webpage concerning its climate change research which contains the documents evaluated in this report.

Abstract

This report critiques National Association of Home Builders (NAHB) research concerning how various land use factors affect travel activity and pollution emissions, and therefore the impacts and benefits of smart growth policies. The NAHB contends that these impacts and benefits are small, so smart growth is an ineffective emission reduction strategy, but these conclusions are based on misinterpretations of smart growth concepts and inaccurate summations of its own research. These misrepresentations significantly understate smart growth's potential impacts and benefits. Actual *travel impacts* are probably four to eight times greater than the NAHB implies (doubling all land use factors typically reduces affected residents' vehicle travel 20-40%, compared with the 5% indicated), and total *benefits* are far greater due to additional co-benefits ignored in this study. The NAHB actually has good reasons to support smart growth policies that prepare communities for future consumer demands, and provide savings that leave households with more money to spend on housing.

Executive Summary

There is little doubt that land use factors significantly affect travel activity, although there is uncertainty about some details. The current state-of-art can be considered either a glass half-full or half-empty: There is robust theoretical and empirical evidence of the direction of impacts, but current models cannot predict their exact magnitudes.

Studies by major professional organizations indicate that smart growth policies that create more compact communities can achieve various planning objectives, including energy conservation and emission reductions. The National Association of Home Builders (NAHB) sponsored research that investigated current understanding of the relationships between land use, travel activity and emissions, and the value of smart growth policies. The NAHB's summary report includes significant omissions and inaccuracies.

- It presents the most negative results, ignoring the majority of studies which indicate that these relationships are significant and measurable. Most research does *not* support the NAHB's conclusions that, "The existing body of research demonstrates no clear link between residential land use and GHG emissions and leaves tremendous uncertainty as to the interplay of these factors," nor "The assumption of a causal connection between density and GHG emissions is based on prevailing beliefs within the planning community and not on verifiable scientific research or analysis."
- It confuses the concepts of *density* and *compact development*. It argues that the relatively small travel reductions caused by increased *density* (holding all other factors constant) means that *compact development* (a set of land use factors) has minimal impacts and benefits.
- Its review relies excessively on older, often outdated studies and omits more recent and better research which indicates a stronger relationship between land use and transport.
- It reports the lowest impact values rather than the full range of values. It repeatedly claims that the elasticity of vehicle travel with respect to density is only -0.05 (increasing density 10% reduces vehicle travel 0.5%), although most research indicates impacts two to four times greater.
- It highlights the incremental costs of compact development but overlooks its significant co-benefits including infrastructure cost savings, consumer cost savings, improved accessibility for non-drivers, improved traffic safety and public health, and habitat preservation.

In these ways the NAHB significantly understates smart growth's potential impacts and benefits. Actual *travel impacts* are probably four to eight times greater than the NAHB implies (doubling all land use factors typically reduces affected vehicle travel 20-40%, compared with the 5% indicated), and total *benefits* are far greater due to additional economic, social and environmental co-benefits. This is not to deny that smart growth can also impose incremental costs, such as increased infrastructure expenses (for curbs and sidewalks) and smaller size lots. However, these incremental costs should be compared with total incremental benefits, not just air emission reductions.

Some of these inaccuracies may reflect legitimate differences of opinion or simple errors, but some appear to be intentional efforts to misrepresent issues.

Introduction

The disciplines of geography, transport planning and modeling, and urban economics recognize that the land use development factors listed in Table 1, which together are called *urban form*, *built environment*, *community design*, *spatial planning* and *urban geography*, affect travel activity, that is, the amount and type of travel that occurs in an area.

Table 1 **Land Use Factors** (Ewing and Cervero 2010; Litman 2007; Mehaffy 2015)

Factor	Definition	Mechanisms
Regional Accessibility	Location relative to regional centers, jobs or services.	Reduces travel distances between regional destinations (homes, services and jobs).
Density	People, jobs or houses per unit of land area (acre, hectare, square mile or kilometer).	Reduces travel distances. Increases destinations within walking and cycling distances. Increases sidewalk, path and public transit efficiencies. May increase local traffic and parking congestion.
Mix	Proximity of different land uses (residential, commercial, institutional, etc.). Sometimes described as *jobs/housing balance*, the ratio of jobs and residents in an area.	Reduces travel distances between local destinations (homes, services and jobs). Increases the portion of destinations within walking and cycling distances.
Centeredness (centricity)	Portion of jobs, commercial and other activities in major activity centers.	Provides agglomeration efficiencies and increases public transit service efficiency.
Connectivity	Degree that roads and paths are connected and allow direct travel between destinations.	Reduces travel distances. Reduces congestion delays. Increases the portion of destinations within walking and cycling distances.
Roadway design and management	Scale and design of streets, to control traffic speeds, support different modes, and enhance the street environment.	Improves walking, cycling and public transit travel. May improve local environments so people stay in their neighborhoods more.
Parking supply and management	Number of parking spaces per building unit or hectare, and the efficiency with which they are priced and regulated.	Increased parking supply disperses destinations, reduces walkability, and reduces the costs of driving.
Walking and Cycling conditions	Quantity and quality of sidewalks, crosswalks, paths, bike parking, pedestrian security and amenities.	Improves pedestrian and bicycle travel, and therefore public transit access. Encourages more local activities.
Transit accessibility	The degree to which destinations are accessible by high quality public transit.	Improves transit access and supports other accessibility improvements.
Site design	Building and parking facility design.	Improves pedestrian access.

This table describes various land use factors that can affect travel behavior and population health.

An extensive and growing body of research investigates these relationships and the role that *smart growth* (also called *compact development*) policies can play in achieving various planning objectives including infrastructure cost savings, consumer cost savings, improved public safety and health, improved mobility for non-drivers, energy conservation and emission reductions. Studies by major professional organizations and agencies conclude that smart growth can reduce energy consumption and pollution emissions (Ewing, et al. 2007; Kimball, et al. 2013; Nichols and Kockelman 2015; TRB 2009; ULI 2010; USDOT 2010). Based on this research many jurisdictions are adopting smart growth policies.

Smart Growth Strategies (Litman 2008; SGN 2006)

- *Strategic planning.* Establish a comprehensive community vision that guides individual land use and transportation decisions.
- *Create more self-contained communities.* Locate compatible land uses within proximity of each other. For example, develop schools, shops and recreation facilities in or adjacent to residential areas. Mix land uses at the finest grain feasible.
- *Foster distinctive, attractive communities with a strong sense of place.* Encourage urban development that creates a sense of civic pride and community cohesion, including attractive public spaces, high-quality design and maintenance standards, preservation of special cultural and environmental resources, and activities that highlight a community's unique features.
- *Encourage "village" development.* Establish well-defined "urban villages," walkable centers that contain an appropriate mixture of land uses (residential, commercial, institutional, recreational) with distinct names and characters. Reduce minimum lot sizes, building setbacks, minimum parking requirements, and minimum street size particularly around transit and commercial centers.
- *Concentrate activities*. Concentrate commercial activities in these areas. Retain strong downtowns and central business districts. Use access management to discourage arterial strip commercial development.
- *Encourage infill development.* Locate new development within already developed areas. Encourage redevelopment of older facilities and brownfields.
- *Reform tax and utility rates.* Structure property taxes, development fees and utility rates to reflect the lower public service costs of clustered, infill development, and focus economic development incentives to encourage businesses to locate in more accessible locations.
- *Manage parking for efficiency.* Encourage shared parking, parking maximums, and other parking management strategies. Reserve the most convenient parking for rideshare vehicles.
- *Avoid overly-restrictive zoning.* Reduce excessive and inflexible parking and road capacity requirements. Limit undesirable impacts (noise, smells and traffic) rather than broad categories of activities.
- *Create a network of interconnected streets.* Keep streets as narrow as possible, particularly in residential areas and commercial centers. Use traffic management and traffic calming to control vehicle impacts rather than dead ends and cul de sacs.
- *Site design and building orientation.* Encourage buildings to be oriented toward city streets, rather than set back behind large parking lots. Avoid large areas of parking or other unattractive land uses in commercial areas.
- *Improve nonmotorized travel conditions*. Encourage walking and cycling by improving sidewalks, paths, crosswalks, protection from fast vehicular traffic, and providing street amenities (trees, awnings, benches, pedestrian-oriented lighting, etc.).
- *Implement mobility management.* Use mobility management to reduce total vehicle traffic and encourage the use of efficient modes.
- *Encourage mixed housing types and prices.* Develop affordable housing near employment, commercial and transport centers. Encourage secondary suites, apartments over shops, lofts, location-efficient mortgages and other affordable housing innovations.

Some organizations question these conclusions. The National Association of Home Builders (NAHB) sponsored research on the relationships between land use factors, travel activity and pollution emissions (Abt Associates 2010; Fruits 2008 and 2010; Liu 2007; Moore and Kopel-Bailey 2008; Pozdena 2008). Based on this research the NAHB (2010) argues that existing research demonstrates no clear link between residential land use and emissions, the effects of density on travel behavior are modest and uncertain, and smart growth imposes additional costs, so increasing development density will not necessarily deliver expected benefits.

Defining Density, Compact Development, Smart Growth and New Urbanism
Density refers to people, jobs or housing units per unit of land area (acre, hectare, square kilometer or square mile). Density is generally associated with other land use factors including centricity, mix, roadway connectivity, transport diversity (good walking, cycling and public transit service) and efficient parking management. Together these are called *compact development* or *urbanization*. Because density is relatively easy to measure, it is often used as an indicator of this set of factors.

In recent years some studies have tried to isolate the effects of individual land use factors (CARB 2010-11; Ewing and Cervero 2010). This research indicates that density itself has only modest travel impacts. It is possible for relatively dense regions to be automobile dependent if they lack centricity, mix, connectivity, modal diversity, and efficient parking management (Eidlin 2010).

Smart growth refers to land use development policies that result in more compact development. *New urbanism* generally refers to smart growth policies implemented at the local or site scale.

These conclusions reflect significant inconsistencies and confusion. The analysis sometimes refers to *density* by itself (holding all other factors constant), in other cases it refers to *compact development*, which refers to a set of factors, as defined in the box above. The NAHB's analysis also tends to consider just one objective, climate change emission reductions, while overlooking other potential smart growth benefits, as summarized in Table 2.

Table 2 **Smart Growth Benefits** (Burchell, et al, 2005; Litman, 2005)

Economic	Social	Environmental
Infrastructure and service cost savings	Improved accessibility options, particularly for nondrivers	Greenspace and wildlife habitat preservation
Transportation cost savings	Improved housing options	Energy conservation
Economies of agglomeration	Community cohesion	Air and water emission reductions
More efficient transportation	Public fitness and health	Reduced "heat island" effects

This report critiques the NAHB's research and the legitimacy of its conclusions. It describes and summarizes the five background papers, and evaluates the NAHB's summary report.

Analysis of Five NAHB Background Reports

Abt Associates (2010)

Abt Associates' report, *Research on Factors Relating to Density and Climate Change* includes a systematic review of literature concerning land use impacts on climate change emissions. Although the report title only refers to *density* it evaluates various land use factors. It concludes that smart growth strategies can reduce vehicle travel and emissions. It states that,

> The research on the relationship between density and travel is virtually unanimous: after controlling for socioeconomic factors, density directly influences VMT and mode choice. However, the weight of the evidence suggests that the effect of density on travel behavior is modest (roughly 5 percent reductions in VMT and vehicle trips with a doubling of density). In comparison, large increases in regional accessibility (accessibility to regional centers), are found to have a much larger impact on travel behavior – roughly 20 percent reductions in VMT.
>
> Based on the modest impacts on VMT of increasing density—and the difficulty of achieving that added density—several researchers suggest that it is not an effective policy tool. But some research suggests that doubling density in combination with other policies, including those that affect land-use diversity, neighborhood design, access to transit, and accessibility, could have more significant impacts on travel behavior – such as reductions in VMT on the order of 25 to 30 percent.

It includes some useful insights and analysis. It highlights the complexity of land use interactions including socioeconomic characteristics of residents, public transit availability and quality, and accessibility to jobs and services. It discusses the impacts of self-selection. It points out that smart growth vehicle travel and emission reductions depend in part on whether there is unmet demand for more compact, multi-modal communities. It discusses various trends that may affect the feasibility and impacts of more compact development, including increases in two-worker households and non-commute trips. It emphasizes the value of applying economic analysis to these issues, for example, by quantifying transport costs.

This report includes some statements that are contradicted by evidence. It states (p. 6), "Studies that consider New Urbanism-type street patterns generally find that they have only weak or no impact on auto use. They have more impact on walking and bicycling, as does pedestrian-oriented design." Early theoretical modeling reached this conclusion but more recent empirical studies indicate that roadway connectivity has a major impact on total vehicle travel.

It argues that public transit improvements have minimal impacts and benefits, based on the assumption that a passenger-mile of transit can at most reduce one vehicle-mile of automobile travel. However, high quality public transit (rail or bus rapid transit) tends to have leverage effects by providing a catalyst for more compact development and allowing households to reduce their vehicle ownership. Other NAHB-sponsored analysis (Liu 2007) shows that households in regions with rail transit systems drive 6% fewer annual miles on average than otherwise comparable households in regions that lack rail. Since this reflects regional effects, the impacts of locating in a transit-oriented development are likely to be much larger. This contradicts the conclusion that public transit can provide minimal benefits.

Fruits (2008 and 2011)

The report, *The Relationship Between Residential Development and Greenhouse Gas Emissions* is a literature review by Portland State University Professor Eric Fruits, working as a private consultant. Professor Fruits subsequently published a summary of this research in the PSU *Center for Real Estate Quarterly Journal*, which he edits (Fruits 2011).

Fruits' literature review is selective, relying largely on older studies while ignoring many recent studies that use more sophisticated analysis methods, such as those by Bento, et al. (2005), Brownstone and Golob (2005 and 2009), Fang (2008), TRB (2009), CARB (2010-2011), and recent research by professors Marlon Boarnet, Jennifer Dill, Lawrence Frank, Susan Handy, Kevin Krizek, Caroline Rodier and Brian Taylor, all of whom have recently published significant, statistically sophisticated, empirical, peer-reviewed studies concerning the land use impacts on travel activity. To be fair, Fruit's 2008 literature review was undertaken before some of these were published, but Bento, et al. (2005) and Brownstone and Golob (2005) are major omissions, and other important subsequent studies could have been reviewed for the 2011 article.

Fruits is highly critical of previous research. In his 2008 study he reaches the following conclusions regarding residential land use impacts on greenhouse gas emissions:

- Much of the literature relating residential land use development to greenhouse gas emissions tends to use fairly informal evaluation techniques such as summary statistics and "eyeballing."
- None of the studies reviewed provide a statistically reliable connection between residential land use and greenhouse gas emissions.
- Most studies do not account for differences in household and demographic characteristics and their contribution to differences in residential land use and development. Similarly, most studies do not account for differences in household and demographic characteristics and their contribution to differences in greenhouse gas emissions.
- Many of the studies' results are sensitive to the unit of analysis. For example, several studies find widely different results on a per capita basis than they find on a per unit of living area basis. Thus, caution should be exercised in applying results to policy prescriptions.
- Even the more rigorous studies suffer from various statistical problems that affect their ability to clearly identify the direction of cause and effect.
- They rely on very few observations and omit relevant explanatory factors (e.g., household and demographic factors).
- In the absence of reliable scientific studies, policy is often stimulated by "concept studies" or "frameworks." These studies assume or presume relationships that have not been reliably demonstrated. Rather, the data presented tend to support policy prescriptions rather than to test hypotheses.

These conclusions are inaccurate, unfair, and inconsistent with other researchers, including those sponsored by the NAHB. While it is true that few studies control for all relevant factors and apply all statistical tests (due largely to data limitations that are only now being overcome), there is a large body of research with overall consistent results. The Transportation Research Board (TRB 2009), Ewing and Cervero (2010), and the California Air Resources Board (CARB 2010-2011) performed detailed reviews

with careful peer review. Recent studies, which Fruits classified as *robust* in his 2008 review (Stone, et al. 2007; VandeWeghe and Kennedy 2007), do find per capita vehicle travel declines with density, indicating that better quality research which used larger data sets and more sophisticated statistical analysis tend to find strong relationships between land use and travel activity.

Fruits' conclusions contradict those of other NAHB-sponsored researchers. Although Abt Associates, Moore and Kopel-Bailey, and Pozdena review many of the same studies and apply many of the same criticisms, they still conclude there is overwhelming evidence that land use factors affect vehicle travel. For example, Abt Associates (2010, p. 5) state, "The research on the relationship between density and travel is virtually unanimous: after controlling for socioeconomic factors, density directly influences VMT and mode choice."

Although there is room for professional judgment concerning the quality and implications of specific studies, it is wrong to claim, as Fruits does, that, "With such mixed results, it is impossible to have confidence that compact development *in any way* affects motor vehicle usage." [emphasis added] Land use factors clearly *do* significantly affect motor vehicle usage, the uncertainty concerns how much.

Concerning impacts of compact development on vehicle travel Fruits argues that (2011, p. 3),

> Empirically, the results are mixed. On the one hand, some studies have found that more compact development is associated with greater vehicle-miles traveled.[1] On the other hand, one widely cited study finds the opposite relationship, but only by assuming that there is no change in the number of trips in more compact developments.[2] Other studies find no significant relationship between the built environment and travel behavior.[3] With such mixed results, it is impossible to have confidence that compact development in any way affects motor vehicle usage.

This paragraph contains significant inaccuracies. Crane's 1996 study and McNally and Ryan's 1993 study were based on theoretical models. Crane speculated that under certain circumstances increased connectivity could increase vehicle travel, but subsequent research by Handy, Tal and Boarnet (2010) and Ewing and Cervero (2010) conclude, based on empirical research, that increased connectivity significantly reduces vehicle travel. Nothing in these articles indicates that more compact development increases vehicle travel, yet this claim is presented as key evidence that the relationship between density and travel is "mixed."

Is there any validity to the statement, "some studies have found that more compact development is associated with greater vehicle-miles traveled"? Only if *compact development* refers only to street connectivity, a single study is described as "some studies," and the facts that the study was purely theoretical, outdated, and the hypothesis subsequently disproven are ignored.

---

[1] Crane, R. (1996), "Cars And Drivers In The New Suburbs: Linking Access To Travel In Neotraditional Planning," *Journal of the American Planning Association*, 62(1):51–65.

[2] McNally, M. G. and Ryan, S. (1993), "Comparative Assessment Of Travel Characteristics For Neotraditional Designs," *Transportation Research Record*, 140:67–77.

[3] For a summary of these studies see Lee, Y., Washington, S., and Frank, L. D. (2009), "Examination Of Relationships Between Urban Form, Household Activities, And Time Allocation In The Atlanta Metropolitan Region," *Transportation Research Part A*, 43:360–373.

Fruits claims that, "At a theoretical level there is no obvious connection between compact development and mode choice." This is untrue. There are clear theoretical grounds for concluding that increased density will decrease vehicle travel by reducing distances between destinations, increasing the portion of destinations within walking and cycling distances, and improving the cost efficiency of alternative modes since all experience economies of scale (more people per acre reduces per capita costs of providing facilities such as sidewalks, and increases transit demand which tends to reduce costs per passenger-mile).

Fruits fails to define *compact development* and uses the term inconsistently. For example, nearly all his transportation-related references (footnotes 2-7) reflect multiple land use factors, yet his key conclusion is that, "While the linkages between *density* and greenhouse gas emissions may seem obvious, available data indicate that the connections are weak, bordering on non-existent. Thus, it is clear that *compact development* is not a useful tool for reducing greenhouse gas emissions." [emphasis added] In this way, he applies the smaller impacts of density by itself to argue that compact development (including accessibility, density, mix, connectivity, transport diversity, etc.) is an ineffective emission reduction strategy.

Liu (2007)

Liu used multiple regression analysis of National Household Travel Survey and Census data to estimate how various geographic and household characteristics affect household vehicle travel distance and time, and gasoline consumption. The results provide strong evidence that compact development reduces vehicle travel and fuel consumption.

Table 3 **NAHB Statistical Models and Estimated Coefficients** (Liu 2007)

	Annual Miles		Gasoline (gals.)	
	Coefficient	Percent	Coefficient	Percent
Intercept	14,832	*100%*	694	*100%*
Single family home	1,645	11%	96	14%
Homeowner	1,297	9%	72	10%
Number of persons in household	1,789	12%	94	13%
Number of workers in household	6,384	43%	264	38%
Male householder	1,633	11%	101	15%
Black householder	-1201	-8%	-81	-12%
Hispanic householder	315	2%	26	4%
Other minority	-1,072	-7%	-72	-10%
Householder has a at least bachelor's degree	-1,294	-9%	-88	-13%
Age of householder	-61	0%	-2.84	0%
Annual household income $23.5k-$41.1k	720	5%	31	5%
Annual household income $41.1k-$58.8k	3,285	22%	168	24%
Annual household income $58.8k-$76.4k	5,241	35%	278	40%
Annual household income $76.4k-$94.0k	5,753	39%	315	45%
Annual household income $94.0k and up	8,597	58%	464	67%
Living in Northeast	-1,803	-12%	-84	-12%
Living in Midwest	65	0%	14	2%
Living in South	1,100	7%	70	10%
MSA has rail	-865	-6%	-74	-11%
0.08 to 0.39 units per acre	-1,600	-11%	-91	-13%
0.39 to 1.56 units per acre	-1,886	-13%	-93	-13%
1.56 to 4.69 units per acre	-4,248	-29%	-201	-29%
4.69 to 7.81 units per acre	-4,623	-31%	-218	-31%
7.81 units or more per acre	-6,574	-44%	-312	-45%
Rural areas in MSA, MSA population under 1 million	-2,589	-17%	-109	-16%
Urban areas in MSA, MSA population under 1 million	-5,445	-37%	-276	-40%
Rural areas in MSA, MSA population 1-3 million	-129	-1%	26	4%
Urban areas in MSA, MSA population 1-3 million	-5,114	-34%	-272	-39%
Rural areas in MSA, MSA population 3 million and up	384	3%	66	9%
Urban areas in MSA, MSA population 3 million and up	-3,816	-26%	-190	-27%
Urban areas, non-MSA	-3,425	-23%	-171	-25%
Urban areas, MSA pop. 3+mil., density<0.39 per acre	510	3%	87	12%
Urban areas, MSA pop. 1-3mil., density<0.39 per acre	1,733	12%	78	11%

This table summarizes Liu's results for vehicle travel and gasoline consumption. See spreadsheet model for additional statistical data.

Table 3 summarizes the analysis results, showing how, controlling for other factors, various household and geographic characteristics affect annual household vehicle travel and fuel consumption. For example, the analysis also indicates that vehicle travel and fuel consumption increase with household incomes. It also indicates that homeowners drive 11% more vehicle-miles and consume 14% more gallons of gasoline than renters of otherwise equal household size, income and location. Similarly, the analysis indicates that households located in Metropolitan Statistical Areas (MSAs) that have rail transit systems drive 6% less and consume 11% less fuel than an otherwise equal household would located in a region that lacks rail, and that vehicle travel and fuel consumption decline with neighborhood density, and in urban areas. Table 4 summarizes these impacts. Although this data set does not allow direct quantification of individual land use factors such as land use mix, road connectivity and walkability (although they are generally associated with urban development and the Northeast region), the results indicate that compact development tends to reduce vehicle travel and fuel use.

Table 4 **Factors That Increase Vehicle Travel and Fuel Consumption** (Liu 2007)

Geographic	Household
• Located in the Midwest or South • Located in a lower-density neighborhood • Located in an rural area • Region lacks rail transit	• Are larger (more people) • Contain more workers • Have higher incomes • Own their homes • Live in single family homes • Are younger • Are less educated • Have a male householder • Have a white householder • Have a Hispanic householder

Liu's analysis indicates that, all else being equal, residents of more compact, urban neighborhoods, and metropolitan regions tend to drive less and consume less fuel.

This analysis also modeled the fuel efficiency of vehicles and travel conditions. It indicates that residents of more compact communities tend to drive at less efficient speeds (below 45 mph) due to congestion. However, this effect does not offset vehicle travel reductions so households in more compact development tend to use less gasoline and generate fewer emissions overall.

Moore and Kopel-Bailey (2008)

The report, *The Relationship Between Residential Development and Environmental Quality: A Literature Review*, critically examined existing literature on the linkage between residential development factors and environmental impacts including stormwater and wastewater, and air pollution emissions. It evaluates the degree that current knowledge can help decision-makers, particularly local officials, determine optimal development policies and projects, taking into account environmental protection as well as other planning objectives.

It discusses the various pathways through which residential development patterns can affect the environment, including direct impacts (land and materials used in construction) and indirect impacts (by affecting travel activity). It critically examines literature on these relationships and summarizes the quality and results.

It identifies various common problems in existing literature, including a lack of clear and consistent definitions, measurement units, scope and analysis methods. It finds that the literature linking residential development patterns and stormwater and wastewater is relatively well documented and the basic causal links largely undisputed, but research concerning impacts on air emissions is more variable in quality and consistency of results. After controlling for other causes (e.g., income) some studies indicate that the effects are small, and so cannot provide unambiguous guidance as to which development pattern is environmentally superior. It concludes that overall, this is not an "actionable" body of literature.

It states,

> Although the scope of this research stopped at the review of the literature, the implications for future policy cannot be ignored. From the perspective of national or state policy, the general findings do not offer clear-cut prescriptions, but directional indicators do emerge from trends in the research: connected, dense, mixed use development that is well designed and integrated into the larger community can have benefits. However, defining the measurements of that end goal is where policy becomes tricky.

It argues that, "Although, the effects of residential development on the environment is a conclusion beyond debate, it is less clear the magnitude of those impacts." It recommends targeted research to better understand these relationships and development of practical tools that local decisions makers can use for comprehensive evaluation of specific policies and projects, including environmental impacts.

Pozdena (2008)

The report, *The Relationship Between Residential Development Patterns and Travel Activity: A Literature Review*, critically evaluates existing research on the relationships between residential land use patterns and travel activity. It includes a systematic analysis of previous studies evaluated based on the type of analysis, their scope and quality. It highlights the weaknesses of individual studies, such as considering a subset of total types of travel (such as commuting) or failure to account for self-selection.

Based on this analysis it describes common weaknesses of current research:

- Much of the literature relating residential development to travel activity use fairly informal measurement techniques that do not test for statistical significance. Even the best studies suffer from various statistical problems that affect the ability to clearly identify the direction of cause and effect. The empirical work is stronger and improves as better data sets become available.
- In general, the independent effect of residential land-use patterns, per se, on travel activity appears to be weak. Other factors, such as income, demographics, and other local factors appear to be much more important determinants of travel activity. This confounds isolation of the independent effects of residential development patterns since income and demographics are also associated with variations in preference for particular residential styles.
- Regional simulation models are a useful platform for studying interactions among land use patterns and travel. However, at present they are not sufficiently developed to reliably simulate the ultimate ("full") effects of neighborhood or regional development patterns on travel activity.
- The focus on commute travel patterns leaves the effect of land use on the greater quantity of non-work trip making activity unknown.
- In the absence of definitive, scientific studies, policy is often stimulated by what we refer to as *Concept Studies*. These studies hypothesize full-effect relationships without empirical study or through informal data analysis. Some of the most forceful claims for, and against, compact residential development and its connection to transportation come from these studies.

It discusses these problems with past research and the additional statistical analysis needed to provide better information.

This study emphasizes that land use factors may have indirect impacts that may reinforce or offset direct effects. A *reinforcing effect* occurs, for example, if moving closer to a transit station reduces a household's vehicle ownership, causing additional vehicle travel reductions besides just the trips shifted from driving to public transit. An *offsetting effect* occurs, for example, if zoning policies raise residential or business property taxes in an urban area causing some people to shift to more automobile-dependent locations. This review therefore divides previous studies into those that evaluate *partial effects* which hold all other factors constant, and those that measure *full effects* which account for these additional indirect impacts.

Research Summary (NAHB 2010)

Climate Change, Density and Development: Better Understanding the Effects of Our Choices, is the NAHB's summary of the five background studies. Many of its conclusions are reasonable, but some inaccurately reflect research finding or misrepresent key issues, as summarized in Table 5. All NAHB researchers except Fruits acknowledge the overwhelming evidence that land use affects travel activity, and integrated smart growth policies can have significant impacts. Yet, the NAHB ignored these findings and only published Fruit's hyper-critical conclusions.

Table 5 **Critique of Specific Claims** (NAHB 2010)

NAHB Claims	Critique
"Higher density development will not necessarily deliver the benefits that many in the policy community ascribe to it."	This statement ignores other land use factors besides density. Researchers estimate that an integrated smart growth program can reduce future transport emissions 7-10%. None of NAHB's research indicates such impacts are unachievable.
"The existing body of research demonstrates no clear link between residential land use and GHG emissions and leaves tremendous uncertainty as to the interplay of these factors."	Untrue. Existing research clearly demonstrates links. All NAHB researchers except Fruits acknowledge that compact development significantly reduces emissions. Although uncertainty exists concerning the magnitude of some impacts, it is no greater than with other public policy issues.
"The assumption of a causal connection between density and GHG emissions is based on prevailing beliefs within the planning community and not on verifiable scientific research or analysis."	Untrue and confuses the issue by only mentioning density. Abundant evidence shows causal connections between land use factors (density, mix, transport connectivity and parking supply) and GHG emissions. All NAHB researchers except Fruits recognize this overwhelming evidence.
"The weight of the evidence suggests that the effect of density on travel behavior is modest. In fact, doubling density results in about a 5% decrease in vehicle trips and VMT."	This is untrue and confuses the issue by referring only to density. Current research indicates that doubling density by itself reduces affected vehicle travel 5-19%, and doubling all compact development factors reduces vehicle travel 20-40%.
"The density and layout of communities have only a modest impact on peoples' transportation choices and travel behavior."	Untrue. Many studies indicate that increasing development density, mix, connectivity and mobility options can reduce vehicle travel 20-40%, which is more than *modest*.
"New Urbanism-type street patterns have little or no impact on auto usage."	Untrue. This was a finding of early theoretical studies but subsequent empirical studies find street connectivity to have significant impacts on travel activity.
"Policies that affect the car costs, such as increases in gas taxes or the price or availability of parking, are more effective in changing travel behavior."	This may be true, but these other policy reforms tend to be more effective and politically acceptable if implemented as part of a smart growth program.
"The decentralization of jobs lessens the ability of public transit – particularly fixed rail systems – to meet travel needs, and increases the complexity of household location decisions, reinforcing the need for auto ownership and neighborhoods that accommodate autos, and increasing VMTs."	These claims are not necessarily true, nor relevant. Smart growth helps reverse these trends, increasing the portion of homes and jobs accessible by alternative modes, and reduces non-commute travel.
"Transit availability has a small impact on auto use."	Untrue. High quality transit can significantly reduce vehicle travel, indicated by the NAHB's own research (Liu 2007).

This table critiques some key claims by the National Association of Home Builders.

Comprehensive Evaluation of Impacts

The NAHB and its researchers emphasize the costs of more compact development but overlook many benefits. Smart growth policies reduce per capita land consumption and improve accessibility, which provides various savings and benefits (Burchell, et al. 2002; IBI 2008). NAHB analysis overlooks most of these benefits, as indicated in Table 6.

Table 6 **Smart Growth Benefits** (Burchell, et al. 2002; IBI 2008; Litman 2005)

Planning Objectives	Considered in NAHB Analysis
Development cost savings (lower costs per capita for road and utility lines)	
Reduced per unit land costs	
Public service savings (lower unit costs for school transport and emergency services)	
Parking cost savings	
Agglomeration efficiencies (increased economic productivity from compact development)	
Improved housing options, particularly more affordable housing in accessible locations	
Household transportation cost savings	
Reduced traffic accidents	
Improved accessibility for non-drivers	
Energy conservation	✓
Pollution emission reductions	✓
Improved public fitness and health	
Openspace and habitat preservation, stormwater management costs, reduced heat island effects	

Smart growth development policies can provide various economic, social and environmental benefits. The NAHB analysis only considered two.

Many of these co-benefits are large. For example, more compact development can save tens of thousands of dollars per housing unit in public infrastructure cost savings (Blais 2010). Residents of more accessible, multi-modal communities can save hundreds of dollars annually in reduced transportation costs, plus residential parking cost savings. More compact development tends to significantly reduce per capita traffic crash rates and increase residents physical fitness and health. It helps preserve farmlands and wildlife habitat.

This is not to ignore the incremental costs of smart growth, which may include more curbs, sidewalks and structured parking, and smaller building lots. However, these should be compared with total smart growth benefits, not just emission reductions.

Developers can benefit overall from smart growth policies. Current demographic and economic trends (aging population, rising fuel prices, increasing urbanization, increasing health and environmental concerns, changing consumer preferences) are increasing future consumer demand for smart growth locations (Litman 2010; ULI 2009). Smart growth can reduce some development costs, including public infrastructure, land and parking facility costs (Blais 2010; Ford 2009). Residents' vehicle savings leaves households more money to spend on housing (NRDC 2010). Although smart growth may require different types of development (more diverse housing types, more infill and retrofits, mixed use projects, etc.) it is not necessarily less profitable than sprawl (USEPA 2010).

Conclusions

There is little doubt that land use factors significantly affect travel activity, although some details of these relationships are uncertain. Robust theoretical and empirical evidence exists of the direction of impacts, although current models cannot predict their exact magnitude.

Several major studies indicate that smart growth policies can help achieve various planning objectives including energy conservation and emission reductions. NAHB sponsored research investigated this research. Their summary document presents incomplete and inaccurate results:

- It presents the most negative results, ignoring the majority of studies which indicate that these relationships are significant and measurable. Most research does *not* support the NAHB's conclusions that, "The existing body of research demonstrates no clear link between residential land use and GHG emissions and leaves tremendous uncertainty as to the interplay of these factors," nor "The assumption of a causal connection between density and GHG emissions is based on prevailing beliefs within the planning community and not on verifiable scientific research or analysis."
- It confuses the concepts of *density* and *compact development*. It argues that the relatively small travel reductions caused by increased *density* (holding all other factors constant) means that *compact development* (a set of land use factors) has minimal impacts and benefits.
- Its review relies excessively on older, often outdated studies and omits more recent and better research which indicates a stronger relationship between land use and transport.
- It reports the lowest impact values rather than the full range of values. It claims that the elasticity of vehicle travel with respect to density is only -0.05 (increasing density 10% reduces vehicle travel 0.5%), although most current research indicates impacts two to four times greater.
- It highlights the incremental costs of compact development but overlooks significant co-benefits including infrastructure cost savings, consumer savings, public safety and health, and habitat preservation.

These misrepresentations significantly understate smart growth's potential impacts and benefits. Actual *travel impacts* are probably four to eight times greater than the NAHB implies (doubling all land use factors typically reduces affected residents' vehicle travel 20-40%, compared with the 5% indicated), and total *benefits* are far greater due to additional co-benefits ignored in this study. Smart growth policies can also impose costs to developers and consumers, such as additional expenses for curbs and sidewalks, and reduced average lot size, but these incremental costs should be compared with total incremental benefits, not just air emission reductions.

The NAHB actually has good reasons to support smart growth policies. Current demographic and economic trends are increasing demand for more compact, multi-modal development, and the vehicle and utility savings that result can leave households with more money to spend on housing, which reduces housing foreclosure risks.

This is not to deny the importance of further research to improve the quality of predictive models for evaluating smart growth policy impacts and benefits. The NAHB should support such research to better guide their industry into the future and more effectively respond to community development goals.

References

Abt Associates (2010), *Research on Factors Relating to Density and Climate Change*, National Association of Home Builders (www.nahb.org); www.nahb.org/fileUpload_details.aspx?contentID=139993.

Gavin Alford and Jeremy Whiteman (2009), *Macro-Urban Form, Transport Energy Use and Greenhouse Gas Emissions: an Investigation for Melbourne*, Department of Transport Victoria (www.transport.vic.gov.au); at www.transport.vic.gov.au/__data/assets/pdf_file/0016/31345/MacroUrbanFormReport_2009.pdf.

Pamela Blais (2010) *Perverse Cities: Hidden Subsidies, Wonky Policy, and Urban Sprawl*, UBC Press (http://perversecities.ca).

Marlon G. Boarnet, Douglas Houston, Gavin Ferguson, and Steven Spears (2011), "Land Use and Vehicle Miles of Travel in the Climate Change Debate: Getting Smarter than Your Average Bear," *Climate Change and Land Policies* (www.lincolninst.edu); draft version at http://economics.ucr.edu/spring11/Boarnet%20paper%20for%205%204%2011%20seminar.pdf.

Robert Burchell, et al (2002), *The Costs of Sprawl – 2000*, TCRP Report 74, Transportation Research Board (www.trb.org); at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_74-a.pdf.

CARB (2010-2011), *Research on Impacts of Transportation and Land Use-Related Policies*, California Air Resources Board (http://arb.ca.gov/cc/sb375/policies/policies.htm).

Wendell Cox (2012), Urban Travel and Urban Population Density," *JOURNEYS*, LTA Academy (http://ltaacademy.lta.gov.sg); at http://ltaacademy.gov.sg/doc/JOURNEYS_Nov%202012.pdf.

Randall Crane (1996), "Cars And Drivers In The New Suburbs: Linking Access To Travel In Neotraditional Planning," *Journal of the American Planning Association*, Vol. 62, No. 1, pp. 51–65; at www.uctc.net/papers/239.pdf.

Michael Dudley (2010), *Planning for "Dickensian Gloom"? Refuting Critics of Smart Growth (Again)*, Planetizen Blog (www.planetizen.com); at www.planetizen.com/node/42679.

EcoNorthwest (2010), *The Relationship Between Residential Development and Environmental Quality: A Literature Review*, National Association of Homebuilders (www.nahb.org); at www.nahb.org/fileUpload_details.aspx?contentID=112939.

Eric Eidlin (2010), "What Density Doesn't Tell Us About Sprawl," *Access 37*, University of California Transportation Center, pp. 2-9; at www.uctc.net/access/37/access37_sprawl.shtml.

Reid Ewing, Keith Bartholomew, Steve Winkelman, Jerry Walters and Don Chen (2007), *Growing Cooler: The Evidence on Urban Development and Climate Change*, Urban Land Institute (www.uli.org); at http://postcarboncities.net/files/SGA_GrowingCooler9-18-07small.pdf.

Reid Ewing and Robert Cervero (2010), "Travel and the Built Environment: A Meta-Analysis," *Journal of the American Planning Association*, Vol. 76, No. 3, Summer, pp. 265-294; at www.climateplanca.org/Travel_Built_Environ.pdf.

Jonathan Ford (2009), *Smart Growth & Conventional Suburban Development: Which Costs More?* U.S. Environmental Protection Agency (www.epa.gov/smartgrowth/sg_business.htm); at www.morrisbeacon.com/images/documents/MBD%20EPA%20infrastructure.pdf.

Lawrence D. Frank , et al. (2011), *An Assessment of Urban Form and Pedestrian and Transit Improvements as an Integrated GHG Reduction Strategy*, Washington State Department of Transportation (www.wsdot.wa.gov); at www.wsdot.wa.gov/research/reports/fullreports/765.1.pdf.

Eric Fruits (2008), *The Relationship Between Residential Development and Greenhouse Gas Emissions*, Appendix A of *Climate Change, Density and Development: Better Understanding the Effects of Our Choices*, National Association of Home Builders (www.nahb.org); at www.nahb.org/fileUpload_details.aspx?contentID=112937&fromGSA=1.

Eric Fruits (2011), "Compact Development And Greenhouse Gas Emissions: A Review Of Recent Research," *Center for Real Estate Quarterly Journal*, Vol. 5, No. 1, Winter; at http://bit.ly/1GuyH7x.

Susan Handy, Gil Tal and Marlon Boarnet (2010), *Draft Policy Brief On The Impacts Of Network Connectivity Based On A Review Of The Empirical Literature*, Research on Impacts of Transportation and Land Use-Related Policies, California Air Resources Board; at http://arb.ca.gov/cc/sb375/policies/policies.htm.

IBI (2008), *Implications Of Alternative Growth Patterns On Infrastructure Costs*, Plan-It Calgary, City of Calgary (www.calgary.ca).

JRC (2011), *Location Efficiency and Housing Type—Boiling it Down to BTUs*, Jonathan Rose Companies for the U.S. Environmental Protection Agency (www.epa.gov); at www.epa.gov/smartgrowth/pdf/location_efficiency_BTU.pdf.

Mindy Kimball, Mikhail Chester, Christopher Gino, and Janet Reyna (2013), "Assessing the Potential for Reducing Life-Cycle Environmental Impacts through Transit-Oriented Development Infill along Existing Light Rail in Phoenix," *Journal of Planning Education & Research* (http://jper.sagepub.com), December, Vol. 33, No. 4, pp. 395-410; at http://jpe.sagepub.com/content/33/4/395.full.

Todd Litman (2005), *Understanding Smart Growth Savings: What We Know About Public Infrastructure and Service Cost Savings*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/sg_save.pdf.

Todd Litman (2007), *Land Use Impacts On Transport: How Land Use Factors Affect Travel Behavior,* VTPI (www.vtpi.org); at www.vtpi.org/landtravel.pdf.

Todd Litman (2008), *Smart Growth Policy Reforms*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/smart_growth_reforms.pdf.

Todd Litman (2009), *Evaluating Criticism of Smart Growth*, VTPI (www.vtpi.org); at www.vtpi.org/sgcritics.pdf.

Todd Litman (2010), *Where We Want To Be: Household Location Preferences And Their Implications For Smart Growth,* VTPI (www.vtpi.org); at www.vtpi.org/sgcp.pdf.

Todd Litman (2011), "Can Smart Growth Policies Conserve Energy and Reduce Emissions?" Portland State University's *Center for Real Estate Quarterly* (www.pdx.edu/realestate/research_quarterly.html), Vol. 5, No. 2, Spring, pp. 21-30; at www.vtpi.org/REQJ.pdf.

Todd Litman (2011b), *An Inaccurate Attack On Smart Growth*, Planetizen (www.planetizen.com/node/49772).

Todd Litman (2015), *Understanding Smart Growth Savings*, VTPI (www.vtpi.org); at www.vtpi.org/sg_save.pdf.

Helen Fei Liu (2007), *Vehicle CO2 Emissions and the Compactness of Residential Development*, HousingEconomics.com; at www.nahb.org/generic.aspx?sectionID=734&genericContentID=86266&channelID=311.

Michael West Mehaffy (2015), *Urban Form and Greenhouse Gas Emissions Findings, Strategies, and Design Decision Support Technologies*, Delft University of Technology (http://abe.tudelft.nl); at http://abe.tudelft.nl/index.php/faculty-architecture/article/view/1092/pdf_mehaffy.

Terry Moore and Jules Kopel-Bailey (2008), *The Relationship Between Residential Development and Environmental Quality: A Literature Review Summary*, EcoNorthwest for the National Association of Home Builders (www.nahb.org); at www.nahb.org/fileUpload_details.aspx?contentID=112939.

NAHB (2010), *Climate Change, Density and Development: Better Understanding the Effects of Our Choices*, National Association of Home Builders (www.nahb.org); at www.nahb.org/fileUpload_details.aspx?contentTypeID=3&contentID=151627&subContentID=319667.

NAHB (2011), *Climate Change: Research Documents*, National Association of Home Builders (www.nahb.org); at www.nahb.org/reference_list.aspx?sectionID=2003.

Brice G. Nichols and Kara Kockelman (2015), "Urban Form and Life-Cycle Energy Consumption: Case Studies at the City Scale," *Journal of Transportation and Land Use*, Vol. 8, No. 3; at www.jtlu.org/index.php/jtlu/article/view/598.

NRDC (2010), *Reducing Foreclosures and Environmental Impacts through Location-Efficient Neighborhood Design*, Natural Resources Defense Council (www.nrdc.org); at www.nrdc.org/energy/files/LocationEfficiency4pgr.pdf.

Randall J. Pozdena (2008), *The Relationship Between Residential Development Patterns and Travel Activity: A Literature Review*, EcoNorthwest for the National Association of Home Builders (www.nahb.org); at www.nahb.org/fileUpload_details.aspx?contentID=112938.

SGN (2006), *This Is Smart Growth*, Smart Growth Network (www.smartgrowth.org) and the International City/County Management Association (www.icma.org); at www.epa.gov/smartgrowth/tisg.htm.

Robert Steuteville (2011), *Does Smart Growth Reduce Carbon Emissions? Bet The House On It*, New Urban Network (www.newurbannetwork.com); at http://newurbannetwork.com/news-opinion/blogs/robert-steuteville/14788/does-smart-growth-reduce-carbon-emissions-bet-house-it.

TRB (2009), *Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions*, Special Report 298, Transportation Research Board (www.trb.org); at http://onlinepubs.trb.org/Onlinepubs/sr/sr298.pdf.

ULI (2009), *Emerging Trends in Real Estate*, Urban Land Institute (www.uli.org); at www.uli.org/ResearchAndPublications/EmergingTrends/Americas.aspx.

ULI (2010), *Land Use and Driving: The Role Compact Development Can Play in Reducing Greenhouse Gas Emissions*, Urban Land Institute (www.uli.org); at www.uli.org/ResearchAndPublications/PolicyPracticePriorityAreas/Infrastructure.aspx.

USDOT (2010), *Transportation's Role in Reducing U.S. Greenhouse Gas Emissions: Report to Congress*, U.S. Department of Transportation (www.dot.gov), at http://ntl.bts.gov/lib/32000/32700/32779/DOT_Climate_Change_Report_-_April_2010_-_Volume_1_and_2.pdf.

USEPA (2010), *Smart Growth: The Business Opportunity for Developers and Production Builders*, U.S. Environmental Protection Agency (www.epa.gov); at www.epa.gov/smartgrowth/sg_business.htm.

www.vtpi.org/NHBAcritique.pdf