- Develop alternative affordable housing options.
- Establish strong pedestrian link from new Greenbridge housing to business district of White Center.
- Consider rezoning under-utilized industrial areas to allow more mixed-used development in central business core.

The surveys conducted as part of the project found that the community supports such changes. The surveys found that the most frequent choices for top priority in community public investment were completing the sidewalk system, developing additional affordable housing, and more parks and open space.

For more information, visit: www.metrokc.gov/kcdot/tp/ortp/Index.htm

Footnotes:

[1] Public health was included in the project via collaboration with the National Institutes for Health funded Neighborhood Quality of Life Study (NQLS.)

[2] LUTAQH was modeled after the Atlanta based SMARTRAQ program (see www.act-trans.ubc.ca).

[3] Each of the analyses conducted controlled for socio-demographic considerations and were significant at the 95% (P=.05) confidence level.

[4] These are the same locations with higher residential and employment densities where transit service is more cost effective.

[5] Frank, Lawrence, Andresen, Martin, Schmid, Tom, 2004. "Obesity Relationships With Community Design, Physical Activity, and Time Spent in Cars." American Journal of Preventive Medicine, Vol. 27, No. 2.

[6] Energy consumption is inferred from the greenhouse gas emissions models which are based on fuel combustion rates.

[7] Increased obesity is associated with higher likelihoods of cardiovascular disease, type II diabetes and colorectal cancer.

[8] Frank, L., Sallis, J., Wolf, K., Piro, R., Linton, L., "Zoning for Health: The Physical Activity, Obesity and Air Quality Impacts of Land Use Regulation."

[9] Quartile 1 is the lowest and 4 is the highest levels of each urban form factor.

[10] Emissions estimates assume that the traveler chose the shortest time-path for each trip taken to account for directional fluctuations in traffic congestion during peak periods. Speed estimates for each link were based on the congested flows from the Puget Sound Regional Council's (PSRC) travel model. Climatic and fleet mix inputs used by the PSRC and Puget Sound Clean Air Agency were accounted for as well. Speed based emissions rates were developed for cold starts and hot stabilized operation for each pollutant. For more information, please see the final report and technical appendices.

[11] Analyses are based on quartiles of each urban form variable and controlled for gender, income, educational attainment, number of household vehicles and network distance to transit (except for VOCs where distance to transit was not significant.) For more information, please see the final report and technical appendices.

[12] VOCs are more associated with cold starts than NOx. This explains why they do not decline as much in association with increased levels of the urban form measures. Therefore, less VMT may be associated with less emissions overall, but increased numbers of short trips, that are often cold starts, generate more VOCs per unit of distance traveled.

[13] Dr. Richard Zabel, National Oceanic and Atmospheric Administration, Seattle, WA 2005.

[14] The Neighborhood Quality of Life Study (NQLS) focuses on King County residents between the ages of 20 and 65 years of age and is led by Dr. James Sallis, Principal Investigator, and co led by Dr. Lawrence Frank and Dr. Brian Saelens.

[15] Frank, L. D., Sallis, J. F., Saelens, B. E., Leary, L. E., Cain, K., Conway, T. L. Under review "A Walkability Index and Its Application to the Trans-disciplinary Neighborhood Quality of Life Study."

[16] A significant body of evidence exists that links levels of physical activity and obesity with the odds of developing a chronic ailment including cancer, cardio-vascular disease and diabetes (Frumkin, Frank and Jackson, "Urban Sprawl and Public Health". Island Press. 2004.) Several recent assessments document major increases in health care costs are associated with these types of ailments that may well be most sensitive to the built environment.

A Study of Land Use, Transportation, Air Quality, and Health (LUTAQH) in King County, WA

Executive Summary

Study Conducted by:

Lawrence Frank and Company, Inc.
Atlanta, Georgia • Pt. Roberts, Washington

In Collaboration with:

The Neighborhood Quality of Life Study (NQLS)
Center for Clean Air Policy
GeoStats, LLP
McCann Consulting

September 27, 2005

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LUTAQH Advisory Committee Members

Elizabeth Speck (chair-health), Emily Allen (communities), Shirley Beresford (health), Jonathan Bez (transit), Paul Carr (air quality), John Eliason (housing), Richard Gelb (sustainable development), Fred Glick (urban design), Bert Gregory (architecture/urban design), Claudia Hirschey (transportation), Peter Hurley (transportation), Alex Johnston (banking), Burk Ketcham (planning), King Cushman (regional planning), Margaret Kitchell (medicine), Bill Osborne (city planning), Rocky Piro (regional planning), David Schraer (community development/ design), Amy Shumann (health), David Solet (health), and Barbara Wright (health)

"Change is Inevitable. In a Progressive Country, Change is Constant."

Benjamin Disraeli, 1867

Overview

Disraeli's wisdom of over 138 years ago demonstrates the need to regularly reevaluate what we do. King County is doing just that – re-evaluating how the county grows and how that growth affects the lives of county residents. King County undertook the Land Use, Transportation, Air Quality and Health Study (LUTAQH) to measure how specific land use and transportation actions affect air quality, mobility and congestion, and public health.[1] The ultimate goal of the study is to guide the allocation of resources in King County as it works to reduce automobile dependency, increase transportation efficiency, improve air quality, and improve the health of county residents. This research documents the impact of land use decisions and transportation investments and suggests strategies for allocating resources to encourage more compact, mixed use neighborhoods with more transportation choices.

LUTAQH's Role

King County is the first local government to fund a study of this kind – a study that explores the links among the built environment, mobility, air quality and public health. The study findings will be used to inform policy and investment decisions. Through its collaboration with the Neighborhood Quality of Life Study (NQLS, funded by the National Institutes of Health),

- Increase residential density in commercial areas and promote more mixed use.
- Expand the regional trail system to connect public spaces with a series of pedestrian and cycling routes within and between neighborhoods within the community and, via a series of regional trails, among communities.
- Introduce improvements to major community streets through streetscape improvements – including development of sidewalks and street design changes that support pedestrian and bicycle use.

Specific Recommendations for Communities

One of the hallmarks and challenges of smarter growth practices is that solutions must be tailored to each community. The recommendations for each type of community outlined below flow directly from the research findings. The suggestions should be considered in a community-based planning process. The three communities described are representative of hundreds of neighborhoods across King County; the suggestions are presented here to demonstrate the kind of neighborhood-by-neighborhood assessment needed for King County to make the land use and transportation changes that will help it meet its goals. Specific strategies proposed for each community are below.

Kent/East Hill (auto-oriented suburban district):

- Consider developing a bus station with direct, rapid connections to the transit station in downtown Kent and with efficient connections to other modes.
- Create a system of linear parks along unimproved rights of way to create a "green ring" of public open space around Kent East Hill.
- Encourage the gradual redevelopment of shopping malls and big box retail to mixed use.
- Discourage surface parking through design guidelines.
- Permit and encourage housing development above retail space.

In the preference survey of neighborhood residents, the investment most frequently picked as the top choice by Kent respondents was affordable housing, followed by a complete sidewalk system and, thirdly, new or expanded freeways. Affordable housing was again chosen most frequently as a second priority, followed by a network of pedestrian and bicycle pathways and then new or expanded freeways.

Redmond (urban center):

- Implement Redmond's new Downtown Transportation Plan.
- Develop appropriate local models for high-density urban housing.
- Permit development of non-traditional housing forms, such as live-work spaces.
- Complete an internal bike path network.
- Redevelop an appropriate street hierarchy that emphasizes the nature of some streets as local service providers.

In the preference survey, when asked to rank their top three investments, Redmond respondents selected affordable housing most frequently, followed by a new or expanded freeway, more open space, and a pedestrian and bicycle trail system. The most frequent selections for second place were a pedestrian and bicycle trail system, improvements to arterial roads, and affordable housing.

White Center (older urban center, or "streetcar suburb"):

- Consider rezoning targeted single-family areas to allow infill duplexes and triplexes to increase residential density.
- Complete the sidewalk and street drainage system, including design and development of natural drainage systems.
- Create an international marketplace/small business incubator building or similar pedestrian destination.

areas where local land use actions support convenient access to transit.

f. Make pedestrian investments coincident with improved transit service. Similarly, communities arguing for more transit service must demonstrate how they will improve pedestrian connections. White Center, for instance, needs sidewalks. Without them, people cannot safely or comfortably walk to transit. Communities should work with transit agencies to identify and implement needed pedestrian facilities when transit projects are being planned.

g. Create a pool of funds for strategic improvements that meet the test of smart development. Earmark five percent of federal funds, jointly pooled from multiple sources – roads, transit, air quality, and public health – to projects that meet the goals of improved transportation efficiency, air quality, and health. The LUTAQH project demonstrates that real gains come when criteria from multiple disciplines are combined. Projects that can meet the test of multiple successes should have access to funds from multiple sources.

IV. Specific Initiatives

a. Partner with the Puget Sound Regional Council (PSRC) on the Vision 2020 Plan Update. The PSRC is in the process of updating its Vision 2020 Plan. As the lead regional planning agency in the central Puget Sound region, the PSRC presents an ideal partner for the advancement of the LUTAQH findings. The Vision 2020 Plan represents a collective and commonly held set of values about how the region should grow. The PSRC developed a set of "position papers" to inform its board and member jurisdictions on the critical issues the region is facing.

One paper focuses on the emerging evidence documenting relationships among land use patterns, transportation investments, and public health. This paper referenced findings from the LUTAQH study documenting links between travel patterns and public health. In addition to public health, LUTAQH includes recommendations for transportation funding and land use regulations based on their impacts on travel choices, regional air quality, and climate change. Findings from these parts of LUTAQH support the Vision 2020 Plan.

Building on the Growth Management Act (GMA) framework in place in the central Puget Sound region, King County should work with cities to add new policies to the Countywide Planning Policies to provide guidance to all jurisdictions in the county on how to address public health, air quality, and climate change concerns through their planning and policy level work.

b. Case studies that point to change. Kent, Redmond, and White Center were the focus of detailed case studies in the LUTAQH study, which included a look at urban form in the communities and a survey asking residents about their travel preferences. Each case study is representative of common neighborhood types in the region. Kent is an auto-oriented suburban district with good proximity between residential and commercial uses, but poor connectivity due to large block structure and surface parking. Redmond is an urban center with a vibrant new commercial center, but limited housing. White Center is an older urban center with a good grid network of streets and a viable commercial core but needs additional residential density and investments in sidewalks and other pedestrian amenities. LUTAQH found all three communities – and by inference, most neighborhoods throughout the region — would benefit from some basic changes in development patterns. Three approaches are recommended for all communities:

LUTAQH is one of the first studies to comprehensively examine land use, transportation, air quality, and health as part of a single effort.[2] The study establishes a baseline of existing measures of land use, transportation investment, travel choices, and explores how these factors are associated with air quality, climate change and health.

Key Findings

1. Whether the goal is to increase transportation efficiency, reduce automobile dependence, or reduce ozone and improve regional air quality and health, the study shows that compact development, a wide variety of land uses close to home and work, and a connected street network with pedestrian facilities can help achieve all of these goals.[3]

2. Residents walk more in neighborhoods that provide a wide variety of retail services and where connections to such services are facilitated through a connected street network.

3. Transit and walking are highly synergistic — transit use was observed to be the highest in locations where walking was the most prevalent; conversely the choice to walk is highest where the convenience and efficiency of transit is the greatest.[4]

4. Residents in the most interconnected areas of the county travel 26 percent fewer vehicle miles per day than those that live in the most sprawling areas of the county.

5. Increased residential density, street connectivity, and land use mix near home and work are associated with significantly lower per capita vehicle emissions; in particular, fewer oxides of nitrogen (NOx) and volatile organic compounds (VOCs), which react in sunlight and form harmful ozone, and fewer greenhouse gas emissions, which contribute to global warming, are released.

6. Residents of the most walkable areas of King County were less likely to be overweight or obese and more likely to report being physically active. Preliminary results suggest that residents of the most walkable communities within the county are more likely to meet the 30 minutes per day of moderate activity recommended by the U.S. Surgeon General.

(Results from the LUTAQH Study will be released in a peer-reviewed paper in the Journal of the American Planning Association this winter. Results presented above were released in a peer-reviewed paper presentation at the Society of the Behavioral Medicine Conference in March 2004.)

Conclusions

The results of LUTAQH clearly show that encouraging compact, mixed use developments offering transportation choices will help King County meet its adopted goals of increasing transit efficiency, reducing automobile dependency, and improving air quality and health. To achieve its goals, the County must coordinate and integrate its decisions to invest and allocate resources and services. Coordination of actions spanning transportation, land use, environment and health is required to bring about more sustainable, health promoting approaches to community design.

The study found that communities already exhibiting some of these attributes are delivering benefits to their residents in the form of less automobile dependency, more opportunities to be physically active and healthier and better air quality at the regional scale. These neighborhoods exist because, in the past, there was investment in compact neighborhoods with well-connected street networks, a mix of uses, and an orientation to transit.

Creating such communities is complex and requires many interlocking strategies, but King County is in a good position to reallocate its resources and become a national leader in making its neighborhoods more livable.

Recommendations

Federal, state, and local laws and policies have put King County in a strong position to act on the findings of this report. Federal transportation and air quality laws require the creation of plans that meet air quality standards and provide transportation choices. The Washington State Growth Management Act established Urban Growth Areas to focus metropolitan growth and to coordinate land use and transportation actions. The King County Comprehensive Plan supports mixed-use developments, non-motorized modes and the reduction of single-occupancy vehicle travel. The allocation of resources to projects and services plays a significant role in the formation of our communities and transportation system.

LUTAQH suggests additional actions and policies that can further King County's goals. Activities related to measuring, planning, and implementing the recommendations of this study are identified. Specific initiatives in targeted neighborhoods are recommended. Many of the actions are completely within the County's sphere of influence because the County has regulatory or fiscal mechanisms in place; the County can monitor its own performance in achieving a goal pursuant to a given strategy. Others require cooperation and partnerships with other jurisdictions.

Study Approach

A group of stakeholders, representing diverse backgrounds and expertise, worked with the project team to compare residents' travel patterns, automobile emissions, physical activity levels, and body mass index in different types of neighborhoods. The team collected detailed, parcel-level data on land use and data on transportation connections in neighborhoods across King County. This data was matched with information on residents' travel habits and physical activity collected by the Puget Sound Regional Council (PSRC), the National Institutes for Health Neighborhood Quality of Life Study, and Group Health Cooperative (Silver Sneakers data). A total of 3,200 households were included in the main portion of the PSRC study. The NIH and Group Health studies were used to apply health, attitudinal and age-related travel characteristics to the household population of the study.

The researchers examined the neighborhood surrounding each household, determining the area within a one-kilometer walk of the home. In many cases this area (known as the network buffer) was considerably smaller than a one-kilometer 'crow-fly' distance because of the limitations of the street network. The researchers then evaluated the characteristics of this area for each household to see how many and what types of destinations residents could reach within one kilometer of home. This information was used to discover the relationship between land use and travel choices. See Figure A.

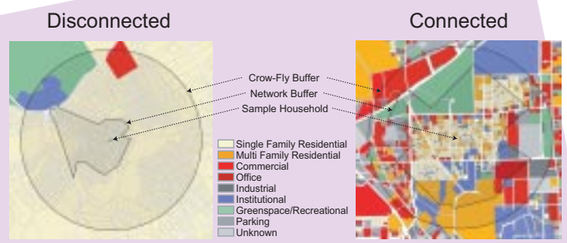

Figure A: Comparing Disconnected and Connected Environments [5]

Figure A shows how neighborhood settings can affect transportation choices. The household in the center of the neighborhood on the left is located in a spread-out ("sprawling") area with few shops and businesses within a walkable distance. The lack of through streets in this neighborhood and the presence of arterials with many lanes and inadequate sidewalks severely limit the destinations residents can reach within one-kilometer of their home. The household on the right is located in a more connected grid street network with different types of destinations within one kilometer, including shops, institutions, and parks. Such neighborhoods usually also have better sidewalks and pedestrian connections.

state and regional governments; public interest groups; other disciplines, especially public health agencies; and the private sector, such as property owners, developers and grant foundations.

II. Policy and Planning

a. Review and change policies and regulations that are a barrier to compact, mixed-use development. Separation of uses has been a hallmark of land use planning across the United States for decades and now presents a barrier to dynamic mixed-use projects. King County should reassess land use policies and regulations.

b. Create approval processes and incentives for urban developments that:

- create connected street networks with bicycle and pedestrian facilities,
- expand the trail network,
- increase density using superior design principles, and
- provide a balanced mix of residential, commercial, institutional, and recreational uses.

c. Develop new criteria for resource allocation in transportation and land use decisions. This can be accomplished by adding:

- research based land-use criteria into the programming process for transportation funding such as the Congestion Mitigation and Air Quality program and other transportation funding sources, and
- health factors in the regional Transportation Improvement Program selection process that recognize the health benefits of projects that enhance walkable communities.

d. Make land-use approvals subject to public health outcomes. Once it is clear that certain kinds of urban form produce certain types of health impacts, the approval process should be used to bring development decisions into alignment with County goals. Incentives should be available for projects meeting the criteria.

e. Develop Health Impact Assessments. Major development and transportation actions that impact urban form can be subject to Health Impact Assessment or other formal statements, similar to Environmental Impact Statements. The level of involvement can range from a review/coordination role to a regulatory/approval-denial permitting function. Data collected and models developed by LUTAQH provide the basis for empirical assessment of health related outcomes of alternative land development and transportation investment proposals.

III. Implementation

a. Improve street connectivity. Work with new developments to maximize connections between new projects and surrounding streets. Kent, for example, has developed an ordinance requiring developers to create neighborhood connections for pedestrians and bicyclists, as well as install appropriate traffic-calming devices.

b. Give priority to non-motorized travel. Walking and bicycling should be considered as functional transportation modes on par with the automobile. Designing new streets and roads as "complete streets" that work for all modes can do this. This can also include retrofitting existing streets with walking and biking facilities and/or traffic calming measures to improve travel speed and safety for these modes.

c. Expand the regional trail network. Trails offer connections between communities and provide opportunities for non-motorized travel to work, shop and recreation.

d. Increase transit access. Increase service frequency where increased ridership would result.

e. Make transit investments that support land-use decisions. Prioritize transit investments in

governments to transit supportive development.

2. Policies and regulations should be evaluated to reduce barriers to building compact, mixed-use developments with incentives for projects that will increase density and diversity in communities countywide.

3. More transportation funding should be allocated to transit and non-motorized improvements. The results suggest that significant savings, in terms of reduced health care costs, could accrue from this action, if done in a concerted fashion.[15]

Recommendations

Federal, state, and local laws and policies put King County in a strong position to act on the findings of this report. Federal transportation and air quality laws require the creation of plans that meet air quality requirements and provide transportation choices. The Washington State Growth Management Act established Urban Growth Areas to focus metropolitan growth, and to coordinate land use and transportation actions. The Comprehensive Plan in King County supports mixed-use developments, non-motorized modes and the reduction of single-occupancy vehicle travel; King County's transit plan also focuses on congestion relief and improved mobility. The allocation of resources for improvements and services plays a significant role in the form of our communities and the transportation system. Decisions about community form and transportation have been linked to growing public health concerns over obesity, lack of physical activity and respiratory diseases.

LUTAQH also identifies additional actions and policies that can further King County's goals, including activities related to measurement, planning, and implementation, as well as specific initiatives in targeted neighborhoods, described in more detail below. Many of the actions are completely within the County's sphere of influence, because the County has the implementation mechanisms (regulatory and/or fiscal), is the actor, and can monitor its performance towards achieving goals pursuant to a given strategy. Others require cooperation and partnerships with other jurisdictions.

The following represent strategies and actions to improve the links between land use, transportation, air quality, and health and are in support of adopted goals within King County's Comprehensive Plan:

I. Measurement & Education

a. Create performance measures. The land use, travel behavior, air quality, climate change, physical activity and BMI measures tested in LUTAQH provide a baseline for specific factors that can be integrated into the County's performance monitoring system and tracked over time to determine adherence with adopted policy. Such a "report card" concept is critical to know if things are getting better or worse and where actions need to be taken to improve the quality of life within the region.

b. Establish level of service criteria for all modes of transportation. What gets measured gets done. The Washington State Growth Management Act requires local governments to adopt level of service standards for arterial streets and transit routes. These standards do not usually include pedestrian trips or calculate the connectedness of a neighborhood. King County should establish level of service measures for walking and bicycling to assess use and adequacy of nonmotorized travel.

c. Educate and inform. The findings of the LUTAQH study can be used to help the general public understand the benefits of new development patterns and can help draw them into a robust public involvement process. This includes working with other cities, counties,

Integration of this information with the travel and health databases enabled researchers to look for relationships between the physical design of the environment where people live and work, and their reported travel, physical activity, and demographic characteristics. This data also allowed researchers to measure vehicle emissions, including ozone precursors and greenhouse gases. Emissions were estimated for each reported trip and then correlated with the land use characteristics of the areas where participants lived and worked. Figure B shows an example of a regional trip.

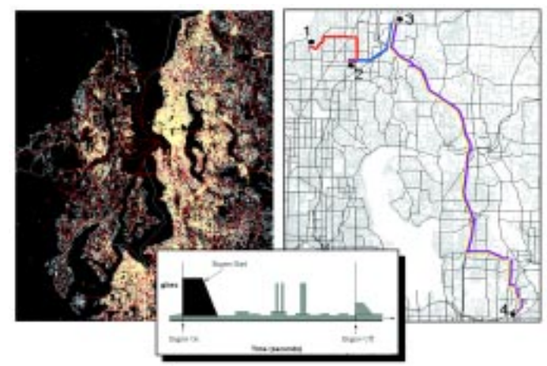

Figure B – Estimating Vehicle Emissions – regional trip and LANDSAT photo
(Source: Dr. William Bachman, GeoStats)

Three communities (White Center, Redmond, and Kent East-Hill) were examined in this study. Applying the study results to real communities increased the usefulness of the research for the development of policies that support transit and nonmotorized travel. The researchers applied the findings to make specific recommendations for improving outcomes in these communities and thereby established a demonstration of the potential benefits of this research project.

What We Found

On a per capita basis, as compared with more compact communities, higher-density residential neighborhoods with mixed land uses and a connected street network are associated with:

- less auto use,
- less air pollution,
- fewer greenhouse gas emissions,
- less energy consumption,[6]
- more transit ridership, walking and overall physical activity, and
- lower levels of obesity.[7]

These outcomes are consistent with many of the goals of the King County Comprehensive Plan. To encourage these outcomes, the County's resource allocations, development regulations, and related policy actions should be consistent with the goals in the Comprehensive Plan, requirements of Washington's Growth Management Act and actual growth/development.[8] This study shows what actions the County might take to further its goals of reducing auto dependency, increasing transportation choice and efficiency, and improving air quality and residents' health. The following sections outline these findings.

Transportation Efficiency and Choice

Transportation efficiency is best served by helping people travel shorter distances, with more opportunities to ride public transit, walk, or bicycle. The study found that mixed use – the commingling of homes with offices, shops, schools, parks, and other destinations – matters most when it comes to transportation efficiency. While residential density is needed to sustain commercial use and to make transit viable, providing retail destinations and activities near where people live and work also is critical. The potential to change travel patterns in King County is enormous — LUTAQH found that 42 percent of trips in the county are three miles or less, mostly distances easily traveled on foot or bicycle. Yet of the 16 percent of trips that are less than one mile, 43 percent are currently made by automobile drivers.

Walking

The research found that residents walk more in mixed-use neighborhoods with good street connections. The land uses most strongly linked to the percentage of household trips made on foot proved to be educational facilities, commercial office buildings, restaurants and taverns, parks, and neighborhood-scale retail establishments, with civic uses and grocery stores following closely. Having establishments such as these within a kilometer of one's home allows people to meet recommended physical activity needs by walking. Data showed the odds of walking increased by 20 percent for each additional park and 21 percent for each additional educational facility within a kilometer distance from where King County residents live. It is anticipated that this relationship is "non-linear" and that smaller increases in walking will likely result as demand for parks and schools is approached and met.

When controlling for demographics, LUTAQAH found for each quartile increase in:

- the number of intersections per square kilometer corresponding with a 14 per cent increase in the odds of walking for non-work travel;
- the levels of residential density corresponding with a 23 percent increase in the odds of walking for non-work travel; and
- the number of retail establishments corresponding with a 19 percent increase in the odds of walking for non-work travel.

The actual number of recreational, educational, retail, entertainment, and other commercial attractions near one's home may be more important than the size of the attraction itself in making the decision to walk. This is an important finding suggesting that more small uses interwoven in residential areas is the best way to encourage walking for errands and other non-work purposes. For example, a big box store does not affect walking as much as several smaller shops with the same total square footage.

The likelihood of walking increases the most when a number of these factors are combined:

- a variety of destinations close to home
- greater street connectivity
- greater residential density

Transit

Increased transit ridership was observed in the same locations where walking was more prevalent. LUTAQH discovered a synergistic relationship between transit use and neighborhood walkability. Neighborhoods with a greater mix of land uses, better street connectivity, and higher density supported both transit use for regional mobility and walking for nearby destinations. Whereas the number of non-residential destinations did the most to influence walking rates, the greatest relationship with transit use came from the total square footage of commercial destinations in the neighborhood.

Thirty-two percent of transit trips are for work commute. The design of the neighborhoods surrounding both home and work are important predictors in the choice to commute by transit. Distance to bus stops or stations also was an important predictor of transit's use. Over a two-day period the odds of someone reporting a transit trip to work decreased by 16 percent with each 1/4 mile increase in the distance to transit from home and 32 percent with each 1/4 mile increase in the distance to transit from work. Each additional vehicle per household was associated with a 45 percent decrease in the odds of taking transit to work.

When comparing across walkability (high to low), mean BMI decreased from 27.5 to 27.0 for low-income communities and from 26.5 to 25.5 for high-income communities, a result that was significant at the 94.3 percent confidence level. These results suggest walkability is an important predictor of BMI when controlling for income.

Demonstrating Causality

The research presented in this report relies on cross sectional data comparing the activities of different people located in different types of neighborhoods. Some would argue we do not know if this is a function of self-selection: that those who like to walk choose walkable neighborhoods. The reality is that when walkable places are created, people choosing to live in them walk more than their counterparts of similar socio-demographic makeup that live in more auto-oriented environments. Research quite similar to LUTAQH, conducted in Atlanta, found that one-third of residents in low-density, low walkability environments would prefer to live in more walkable places. These results indicate that both preference and built environment predict behavior.

The Implications for Resource Allocation

As stated above, a primary objective of LUTAQH is to guide the allocation of resources in the County to reduce automobile dependency, increase transportation efficiency, improve air quality, and improve health for King County residents. The study used primarily quantitative forms of analysis to examine the level of transit service, road congestion (relative travel time), and the walkability of the pedestrian environment at the individual and community levels in a variety of neighborhoods.

The past allocation of resources for transit, roads, and pedestrian and bike facilities has influenced the form of our communities. Transportation investment priorities have changed considerably over time. For example, the vintage of each community included in the case studies is reflected in each of its street network. White Center is an early 20th Century urban center – a classic "streetcar suburb" – with a gridiron layout of streets and blocks. Kent East Hill was developed more recently with a small network of auto-oriented arterials and many private roads that are part of self-contained developments, often with only one or two outlets to collector or major arterials. These differences are the result of decisions and investments made in past decades: in one case, to build a compact neighborhood centered around transit; in the second, to invest in automobile arterials while allowing somewhat isolated developments with separated uses. The LUTAQH study reveals how these decisions have affected the travel patterns, air pollution, and levels of physical activity observed in differing urban environments.

The results of the LUTAQH study indicate King County should consider allocating its resources to better facilitate reduced auto dependence, increase transit use, and improve the ability to walk and bicycle to destinations within neighborhoods. Whether the goal is to increase transportation efficiency, reduce automobile dependence or improve air quality and health, the study shows more compact development, a wider variety of land uses close to home and work, and a more connected street network with pedestrian facilities help achieve all of these goals. In order to create these conditions, the LUTAQH study indicates the County should redirect its resources in the following ways:

1. Transportation investments should place a high priority on the integration of transit and improvements for non-motorized travel, by creating safe facilities and convenient connections for walking, bicycling and access to transit. The County should give higher priority to new transit investments in areas best able to support transit use – based both on current conditions, and tangible commitments by local

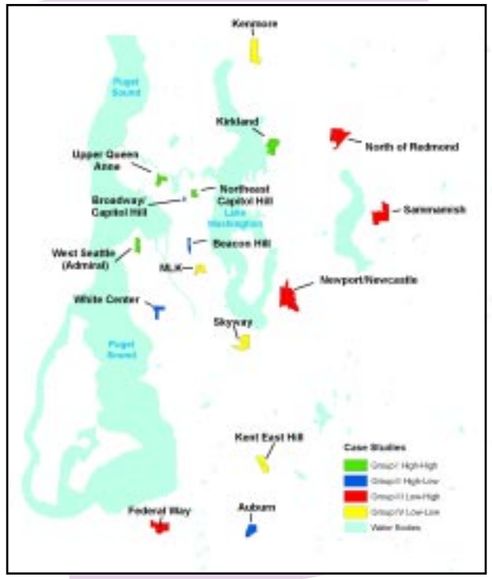

Figure E: Sixteen NQLS Communities

A higher proportion of participants in the more walkable communities (both low and high income) were found to achieve the U.S. Surgeon General recommended 30 minutes of moderate and vigorous activity per day (see Figure F). For low-income (SES) communities, the percent meeting the 30-minute threshold increased from 46 to 52 percent as walkability increased. For high-income (SES) communities, the percent meeting the 30-minute threshold increased from 44 to 58 percent as walkability increased. Results presented across walkability are significant at the 95 percent confidence level when adjusting for age and gender.

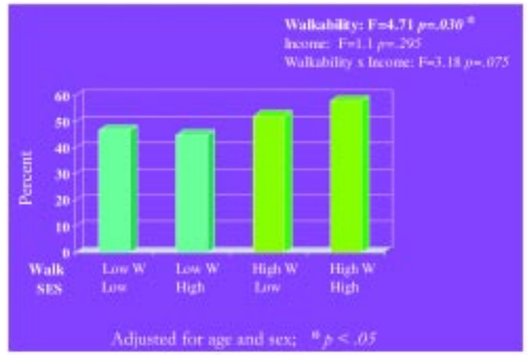

Figure F: Percent Meeting 30 Minutes Per Day Guideline: Moderate and Vigorous Activity (from Neighborhood Quality of Life Study)
(Note: W = walkability / SES = income)

Mean body mass index (BMI) was found to be lower in the more walkable communities suggesting that a lower proportion of people in these more walkable communities are obese or have a BMI exceeding 30. (See Figure G). The results hold true when comparing residents of communities with similar income but differing levels of walkability, but are most alarming in the low walk-low income communities where the mean of 27.5 is halfway between overweight (BMI = 25) and obese (BMI = 30).

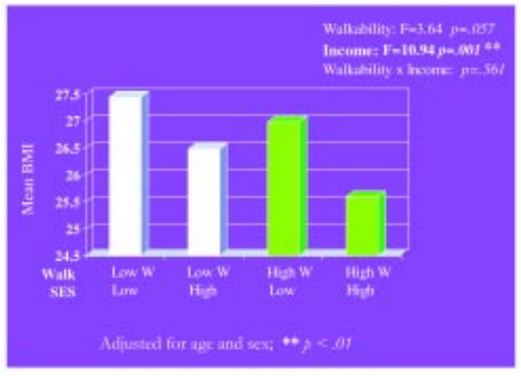

Figure G: Body Mass Index and Walkability (from Neighborhood Quality of Life Study)
(Note: W = walkability / SES = income)

Significant differences were found in travel times between transit and driving to major destinations in the region. In many parts of the county it takes as much as three times longer to get to a major urban destination using transit as opposed to a car.

Not surprisingly, the land uses most closely associated with the greater percentage of work trips on transit are also those associated with typical downtown areas: more commercial office floor space and retail floor space and a greater number of large retail attractions and office buildings. Areas that included predominantly fast food outlets, high tech companies, office parks and vacant land were found to be associated with lower transit ridership. One of the best indicators of transit use was the cost of parking and the level of employment density at the work trip destination, both variable measures directly related to typical downtown areas (parking charges and higher density) and suburban development (no parking charges and lower density).

All of the relationships found between transit use and urban form controlled for household size, income and number of household vehicles.

Automobile Dependency

Clearly where people are walking more and taking transit more frequently, they are driving less. Automobile dependency, as measured by vehicle miles traveled (VMT), decreased in neighborhoods with higher residential density and better street connectivity. The typical person surveyed drove an average of 29 miles per day, but the variation between persons was quite large. Compactness, the mix of land uses close to home, and a high retail floor area ratio were important factors linked to driving fewer miles. The results suggest that certain combinations of land uses can work synergistically to enable people to drive less.

A highly mixed land use pattern allows residents to accomplish a variety of activities within a small area without a car. Places where driving was lowest had more schools, grocery stores, rentable civic space, and more rentable space for doctors and dentists and other professional services. While the absolute number of non-residential destinations was most important, having more floor space devoted to commercial offices and neighborhood retail also was associated with less driving.

Fewer vehicle miles of travel (VMT) were observed for residents located in areas with greater residential density, land use mix, street connectivity, and retail floor area ratio as shown in Table 1.

Urban Form Factors	controlling for gender, income, age, education, total number of household vehicles, distance to nearest bus stop			
	Quartiles of Urban Form Variables			
	1	2	3	4
Retail Floor Area	30.16	30.48	30.50	25.57
Intersection Density	34.03	28.83	30.01	25.46
Residential Density	29.77	29.14	28.13	27.17
Mixed Use	32.26	30.38	27.94	27.15

Table 1 - Vehicle miles traveled across urban form factors[9]

The greatest differences in VMT were observed across levels of intersection density where mean VMT was 34 miles per person in the least and 25 miles in the most connected environments of King County. This represents 26% fewer vehicle miles of travel for residents who live in communities that have the most interconnected street networks in the county. By providing a more grid street network, with shorter blocks, more direct and shorter routes can be chosen. Increases in retail, residential and types of housing indicate an increased level of destinations nearby. More direct routes and nearer destinations can decrease travel distance for all modes and make walking, bicycling and transit

more convenient and viable.

More research will be helpful in further gauging which combinations of uses are the most synergistic in reducing auto reliance for specific types of trips.

Interestingly, not all commercial uses were associated with lower vehicle miles of travel. Neighborhoods with more convenience stores and fast food restaurants were linked with higher VMT. This is believed to be a function of the environment in which these uses are located, rather than the uses themselves. These analyses were controlled for gender, income, age, educational attainment, number of vehicles, and distance to transit. That is, the results transcend household characteristics and were independent of those variables.

Air Quality

The travel data from the study allowed the researchers to estimate the pollutants emitted during both automobile and transit trips. The analysis focused on the two pollutants most associated with smog and harmful ozone formation — volatile organic compounds (VOCs) and oxides of nitrogen (NOx).

Increased residential density, intersection density, land use mix, and floor area ratio (retail square footage divided by land area in retail use) near home and work were associated with lower per capita generation of NOx and VOCs.[10] At present, the region is more focused on strategies to reduce VOCs. As shown in Figure C, significantly lower levels of VOCs are generated by households located in areas with more intersections per square kilometer – more intersections correspond with areas with higher levels of street connectivity and direct connections between residences and nearby destinations.

Households with fewer than 36 intersections per square kilometer generated approximately 17.5 grams of VOCs per person per day, whereas those with more than 69 intersections per square kilometer generated about

* Controlled for gender, income, age, education level (bachelor degree or not), total number of vehicles in the household

* VOC differences across quartiles significant (p<0.001)

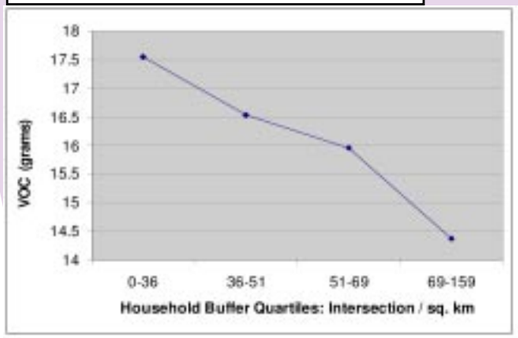

Figure C: Volatile Organic Compounds & Intersection Density Where People Live * (n=2467)

14.4 grams of VOCs per person per day.

These analyses also investigated the relationships between urban form where people work and the generation of VOCs. Significantly lower levels of VOC generation were found for respondents working in areas with higher concentrations of retail activity. As shown in Figure D, the more retail square footage within a kilometer distance of work locations, the fewer VOCs they generate. This analysis suggests that about 150,000 square feet of retail use within one kilometer of where people work is required before significant VOC reductions are observed. For work environments, the amount of retail was the best urban form predictor of VOC generation.

The research also showed street connectivity where people live appeared to be the most closely associated with the generation of oxides of nitrogen. Mean emissions of NOx declined from 29 to 23 grams per person per day, a 21 percent reduction, between residents of the least to the most connected environments.[11]

* Controlled for gender, income, age, total number of vehicles in the household

* VOC differences across quartiles significant (p<0.001

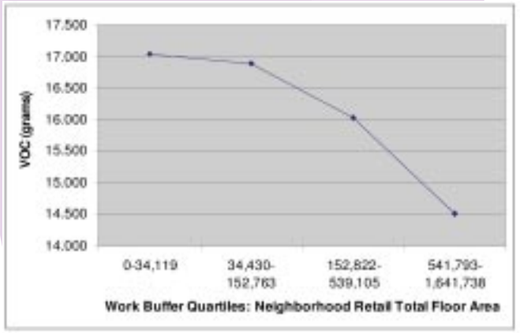

Figure D: Volatile Organic Compounds and Retail Use Where You Work * (n=2467)

Climate Change

Vehicle emissions account for over 60 percent of greenhouse gases, a major cause of climate change, in the central Puget Sound region. Climate change has been associated with loss of snow pack, which in turn affects water supply during critical times of the year for salmon.[12] Climate change also has been associated with lower water reservoir levels in the Cascades in recent years and droughts are projected to worsen. Projections suggest that this could one day threaten our ability to meet the basic water needs of King County residents; water availability for irrigation and for hydropower is already impacted.

In collaboration with the Center for Clean Air Policy (CCAP), LUTAQH extended its assessment to include measures of greenhouse gas formation. CCAP partnered with King County on this study by providing funding through the Bullitt Foundation and technical assistance to develop speed sensitive estimates of carbon dioxide (CO_2) production that could be used in the LUTAQH study. The study found that land use variables such as having retail close to home, intersection density and residential density and travel patterns including vehicle miles traveled (also a function of land use) explained about 24 percent of the variation in household level CO_2 production. Higher levels of land use mix, intersection density and residential density are associated with less greenhouse gas production on a per capita basis. The results control for vehicle ownership, household size, and income and suggest that urban form influences CO_2 indirectly through VMT and directly through travel speed and engine operation (such as cold start functions). These results inform and support the efforts now underway by the Puget Sound Clean Air Agency to reduce greenhouse gas formation within the central Puget Sound region through transportation efficient land use.

Physical Activity and Health[13]

The influence of urban form on health was studied through use of data collected for the Neighborhood Quality of Life Study (NQLS – see www.nqls.org). Sixteen NQLS communities were selected across King County to represent low and high levels of walkability (as measured by land use mix, density, connectivity, and floor area ratio of retail) and low and high levels of income, Socio-Economic Status (SES). These sixteen communities are shown in Figure E. Queen Anne, for example, is a high walkability and high income community shown in green, whereas Sammamish is a low walk and high income community shown in red. Community selection was conducted at the census block group level where measures of walkability were matched with census data on income and ethnicity.[14] About seventy-five participants between the age of 20 and 65 were recruited from each community and their physical activity levels were measured objectively with a physical activity monitor.