600 NE Grand Ave.
Portland, OR 97232-2736
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Metro | Agenda

Meeting: Transportation Policy Alternatives Committee (TPAC)
Date: Friday, August 31, 2012
Time: 9:30 a.m. to 12 p.m. (noon)
Place: Metro, Council Chamber

9:30 AM	**1.**		**Call to Order and Declaration of a Quorum**	**Elissa Gertler, Chair**
9:35 AM	**2.**	*	**Comments from the Chair and Committee Members** • Process to Request Regional Transportation Functional Plan Exemption or Extension • Gaps and Priorities for Recruitment of TPAC Community Representatives and Other Committee Positions	
9:40 AM	**3.**		**Citizen Communications to TPAC Agenda Items**	
9:45 AM	**4.**	*	**Consideration of the TPAC Minutes for July 27, 2012**	
9:50 AM	**5.**	*	Amend the 2012-13 Unified Planning Work Program (UPWP) to Add the OR8/OR47 Intersection Improvement Project: **Resolution No. 12-4366** – RECOMMENDATION TO JPACT REQUESTED • *Purpose*: TPAC consideration of proposed UPWP amendment. • *Outcome*: Recommendation to JPACT for inclusion of work plan and budget in the 2012-13 UPWP.	**Josh Naramore**
9:55 AM	**6.**	*	Possible Comment Letter on the Portland Metro Area Scenario Planning – DISCUSSION/DIRECTION TO STAFF • *Purpose*: TPAC member opinions on providing comment letter. • *Outcome*: TPAC direction on whether to write a comment letter.	**Tom Kloster**
10:05 AM	**7.**	*	Proposed 2015-18 Metropolitan Transportation Improvement Program Process and Schedule – INFORMATION/ DISCUSSION • *Purpose*: Present proposed process and schedule for 2015-18 MTIP. • *Outcome*: TPAC input on presentation of 2015-18 MTIP options to JPACT.	**Ted Leybold** **Josh Naramore**

11:05 AM	**8.**	*	Oregon Transportation Research & Education Consortium (OTREC) Report: Contextual Influences on Trip Generation – <u>INFORMATION/DISCUSSION</u>	**Kelly Clifton, PSU** **Miranda Bateschell**

- *<u>Purpose</u>*: Present the results of a PSU/OTREC/Metro-sponsored research project on trip generation. Provide Metro and community partners with a consistent and reliable method for adjusting ITE's trip generation rates for different urban contexts.

- *<u>Outcome</u>*: An understanding of how to consider non-automobile modes and determine trip rates that are sensitive to the urban environment where development is located.

12 PM	**9.**	**<u>ADJOURN</u>**	**Elissa Gertler, Chair**

* Material available electronically.
\# Material will be distributed in advance of the meeting.

For agenda and schedule information, call Kelsey Newell at 503-797-1916, e-mail: kelsey.newell@oregonmetro.gov.
To check on closure or cancellations during inclement weather please call 503-797-1700.

Future TPAC discussion items:

- MOVES update
- High Speed Rail
- Context sensitive design and least cost planning
- A briefing on the Metro Auditor's *Tracking Transportation Project Outcomes* report
- Congestion Pricing Pilot Study

2012 TPAC Work Program
8/24/12

August 31, 2012 – Regular Meeting	September 28, 2012 – Regular Meeting
• Amend the 2012-13 Unified Planning Work Program (UPWP) to Add the OR8/OR47 Intersection Planning Project – Action • Possible Comment Letter on the Portland Metro Area Scenario Planning – Discussion • Proposed 2015-18 MTIP Process and Schedule – Discussion • Contextual Influences on Trip Generation (OTREC report) – Information	• Regional Travel Options Recommendation and Grant Criteria – Discussion • 2010-2013 MTIP Amendment to Transportation System Management and Operations (TSMO) Funding - Action • 2014-2015 MTIP Amendment to Sub Allocate TSMO – Action
October 26, 2012 – Regular Meeting	**November 30, 2012 – Regular Meeting**
• Climate Smart Communities Scenarios – Discussion	• Climate Smart Communities Scenarios – Discussion

Parking Lot:

- MOVES update
- High Speed Rail
- Context sensitive design and least cost planning
- A briefing on the Metro Auditor's *Tracking Transportation Project Outcomes* report
- Congestion Pricing Pilot Study
- Metropolitan Planning Area boundary update
- Sustainable Transportation Analysis and Rating System (STARS)

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Metro | *Memo*

Date: August 24, 2012

To: TPAC, MTAC and interested parties

From: John Mermin, Senior Transportation Planner

Subject: Regional Transportation Functional Plan - Extension and Exemption processes

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PURPOSE

This memo provides guidance on how Metro will administer requests for extensions or exemptions from the Regional Transportation Functional Plan (RTFP).

BACKGROUND

The Regional Transportation Functional Plan (RTFP) is part of Metro Code (Chapter 3.08) and implements the policies contained in the Regional Transportation Plan. Per the Oregon Transportation Planning Rule (TPR), Cities and Counties local transportation system plans and implementing ordinances must be consistent with the RTFP.

During the Spring of 2012 Metro adopted a streamlined process for exemptions and extensions to be issued by its COO. To efficiently handle the large volume of requests for extensions and exemptions, Metro staff has proposed a batched process, whereby jurisdictions submit requests during designated windows this Fall. This process is described below.

EXTENSION REQUESTS

The original deadlines for RTFP compliance (See table 1 at end of memo) were developed in consultation with individual jurisdictions. The RTFP allows a city or county to seek an extension of time for compliance using a form provided by Metro. See attachment 1 for extension form. Metro staff will provide electronic copies in Word on its webpage. www.oregonmetro.gov/tsp For efficiency of processing, **please submit the extension form to Metro's COO between October 1 and 12th.** The criteria for receiving an extension is that:

1) Progress has been made toward compliance, or

2) There is good cause for failing to meet the deadline for compliance.

Upon receipt of an extension request, Metro will notify ODOT as required by the RTFP and will post the request on its website. Metro is required to respond to the request within 30 days.

EXEMPTION REQUESTS

Metro staff has identified four cities that likely meet the criteria for exemption. These include Rivergrove, Maywood Park, Johnson City, King City and Durham. (Note - The City of Durham has requested and received exemption as of August 15, 2012.) The criteria for exemption include:

1) Existing transportation system is generally adequate to meet its needs;

2) Little population or employment growth is expected; and

3) Exempting them would not make it more difficult to accommodate regional or state needs or to meet regional performance targets

Metro staff will contact these jurisdictions directly, since they do not typically participate in TPAC, MTAC or the County coordinating committees. Jurisdictions interested in an exemption should **submit a letter to Metro's COO, between November 5th and November 16th**. See attachment 2 for a sample letter. Upon receipt of an exemption request, Metro will notify ODOT & DLCD as required by RTFP, as well as post the request on its webpage. Metro will also contact the lead staff at the three County coordinating committees, Portland, and TriMet to give them a chance to inform neighboring jurisdictions and to submit comments if interested. Metro is required to respond to the request within 30 days.

Table 1. Existing RTFP Compliance Deadlines

Jurisdiction	2011	2012	2013
Beaverton	City is in compliance with RTFP		
Clackamas County		•	
Cornelius			•
Damascus	•		
Durham	Metro has issued exemption from RTFP through 2022		
Fairview		•	
Forest Grove			•
Gladstone			•
Gresham			•
Happy Valley		•	
Hillsboro			•
Johnson City	Metro supports city requesting exemption from RTFP		
King City	Metro supports city requesting exemption from RTFP		
Lake Oswego			•
Maywood Park	Metro supports city requesting exemption from RTFP		
Milwaukie		•	
Multnomah County	•		
Oregon City		•	
Portland			•
Rivergrove	Metro supports city requesting exemption from RTFP		
Sherwood		•	
Tigard	City is in compliance with RTFP		
Troutdale	•		
Tualatin		•	
West Linn		•	
Wilsonville		•	
Washington County		•	
Wood Village	•		

Metro

Extension of RTFP Compliance Deadlines

Jurisdiction: ____________________

Date: ____________________

Contact: ____________________

Telephone: ____________________

Email ____________________

Requests for extensions of Regional Transportation Functional Plan (RTFP) compliance deadlines, as authorized in Title 6 of the plan, must be filed with Metro's Chief Operating Officer (COO) on this application form.

Metro Code, 3.08.620, sets forth the criteria and procedure for Metro consideration of extensions of compliance deadlines. The criteria, from Metro Code 3.08.620(B), are as follows:

> *The Chief Operating Officer may grant an extension if: (1) the city or county is making progress toward compliance or (2) there is good cause for failure to meet the deadline for compliance.*

Please complete this application form and submit it to the Chief Operating Officer with a copy to John Mermin, Planning and Development Department:

Martha Bennett
Chief Operating Officer
Metro
600 NE Grand Avenue
Portland, OR 97232

Please submit this request between October 1 – October 12th, 2012.

Part I (*to be completed by the local government*)

a. Describe progress made toward compliance with the Functional Plan requirement(s) for which the local government needs more time. Provide desired date for a revised deadline.

b. Or, explain why the local government has not been able to meet the deadline set for compliance with the Functional Plan requirement(s). Provide desired date for a revised deadline.

Part II *(to be completed by Metro)*

a. Metro staff recommendation

Attachment 2. Sample RTFP Exemption Request Letter

Date

Martha Bennett
Chief Operating Officer
Metro
600 NE Grand Ave
Portland, OR 97232

Dear Ms, Bennett,

I am writing to request an exemption from the regional transportation functional plan. The City staff has discussed this request with Metro staff, who agrees that the City should be exempt from regional transportation functional plan requirements.

The City meets the exemption criteria established in Metro Code Section 3.08.640 as follows:

- XXX
- XXX
- XXX

Sincerely,

CC: John Mermin, Senior Transportation Planner

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TRANSPORTATION POLICY ALTERNATIVES COMMITTEE
July 27, 2012
Metro Regional Center, Council Chamber

MEMBERS PRESENT	AFFILIATION
Karen Buehrig	Clackamas County
David Eatwell	Community Representative
Carol Gossett	Community Representative
Heidi Guenin	Community Representative
Nancy Kraushaar	City of Wilsonville Representing Cities of Clackamas Co.
Katherine Kelly	City of Gresham, Representing Cities of Multnomah Co.
Scott King	Port of Portland
Alan Lehto	TriMet
Margaret Middleton	City of Beaverton, Representing Cities of Washington Co.
Dave Nordberg	Oregon Department of Environmental Quality
Paul Smith	City of Portland
Satvinder Sandhu	Federal Highway Administration
Rian Windsheimer	Oregon Department of Transportation

MEMBERS EXCUSED	AFFILIATION
Andy Back	Washington County
Chris Beanes	Community Representative
Brent Curtis	Washington County
Elissa Gertler, Chair	Metro
John Hoefs	C-TRAN
Nancy Kraushaar	City of Oregon City, Representing Cities of Clackamas Co.
Dean Lookingbill	Southwest Washington Regional Transportation Committee
Karen Schilling	Multnomah County
Charlie Stephens	Community Representative
Sharon Zimmerman	Washington State Department of Transportation

ALTERNATES PRESENT	AFFILIATION
Clark Berry	Washington County
Lynda David	Southwest Washington Regional Transportation Committee
Phil Healy	Port of Portland
Tom Kloster, Chair	Metro
Lainie Smith	Oregon Department of Transportation
Joanna Valencia	Multnomah County

STAFF: Dick Benner, Ted Leybold, Robin McArthur, Josh Naramore, Kelsey Newell, Dylan Rivera, Marc Week.

1. CALL TO ORDER AND DECLARATION OF A QUORUM

Chair Tom Kloster declared a quorum and called the meeting to order at 9:33 a.m.

2. COMMENTS FROM THE CHAIR AND COMMITTEE MEMBER

Mr. Ted Leybold of Metro provided an update on the Regional Travel Options (RTO) workgroup. The RTO workgroup was formed over the past year to make recommendations on sub allocations of grant process and the system management operations grant process. The group has discussed grant criteria for the new strategic plan that was recently adopted. The next meeting, which may be the last, will be held on August 20, which will develop the recommendation for the TPAC, JPACT approval.

Chair Tom Kloster noted that Ms. Joanna Valencia would be representing Multnomah County but has not officially been appointed. Ms. Nancy Kraushaar has returned to TPAC but is now representing the City of Wilsonville but still Cities of Clackamas County.

Ms. Carol Gossett noted that the City of Portland has adopted a resolution for the development of the Sullivan's Gulch Biking Trail. Ms. Gossett recognized Paul Smiths contribution to making the project happen.

3. CITIZEN COMMUNICATIONS TO TPAC ON NON-AGENDA ITEMS

There was none.

4. CONSIDERATION OF THE TPAC MINUTES FOR JUNE 29, 2012

MOTION: Ms. Lainie Smith moved, Mr. Scott King seconded, to approve the Transportation Policy Alternatives Committee (TPAC) minutes for June 29, 2012.

ACTION TAKEN: With all in favor, the motion passed.

5. PORTLAND METRO AREA SCENARIO PLANNING.

Mr. Bob Cortright of the Department of Land Conservation & Development (LCDC) discussed a draft Metropolitan Scenario Planning Rule by the LCDC. House Bill 2001 mandated that the LCDC shall by the end of 2012 adopt a rule that provides guidance to Metro and area local entities about when to adopt amendments to preferred scenarios to meet GHG reduction targets and when local governments need to amend plans to meet those reduction targets and when to update plans. The LCDC attempted to adopt these rules without creating new procedures on Metro or local governments. The LCDC convened a Rulemaking Advisory Committee (RAC) to tailor this rule to the area and to be informed on the work of the climate smart scenarios. Mr. Cortright explained how scenarios updates would go along with the UGB update process. On September 20^{th} The LCDC will hold a public hearing in Salem and another hearing on September 19th in Portland. Chair Kloster noted that at the August TPAC meeting Metro Staff would ask whether the committee wants to draft comments on the rules.

The committee discussed the following items:

- Committee members appreciated the LCDC for reaching out to the RAC members.
- Members asked when the review of the targets would take place. Mr. Cortright stated that the review of the targets is scheduled for 2015.

6. SUSTAINABLE TRANSPORTATION ANALYSIS & RATING SYSTEM (STARS)

Mr**.** Peter Hurley of the Portland Bureau of Transportation and Ms. Kelly Rodgers of the Sustainable Transportation Council provided a presentation on Sustainable Transportation Analysis & Rating System (STARS). STARS is a performance-based process for developing, analyzing, rating and comparing outcome based transportation plans and projects. STARS was developed by the Portland (OR) Bureau of Transportation, the North American Sustainable Transportation Council (STC) and the Santa Cruz County Regional Transportation Commission. STARS is a voluntary, national system for use by public agencies and private consultants to simplify alternative analysis and decision making. STARS intends to improve transportation outcomes by certifying and rewarding performance, much in the way LEED and the Living Building Challenge are improving building performance. STARS is designed to improve the Triple Bottom Line performance of transportation plans and projects, specifically to: Improve safe, affordable, healthy and equitable access to jobs, school, housing and goods; Cut petroleum use and greenhouse gas emissions; Provide local and regional economic benefit while reducing transportation capital and operating costs.

The committee discussed the following items:

- The committee asked about the factor of "Speed Consistency" in relation to the Colombia River Crossing. Mr**.** Hurley briefly explained technical aspects of the Speed consistency factor.
- The committee asked how the program compares to envision tools. Mr**.** Hurley noted that envision was similar the STARs but STARS is backwards forecasting and uses less adjustable factors.
- The committee discussed the factor of "Vehicle Miles Traveled" and how the program will have to changes with vehicle electrification. There are other key components to VMT other than fuel consumption such as health and equity.
- The committee discussed the scale that STARS program can be used. The program was designed for corridor and larger projects. It is being tested in places like bike corridors but may not be appropriate for a project such as an intersection.

7. <u>STATEWIDE TRANSPORTATION IMPROVEMENT PROGRAM UPDATE</u>

Mr. Leybold and Mr. Windsheimer provided an update on the proposed STIP process changes the OTC is considering. In response to direction from the Governor's office, ODOT staff has put together a proposal to the OTC for feedback and direction. The proposal would put all STIP allocations into two large categories, "Fix It" and "Enhance it". At the July OTC meeting, the commission he "Fix it" section of the proposal to move ahead while the "Enhance it" section is still under further OTC consideration. ODOT staff will work to balance out federal funding requirements. The OTC is considering changes of the allocation process for to Region I. Mr. Windsheimer overviewed three possible changes to Region I to include; keep the current process; JPACT continuing to be the allocation body in the Metro region while ODOT holds its own process outside of the MPO; The creation of an ACT or ACT like body for the entire Region I. Pat Egan will come to a special JPACT meeting to have a conversation with the local elected officials to discuss how the changes will work.

The committee discussed the following items:

- Some members expressed concern that the creation of an ACT for all of Region I would unfairly dilute the population of the Portland Metros representation given that the Metro area holds the vast majority of the Region I population.
- The committee discussed cross the eligibility of the proposed two categories. Mr. Windsheimer noted that "fit it" category would still have community involvement in decision-making and that "Enhance It" money can be used to leverage "Fix It" projects.

- Members stated they were relieved that the time line was moved back to give jurisdictions more time to comment and prepare applications.
- It was noted that Transportation and Growth Management, State Planning Congestion Mitigation and Air Quality and IOF funding remained separate from the two categories.
- Committee members asked why Intelligent Transportation Systems funds were in the "Fix it" categories.

10. ADJOURN

Chair Kloster adjourned the meeting at 11:25 a.m.

Respectfully submitted,

Marcus Week
Recording Secretary

ATTACHMENTS TO THE PUBLIC RECORD FOR JULY 27, 2012
The following have been included as part of the official public record:

ITEM	DOCUMENT TYPE	DOC DATE	DOCUMENT DESCRIPTION	DOCUMENT NO.
2	Email	07/24/12	NEEA LED streetlights article	072712t-01
4	Minutes	07/20/12	June 19 TPAC Minutes	072712t -02
5	Chart	07/27/12	Summary of Proposed Scenario Planning Process for Portland Metropolitan Area	072712t -03
6	PPT	07/27/12	Sustainable Transportation and Analysis Rating System	072712t -04
7	Handout	7/12	New funding allocation and project selection Timeline for 2015-2018 draft	072712t -05
7	Handout	6/11/12	Draft Multi-Modal transportation program/project Application	072712t-06

BEFORE THE METRO COUNCIL

FOR THE PURPOSE OF AMENDING THE FY 2012-13 UNIFIED PLANNING WORK PROGRAM (UPWP) TO ADD FUNDING FOR THE OR 8/47 INTERSECTION IMPROVEMENT PROJECT	)))))	RESOLUTION NO. 12-4366 Introduced by Chief Operating Officer Martha Bennett with the concurrence of Council President Tom Hughes

WHEREAS, the Unified Planning Work Program (UPWP) describes all Federally-funded transportation planning activities for the Portland-Vancouver metropolitan area to be conducted in FY 2012-13; and

WHEREAS, the FY 2012-13 UPWP indicates Federal funding sources for transportation planning activities carried out by Metro, Southwest Washington Regional Transportation Council, TriMet, Oregon Department of Transportation and other local jurisdictions; and

WHEREAS, approval of the budget elements of the FY 2012-13 UPWP is required to receive federal transportation planning funds; and

WHEREAS, regional flexible transportation funds (Urban – Surface Transportation Funding) were awarded by the Joint Policy Advisory Committee on Transportation (JPACT) and the Metro Council to the City of Forest Grove; and

WHEREAS, those funds were adopted by JPACT and the Metro Council as a part of the 2012-15 Metropolitan Transportation Improvement Program (MTIP) to be available to Metro in fiscal year 2013; and

WHEREAS, a planning phase for this project has recently been identified and therefore the OR 8/47 intersection improvement project was not included in the adopted FY 2012-13 UPWP;

WHEREAS, all Federally-funded transportation planning projects for the Portland-Vancouver metropolitan area must be included in the FY 2012-13 UPWP; now therefore

BE IT RESOLVED that the Metro Council hereby amends the FY 2012-13 UPWP to add the OR 8/47 intersection improvement project as shown in the attached Exhibit A.

ADOPTED by the Metro Council this [insert date] day of [insert month], 2012

____
Tom Hughes, Metro Council President

Approved as to Form:

____
Alison Kean Campbell, Metro Attorney

OR 8/47 Intersection Improvement Project

Description:

There is a need for improving safety, operations, and capacity where the intersection of Regional Freight Corridors 23 (Hwy 47 or Quince St.) and Regional Freight Corridor 24 (Hwy 8 or Pacific Ave) come together. This intersection is not only significant because of it's close proximity to the City Industrial Park, but because it is the primary through-route for freight traveling to and from Highway 26, the Oregon Coast, and areas south of Forest Grove. This improvement project meets the highest level criteria of reducing freight vehicle delay by addressing a bottleneck at an intersection of two freight routes. Additionally, the project will add a new pedestrian crossing where currently none exist.

Objectives:

The first phase (i.e. development phase) of the project has three main objectives: research/analysis, development of key design elements, and completion of a project prospectus. The first phase includes a 30% design of the improvements and the second phase of the project will be final design and construction.

Previous Work:

No formal work has occurred on this project yet. Some preliminary planning, traffic count collection, and cost estimating was completed during the development of application for funding.

Methodology:

A consultant with experience in traffic planning, design, and engineering will be hired for the project. The initial project phase entails completing a planning phase including 30% design for intersection Improvements. The initial project phase includes data collection and analysis, design element development, and preparation of project prospectus. Later phase includes final design and construction.

Tangible Products Expected in FY 2012-13:

- Research/Analysis
- Design Element Development
- Project Prospectus

Entity/ies Responsible for Activity:

City of Forest Grove – Lead Agency
Metro – Cooperate/Collaborate
Oregon Department of Transportation – Cooperate/Collaborate

Schedule for Completing Activities:

Development Phase Tasks		Begin	Complete	Comments
1	Project Management and Coordination			Complete Project Charter. Project management and coordination ongoing throughout project duration.
2	Data Collection and Analysis			Complete Survey of Existing Conditions, Utilities Memorandum, Traffic Analysis Report and Access Management Strategy
3	Design Element Development			Complete Land Use and Environmental Narrative Reports, Concept Drawings and Total Project Cost Estimates
4	Project Prospectus			Complete Project Prospectus, Parts 1, 2 and 3

Notes: Schedule dates to be included once consultant has been selected.

FY 2012-13 Costs and Funding Sources:

Requirements:				**Resources:**		
Personal Services						
Interfund Transfers						
Materials & Services						
TOTAL	$	175,000		TOTAL	$	175,000
Full-Time Equivalent Staffing						
Regular Full-Time FTE						
TOTAL						

STAFF REPORT

IN CONSIDERATION OF RESOLUTION NO. 12-4366, FOR THE PURPOSE OF AMENDING THE FY 2012-13 UNIFIED PLANNING WORK PROGRAM (UPWP) TO ADD FUNDING FOR THE OR 8/47 INTERSECTION IMPROVEMENT PROJECT

Date: August 20, 2012

Prepared by: Josh Naramore
(503) 797-1825

BACKGROUND

On April 19, 2012, the Metro Council adopted the FY 2012-13 Unified Planning Work Program ("UPWP") via Resolution No. 12-4335 ("FOR THE PURPOSE OF CERTIFYING THAT THE PORTLAND METROPOLITAN AREA IS IN COMPLIANCE WITH FEDERAL TRANSPORATION PLANNING REQUIREMENTS AND ADOPTING THE FY 2012-13 UNIFIED PLANNING WORK PROGRAM ").

This resolution is an amendment to the FY 2012-13 UPWP to add the OR 8/47 intersection improvement project. This project was awarded regional flexible funds by the Joint Policy Advisory Committee on Transportation (JPACT) and the Metro Council and was adopted as part of the 2012-15 Metropolitan Transportation Improvement Program (MTIP) by Resolution 12-4332.

Funds were originally programmed in fiscal year 2012-13 that runs from October 1, 2012 – September 30, 2013 to begin preliminary engineering. However, it was recently determined that a planning phase is needed to better develop more preliminary design details, further refine cost estimates, and allow more time to secure additional matching funds. The planning phase cost is estimated to be $175,000. Per federal requirements, all transportation planning projects that are federally funded are required to be included in the UPWP. The proposed UPWP narrative for the OR 8/47 intersection improvement project is included in Exhibit A.

ANALYSIS/INFORMATION

1. **Known Opposition** – No known opposition
2. **Legal Antecedents**

   Metro Council Resolution No. 12-4335: FOR THE PURPOSE OF CERTIFYING THAT THE PORTLAND METROPOLITAN AREA IS IN COMPLIANCE WITH FEDERAL TRANSPORTATION PLANNING REQUIREMENTS AND ADOPTING THE FY 2012-13 UNIFIED PLANNING WORK PROGRAM, adopted by the Metro Council on April 19, 2012.

   Metro Council Resolution No. 12-4332: FOR THE PURPOSE OF APPROVING THE 2012-2015 METROPOLITAN TRANSPORTATION IMPROVEMENT PROGRAM FOR THE PORTLAND METROPOLITAN AREA, adopted by the Metro Council March 15, 2012.
3. **Anticipated Effects** – Approval will mean that grants can be submitted and contracts executed so work can commence work on this project between now and June 30, 2013, in accordance with established Metro priorities.
4. **Budget Impacts** – None anticipated.

RECOMMENDED ACTION

Approve Resolution No. 12-4366 and amend the FY 2012-13 UPWP.

Proposed Administrative Rules for

Portland Area Land Use and Transportation Scenario Planning

Background

House Bill 2001, adopted by the 2009 Legislature, directs the Land Conservation and Development Commission (LCDC) to adopt administrative rules to guide Metro and local governments in the Portland metropolitan area as they conduct land use and transportation scenario planning to reduce greenhouse gas emissions from light vehicle travel. LCDC is required to adopt the scenario planning rules by January 1, 2013. The proposed rules would apply only to the Portland metropolitan area.

Scenario planning by the Portland metropolitan area is one part of a statewide effort to reduce greenhouse gas emissions from all sources. Scenario planning considers other efforts to reduce emissions from the transportation sector including expected changes to the transportation system, and improvements to vehicle and fuel technologies as well as other factors

Why is the rule needed?

In 2007, the Oregon Legislature affirmed that global warming poses a serious threat to the economic well-being, public health, natural resources and environment of Oregon. The legislature set a statewide goal of reducing greenhouse gas emissions by 75% below 1990 levels by 2050.

Light vehicles – passenger cars, vans and pickup trucks - are responsible for 20% of Oregon's greenhouse gas emissions, and much of that comes from travel within Portland metropolitan area. Changes to land use and transportation patterns in metropolitan areas that reduce the distances people need to drive and that expand transportation options are and important and effective way reduce greenhouse gas emissions. Through scenario planning the region can explore and develop an approach to reduce greenhouse gas emissions that best meets a range of regional and local needs – for economic growth, livable communities, clean air, and other values.

What will this rule do?

The proposed rules would require Metro - in coordination with area local governments and other agencies – to develop, evaluate and cooperatively select a preferred land use and transportation scenario for meeting state adopted targets for reducing greenhouse gas emissions from light vehicle travel by 20% by the year 2035.

The proposed rules:

- describe how Metro is to conduct scenario planning, including the factors Metro is required to consider in developing and selecting a preferred scenario.
- require that Metro adopt a preferred scenario by December 2014 as an amendment to the regional framework plan.
- describe the process by which LCDC will review and approve Metro's preferred scenario
- outline the process for Metro and local governments to make necessary amendments to other regional and local plans to carry out the preferred scenario.

The proposed rules would also require that Metro monitor and report on progress in carrying out the preferred scenario, and to update the preferred scenario at regular intervals.

How does the proposed rule relate to existing plans and other planning requirements?

The proposed rules would integrate requirements for scenario planning into the existing framework for land use and transportation planning in the Portland metropolitan area. As much as much as possible, the proposed rules are intended to use existing plans and avoid creating new procedures or requirements for Metro, and area local governments. For example, monitoring and updates to the preferred scenario are to be done as part of reports and updates that region is already scheduled or required to conduct – such as urban growth boundary updates.

Metro and area local governments are already in the process of exploring the region's options for reducing GHG emissions and meeting other important regional goals through the region's Climate Smart Communities project. Initial findings from the project – available on the project website – indicate that the state targets can be met, and that existing plans move the region in the right direction, but that additional efforts will be needed.

Through scenario planning, local governments will consider a range of actions to reduce emissions, including new programs or investments which support changes to land use patterns which reduce the distances people need to drive, expanding transportation options and encouraging the use of electric vehicles or other low-emission technologies.

Who may be affected?

As provided in HB 2001, the proposed rules would apply only to the Portland metropolitan area. While the Eugene-Springfield metropolitan area is also required to conduct scenario planning, it would not be subject to these rules. The state's other metropolitan areas (Salem, Bend, Corvallis, and the Rogue Valley) are encouraged, but not required, to conduct scenario planning, and are also unaffected by the proposed rules.

How was this proposal developed?

The department developed the proposed rule with the assistance of a Rulemaking Advisory Committee (RAC) The department and the RAC developed the rule based on the requirements in HB 2001. The RAC met four times between February and May 2012 to advise the department on the details of the proposed rule.

Rulemaking materials available

The proposed rule and other supporting documents, including the Statement of Need and Fiscal Impact, provide additional information about this proposed rulemaking. The documents can be viewed at:
http://www.oregon.gov/LCD/rulemaking.shtml

The principal documents the Department used to develop the proposed rules include the relevant provisions of House Bill 2001, and supporting materials provided to the Rulemaking Advisory Committee (RAC). These documents, including the RAC meeting summaries and the supporting documents are available on the Department's website at:
http://www.oregon.gov/LCD/meetings.shtml - SB_1059_and_HB_2001_Rulemaking
The public can also view copies of these documents at the Department's Salem office at 635 Capitol St. NE, Suite 150.

Further Information about Metro's Climate Smart Communities Project

As discussed above, Metro and area local governments are already in the process of developing and evaluating possible ways for the region to reduce greenhouse gas emissions, and to meet other regional goals and objectives through the Climate Smart Communities project. Detailed information about the options being considered and the methods for evaluating different options is available on Metro's website at:
http://www.oregonmetro.gov/index.cfm/go/by.web/id=36945

Public hearings

Two public hearings on the proposed rules are scheduled:

- September 19th in Portland at the Metro Council Chambers (800 NE Grand Avenue, Portland)
- September 20th at 9:00 am in Salem at the state Agriculture Building, 635 Capitol St. NE, in the Basement Hearing Room.

LCDC will consider adopting the proposed rule at its November 2012 meeting in Newberg. (See DLCD website for details.)

How to comment

Interested persons may submit comments on the proposed rulemaking in writing via mail, fax, or email at any time prior to the close of the hearing on September 20.

Please address written comments to the Chair of the Land Conservation and Development Commission care of Casaria Taylor at the Department of Land Conservation and Development, 635 Capitol St, NE, Suite 150, Salem, OR 97301-2540 or email comments to Casaria Taylor at casaria.taylor@state.or.us. You may also fax comments to (503) 378-5518.

Interested persons may testify during the public hearings on September 19th or 20th, or submit written comments at the hearing by providing 20 copies to the commission's assistant.

If you have questions about the proposed rule or would like additional information, contact Bob Cortright at (503) 373-0050 ext. 241 or by email to bob.cortright@state.or.us.

Summary of Proposed Scenario Planning Process for Portland Metropolitan Area

(Objective: Integrate scenario planning required by HB 2001 into existing process for coordinated regional and local planning in the Portland metropolitan area)

	Selection of Preferred Scenario	**Regional Implementation**	**Local Implementation**			**Monitoring**	**Update**
Responsible Agency	Metro		Cities & Counties			Metro	
Action	Amendment to Regional Framework Plan; Growth Concept	Adopt or amend Functional Plans, including the Regional Transportation System Plan	Update / Amend Comprehensive Plans	Update /Amend Transportation System Plans	Other Plan Amendments	Performance Measure Report to LCDC	Amendment to Regional Framework Plan
Timing	By December 2014	Within 1 year of LCDC Approval of Preferred Scenario (Early 2016)	Within two years of Metro adoption of Functional Plan amendments or as otherwise specified in Metro's Functional Plans (Early 2018)		Starting 1 year from Metro adoption of preferred scenario (December 2015)	Every two years (December 2017)	In conjunction with Urban Growth Report, UGB review (2020)
Standards	Land use and transportation concept map, policies programs that achieves GHG reduction targets; sets performance measures and targets for implementation	Amendments consistent with and adequate to implement relevant parts of the preferred scenario including requirements and timelines for local comp plan and TSP amendments	Consistent with regional functional plan requirements adopted by Metro		Consistent with preferred scenario	- Evaluates progress in implementing preferred scenario and performance measures - Assesses whether additional or corrective actions are needed	-Revise preferred scenario to meet updated targets -Focus on additional actions and programs to implement growth concept in the preferred scenario
Review	By LCDC "in manner of periodic review"		Local amendments reviewable as provided by Metro in functional plans. (Appeals to LUBA)			Reports to LCDC	
Link to existing regional process	Scenario planning is new, but Regional Framework Plan is to be updated every 7 years.	Functional plans are Metro's method to implement framework plan, provide direction to locals	Process for local implementation corresponds with existing arrangement for implementation of functional plan amendments			Expands scope of report currently required by ORS 197.301	Ties review and update of preferred scenario to UGB monitoring and update required by ORS 197.299

July 27, 2012

PROPOSED RULE AMENDMENTS AND NEW RULES

August 1, 2012

DIVISION 44

METROPOLITAN GREENHOUSE GAS REDUCTION TARGETS AND PORTLAND METROPOLITAN AREA SCENARIO PLANNING

660-044-0000
Purpose

(1) This division implements provisions of section 37 (6), chapter 865, Oregon Laws 2009, and section 5 (1), chapter 85, Oregon Laws 2010, that direct the Land Conservation and Development Commission ("commission") to adopt rules setting targets for reducing greenhouse gas emissions from light vehicle travel for each of the state's metropolitan areas for the year 2035 to aid in meeting the state goal in ORS 468A.205 to reduce the state's greenhouse gas emissions in 2050 to 75 percent below 1990 levels.

(2) This division also implements provisions of Oregon Laws 2009, chapter 865, Section 38 regarding land use and transportation scenario planning to reduce greenhouse gas emissions in the Portland metropolitan area. The commission's intent and expectation is that the requirements set forth in this rule will be integrated into and addressed as part of existing procedures for coordinated regional planning in the Portland metropolitan area. The requirements set forth in this division for scenario planning apply only to the Portland metropolitan area. Nothing in this division is intended to require scenario planning be conducted by other metropolitan areas, or provide for commission or department review or approval of scenario plans developed or adopted by other metropolitan areas. While a preferred scenario may include assumptions about state or federal policies, programs or actions that would be put in place to reduce greenhouse gas emissions, nothing in this division or commission approval of a preferred scenario is intended to grant authority to the commission, Metro or local governments to approve or require implementation of those policies, programs or actions.

(3) ~~(2)~~The targets in this division provide guidance to local governments in metropolitan areas on the level of reduction in greenhouse gas emissions to achieve as they conduct land use and transportation scenario planning. Land use and transportation scenario planning to meet the targets in this division is required of the Portland metropolitan area and is encouraged, but not required, in other metropolitan areas. Success in developing scenarios that meet the targets will depend in large part on the state funding for scenario planning; on the state developing strategies and actions that reduce greenhouse gas emissions from light vehicle travel within metropolitan areas; and on state and local governments jointly and actively engaging the public on the costs and benefits of reducing greenhouse gas emissions.

(4) ~~(3)~~Land use and transportation scenario planning is intended to be a means for local governments in metropolitan areas to explore ways that urban development patterns and transportation systems would need to be changed to achieve significant reductions in greenhouse gas emissions from light vehicle travel. Scenario planning is a means to address benefits and costs of different actions to accomplish reductions in ways that allow communities to assess how to meet other important needs, including accommodating economic development and housing needs, expanding transportation options and reducing transportation costs.

(5) ~~(4)~~The expected result of land use and transportation scenario planning is information on the extent of changes to land use patterns and transportation systems in metropolitan areas needed to significantly reduce greenhouse gas emissions from light vehicle travel in metropolitan areas, including information about the benefits and costs of achieving those reductions. The results of land use and transportation scenario planning are expected to inform local governments as they update their comprehensive plans, and to inform the legislature, state agencies and the public as the state develops and implements an overall strategy to meet state goals to reduce greenhouse gas emissions.

(6) ~~(5)~~The greenhouse gas emissions reduction targets in this division are intended to guide an initial round of land use and transportation scenario planning over the next two to four years. The targets are based on available information and current estimates about key factors, including improvements in vehicle technologies and fuels. Pursuant to OAR 660-044-0035, the commission shall review the targets by June 1, 2015, based on the results of scenario planning, and updated information about expected changes in vehicle technologies and fuels, state policies and other factors.

(7) ~~(6)~~Success in meeting the targets will require a combination of local, regional and state actions. State actions include not only improvements in vehicle technology and fuels, but also other statewide efforts to reduce greenhouse gas emissions from light vehicle travel. These efforts—which are programs and actions to be implemented at the state level—are currently under review by the Oregon Department of Transportation as part of its Statewide Transportation Strategy to reduce greenhouse gas emissions. As metropolitan areas develop scenario plans to reduce greenhouse gas emissions and compare them to the targets in this division, it is incumbent that metropolitan areas and the state work as partners, with a shared responsibility of determining how local and statewide actions and programs can reach the targets.

(8) ~~(7)~~Nothing in this division is intended to amend statewide planning goals or administrative rules adopted to implement statewide planning goals.

Stat. Auth.: ORS 197.040; Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(6) and (8); Chapter 85 Oregon Laws 2010 Special Session (Senate Bill 1059) §5
Stats. Implemented: Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(6) and (8); Chapter 85 Oregon Laws 2010 Special Session (Senate Bill 1059) §5
Hist.: LCDC 5-2011, f. 5-26-11, cert. ef. 6-1-11

660-044-0005
Definitions

For the purposes of this division, the definitions in ORS 197.015 and the statewide planning goals apply. In addition, the following definitions shall apply:

(1) "1990 baseline emissions" means the estimate of greenhouse gas emissions from light vehicle travel in each metropolitan area for the year 1990, as presented by the Department of Environmental Quality and the Oregon Department of Energy included in the Agencies' Technical Report.

(2) "2005 emissions levels" means an estimate of greenhouse gas emissions from light vehicle travel in a metropolitan area for the year 2005.

(3) "2035 greenhouse gas emissions reduction goal" means the percentage reduction in greenhouse gas emissions from light vehicle travel in a metropolitan area needed by the year 2035 in order to meet the state goal of a 75 percent reduction in greenhouse gas emissions from 1990 levels by the year 2050 as recommended by the Department of Environmental Quality and the Oregon Department of Energy in the Agencies' Technical Report.

(4) "Agencies' Technical Report" means the report prepared by the Oregon Department of Transportation, the Department of Environmental Quality and the Oregon Department of Energy and submitted to the commission on March 1, 2011, that provides information and estimates about vehicle technologies and vehicle fleet to support adoption of greenhouse gas reduction targets as required by section 37 (7), chapter 865, Oregon Laws 2009, and section 5 (2), chapter 85, Oregon Laws 2010.

(5) "Design type" means the conceptual areas described in the Metro ~~2040~~ Growth Concept text and map in Metro's regional framework plan, including central city, regional centers, town centers, station communities, corridors, main streets, neighborhoods, industrial areas and employment areas.

(6) "Framework plan" or "regional framework plan" means the plan adopted by Metro pursuant to ORS 197.015(17).

(7) "Functional plan" or "regional functional plan" means an ordinance adopted by Metro to implement the regional framework plan through city and county comprehensive plans and land use regulations.

(8) ~~(5)~~"Greenhouse gas" means any gas that contributes to anthropogenic global warming including, but not limited to, carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride. ORS 468A.210(2). Greenhouse gases are generally measured in terms of CO_2 equivalents—CO_2e—which means the quantity of a given greenhouse gas multiplied by a global warming potential factor provided in a state-approved emissions reporting protocol.

(9) ~~(6)~~"Greenhouse gas emissions reduction target" or "target" means the percent reduction in greenhouse gas emissions from light vehicle travel within a metropolitan area from 2005 emissions levels that is to be met by the year 2035 through scenario planning. Greenhouse gas emissions reduction targets are expressed as a percentage reduction in emissions per capita, *i.e.*, total emissions divided by the population of the metropolitan area. Targets represent additional reductions from 2005 emissions levels beyond reductions in vehicle emissions that are likely to result by 2035 from the use of improved vehicle technologies and fuels and changes to the vehicle fleet. When determining whether a scenario meets a target, the reduction per capita is to be calculated as a percentage of the emissions per capita assuming 2005 light vehicle travel per capita and 2035 baseline assumptions for light vehicle technologies, fuels and fleet as set forth in Tables 1 and 2 of OAR 660-044-0010. The combined effect of the baseline assumptions for light vehicle technologies, fuels and fleet from 1990 to 2035, estimated changes to light vehicle travel from 1990 to 2005, and scenario planning to meet targets from 2005 to 2035 is to meet the greenhouse gas emissions reduction goal from 1990 to 2035.

(10) ~~(7)~~"Greenhouse gas emissions reduction toolkit" means the toolkit prepared by the Oregon Department of Transportation and the department to assist local governments in developing and executing actions and programs to reduce greenhouse gas emissions from light vehicle travel in metropolitan areas as provided in section 4, chapter 85, Oregon Laws 2010.

(11) ~~(8)~~"Land use and transportation scenario planning" means the preparation and evaluation by local governments of two or more land use and transportation scenarios and the cooperative selection of a preferred scenario that accommodates planned population and employment growth while achieving a reduction in greenhouse gas emissions from light vehicle travel in the metropolitan area. Land use and transportation scenario planning may include preparation and evaluation of alternative scenarios that do not meet targets specified in this division.

(12) ~~(9)~~"Light vehicles" means motor vehicles with a gross vehicle weight rating of 10,000 pounds or less.

(13) ~~(10)~~"Light vehicle travel within a metropolitan area" means trips made by light vehicles that begin and end within the same metropolitan planning area, and that portion of other trips made by light vehicles that occurs within the metropolitan planning area, including a portion of through trips (*i.e.*, trips that pass through the metropolitan planning area but do not begin or end there) and that portion within the metropolitan planning area of other light vehicle trips that begin or end within the metropolitan planning area. Trips and portions of trips that are within the metropolitan planning area are illustrated by solid lines as shown in Figure 1.

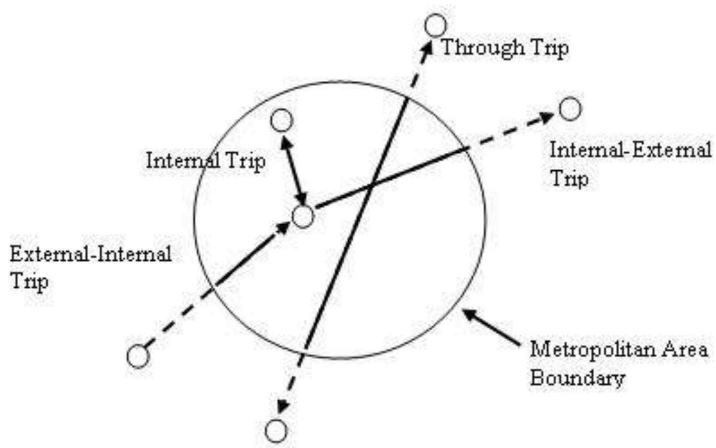

Figure 1. Light vehicle travel within a metropolitan area. Circles indicate trip origins and destinations. Arrows indicate the direction of travel. Solid lines indicate the portion of each type of trip that is considered travel within a metropolitan area for purposes of this definition.

(14) "Metro" means the metropolitan service district organized for the Portland metropolitan area under ORS chapter 268.

(15) ~~(11)~~"Metropolitan planning area" or "metropolitan area" means lands within the boundary of a metropolitan planning organization as of the effective date of this division.

(16) ~~(12)~~"Metropolitan planning organization" means an organization located wholly within the State of Oregon and designated by the Governor to coordinate transportation planning in an urbanized area of the state pursuant to 49 U.S.C. 5303(c). ORS 197.629(7). Included are metropolitan planning organizations for the following areas: the Portland metropolitan area, the Bend metropolitan area, the Corvallis metropolitan area, the Eugene-Springfield metropolitan area, the Salem-Keizer metropolitan area and the Rogue Valley metropolitan area.

(17) "Planning period" means the period of time over which the expected outcomes of a scenario plan estimated, measured from a base year, typically 2005, to a future year that corresponds with greenhouse gas emission targets set forth in this division.

(18) "Preferred land use and transportation scenario" means a generalized plan for the Portland metropolitan area adopted by Metro through amendments to the regional framework plan that achieves the targets for reducing greenhouse gas emissions set forth in OAR 660-044-0020 as provided in OAR 660-044-0040

(19) ~~(13)~~"Scenario planning guidelines" means the guidelines established by the Oregon Department of Transportation and the department to assist local governments in conducting land use and transportation scenario planning to reduce greenhouse gas emissions from light vehicle travel in metropolitan areas as provided in section 3, chapter 85, Oregon Laws 2010.

(20) ~~(14)~~"Statewide Transportation Strategy" means the statewide strategy adopted by the Oregon Transportation Commission as part of the state transportation policy to aid in achieving the greenhouse gas emissions reduction goals set forth in ORS 468A.205 as provided in section 2, chapter 85, Oregon Laws 2010.

Stat. Auth.: ORS 197.040; Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(6) and (8); Chapter 85 Oregon Laws 2010 Special Session (Senate Bill 1059) §5
Stats. Implemented: Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(6) and (8); Chapter 85 Oregon Laws 2010 Special Session (Senate Bill 1059) §5
Hist.: LCDC 5-2011, f. 5-26-11, cert. ef. 6-1-11

No amendments are proposed to the following rules in this division:

660-044-0010
Target Setting Process and Considerations

660-044-0020
Greenhouse Gas Emissions Reduction Target for the Portland Metropolitan Area

660-044-0025
Greenhouse Gas Emissions Reduction Targets for Other Metropolitan Areas

660-044-0030
Methods for Estimating Greenhouse Gas Emissions and Emissions Reductions

660-044-0035
Review and Evaluation of Greenhouse Gas Reduction Targets

660-044-0020
Greenhouse Gas Emissions Reduction Target for the Portland Metropolitan Area

<u>(The text of this rule is included for information only. No amendments are proposed to this rule.)</u>

(1) Purpose and effect of targets

(a) Metro shall use the greenhouse gas emissions reduction targets set forth in section (3) of this rule as it develops two or more alternative land use and transportation scenarios that accommodate planned population and employment growth while achieving a reduction in greenhouse gas emissions from light vehicle travel in the metropolitan area as required by section 37 (6), chapter 865, Oregon Laws 2009.

(b) This rule does not require that Metro or local governments in the Portland metropolitan area select a preferred scenario or amend the Metro regional framework plan (as defined in ORS 197.015(16)), functional plans, comprehensive plans or land use regulations to meet targets set in this rule. Requirements for cooperative selection of a preferred land use and transportation scenario and for implementation of that scenario through amendments to comprehensive plans and land use regulations as required by section 37 (8), chapter 865, Oregon Laws 2009, shall be addressed through a separate rulemaking that the commission is required to complete by January 1, 2013.

(2) This rule applies to the Portland metropolitan area.

(3) The greenhouse gas emissions reduction target, as set forth in OAR 660-044-0005(6), for the Portland metropolitan area is a 20 percent reduction per capita in greenhouse gas emissions in the year 2035 below year 2005 emissions levels.

(4) The greenhouse gas emissions reduction target in section (3) of this rule identifies the level of greenhouse gas emissions reduction to be met through land use and transportation scenario planning consistent with baseline assumptions and guidance in OAR 660-044-0010(2)(b)(A) to (C), including reductions expected to result from actions and programs identified in the Statewide Transportation Strategy.

Stat. Auth.: ORS 197.040; Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(6); Chapter 85 Oregon Laws 2010 Special Session (Senate Bill 1059) §5
Stats. Implemented: Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(6); Chapter 85 Oregon Laws 2010 Special Session (Senate Bill 1059) §5
Hist.: LCDC 5-2011, f. 5-26-11, cert. ef. 6-1-11

Proposed New Rules

660-044-0040
Cooperative Selection of a Preferred Scenario; Initial Adoption

(1) Metro shall by December 31, 2014, amend the regional framework plan and the regional growth concept to select and incorporate a preferred land use and transportation scenario that meets targets in OAR 660-044-0020 consistent with the requirements of this division.

(2) In preparing and selecting a preferred land use and transportation scenario Metro shall:

(a) Consult with affected local governments, the Port of Portland, TriMet, and the Oregon Department of Transportation;
(b) Consider adopted comprehensive plans and local aspirations for growth in developing and selecting a preferred land use and transportation scenario;
(c) Use assumptions about population, housing and employment growth consistent with the coordinated population and employment projections for the metropolitan area for the planning period;
(d) Use evaluation methods and analysis tools for estimating greenhouse gas emissions that are:
(A) Consistent with the provisions of this division;
(B) Reflect best available information and practices; and,
(C) Coordinated with the Oregon Department of Transportation.
(e) Make assumptions about state and federal policies and programs expected to be in effect in over the planning period, including the Statewide Transportation Strategy, in coordination with the responsible state agencies;
(f) Evaluate a reference case scenario that reflects implementation of existing adopted comprehensive plans and transportation plans;
(g) Evaluate at least two alternative land use and transportation scenarios for meeting greenhouse gas reduction targets and identify types of amendments to comprehensive plans and land use regulations likely to be necessary to implement each alternative scenario;
(h) Develop and apply evaluation criteria that assess how alternative land use and transportation scenarios compare with the reference case in achieving important regional goals or outcomes;
(i) If the preferred scenario relies on new investments or funding sources to achieve the target, evaluate the feasibility of the investments or funding sources including:
(A) a general estimate of the amount of additional funding needed;
(B) identification of potential/likely funding mechanisms for key actions, including local or regional funding mechanisms; and,
(C) coordination of estimates of potential state and federal funding sources with relevant state agencies (i.e. the Oregon Department of Transportation for transportation funding); and,

(D) **Consider effects of alternative scenarios on development and travel patterns in the surrounding area (i.e. whether proposed policies will cause change in development or increased light vehicle travel between metropolitan area and surrounding communities compared to reference case)**

(3) The preferred land use and transportation scenario shall include:

(a) A description of the land use and transportation growth concept providing for land use design types;

(b) A concept map showing the land use design types;

(c) Policies and strategies intended to achieve the target reductions in greenhouse gas emissions in OAR 660-044-0020;

(d) Planning assumptions upon which the preferred scenario relies including:

(A) **assumptions about state and federal policies, programs;**

(B) **assumptions about vehicle technology, fleet or fuels, if those are different than those provided in OAR 660-044-0010;**

(C) **assumptions or estimates of expected housing and employment growth by jurisdiction and land use design type; and**

(D) **assumptions about proposed regional programs or actions other than those that set requirements for city and county comprehensive plans and land use regulations, such as investments and incentives.**

(e) Performance measures and targets to monitor and guide implementation of the preferred scenario. Performance measures and targets shall be related to key elements, actions and expected outcomes from the preferred scenario. The performance measures shall include performance measures adopted to meet requirements of OAR 660-012-0035(5).

(f) Recommendations for state or federal policies or actions to support the preferred scenario.

(4) When amending the regional framework plan, Metro shall adopt findings demonstrating that implementation of the preferred land use and transportation scenario meets the requirements of this division and can reasonably be expected to achieve the greenhouse gas emission reductions as set forth in the target in OAR 660-044-0020. Metro's findings shall:

(a) Demonstrate Metro's process for cooperative selection of a preferred alternative meets the requirements in (2)(a)-(j);

(b) Explain how the expected pattern of land use development in combination with land use and transportation policies, programs, actions set forth in the preferred scenario will result in levels of greenhouse gas emissions from light vehicle travel that achieve the target in 660-044-0020;

(c) Explain how the framework plan amendments are consistent with and adequate to carry out the preferred scenario, and are consistent with other provisions of the Regional Framework Plan; and,

(d) Explain how the preferred scenario is or will be made consistent with other applicable statewide planning goals or rules.

(5) Guidance on evaluation criteria and performance measures.

(a) The purpose of evaluation criteria referred to in subsection (2)(h) is to encourage Metro to select a preferred scenario that achieves greenhouse gas emissions reductions in a way that maximizes attainment of other community

goals and benefits. This rule does not require the use of specific evaluation criteria. The following are examples of categories of evaluation criteria that Metro might use:

- **(A) Public health;**
- **(B) Air quality;**
- **(C) Household spending on energy or transportation;**
- **(D) Implementation costs;**
- **(E) Economic development;**
- **(F) Access to parks and open space; and,**
- **(G) Equity**

(b) The purpose of performance measures and targets referred to in subsection (3)(e) is to enable Metro and area local governments to monitor and assess whether key elements or actions that make up the preferred scenario are being implemented, and whether the preferred scenario is achieving the expected outcomes. This rule does not establish or require use of particular performance measures or targets. The following are examples of types of performance measures that Metro might establish:

- **(A) Transit service revenue hours:**
- **(B) Mode share;**
- **(C) People per acre by 2040 Growth Concept design type;**
- **(D) Percent of workforce participating in employee commute options programs; and,**
- **(E) Percent of households and jobs within one quarter mile of transit**

Stat. Auth.: ORS 197.040; Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(8)
Stats. Implemented: Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(8)
Hist.:

OAR 660-044-0045

Adoption of Regional Plans to Implement the Preferred Scenario

(1) Within one year of the commission's approval of Metro's amendments to the regional framework plan to select and incorporate a preferred land use and transportation scenario, Metro shall adopt or amend regional functional plans to implement the framework plan amendments.

(2) The regional functional plans or amendments shall set requirements, deadlines and compliance procedures for local comprehensive plans, including for amendments to local comprehensive and local transportation system plans needed to carry out the framework plan amendments. The functional plan amendments shall require that affected cities and counties adopt implementing amendments to comprehensive plans and land use regulations within two years of acknowledgement of Metro's functional plan amendments or by a later date specified in the adopted functional plan.

(3) The regional functional plans or amendments shall require local governments to amend local comprehensive plans, transportation system plans and land use regulations to:

(a) Use population, housing and employment allocations to specific areas and land use design types that are consistent with estimates in framework plan including assumptions about densities, infill, and redevelopment;

(b) <u>Apply comprehensive plan designations and zoning districts that are consistent with land use design type, including allowing uses and densities that are consistent with land use design type; and limiting uses that would be incompatible with the design type specified in the preferred scenario; and,</u>

(c) <u>Include other provisions needed to implement the amended framework plan.</u>

<u>(4) As part of its adoption, Metro shall adopt findings which demonstrate that actions required by functional plans or amendments are consistent with and adequate to carry out the relevant portions of the preferred land use and transportation scenario set forth in the adopted framework plan amendments. The findings shall demonstrate that assumptions or allocations of housing and employment growth to specific areas are consistent with the estimates or assumptions in the framework plan amendments. In the event Metro's allocations or assumptions vary from those upon which the framework plan amendments are based, Metro shall demonstrate that the revised assumptions or allocations, in combination with other measures adopted to as part of the functional plans or amendments will meet the GHG reduction target in OAR 660-044-0020.</u>

<u>(5) Those portions of the preferred scenario in the framework plan that Metro chooses to implement by setting requirements for city and county comprehensive plans and land use regulations shall be set forth in amendments to the appropriate functional plan. The amendments shall meet the following minimum planning standards:</u>

(a) <u>The Council shall follow the process set forth in the Metro Charter for adoption of amendments to the Regional Framework Plan;</u>

(b) <u>To adopt or amend a functional plan, the Council shall follow the process set forth in the Metro Charter for adoption of ordinances;</u>

(c) <u>The Council shall strive for flexibility when establishing new requirements for cities and counties, and shall consider offering optional compliance paths to cities and counties, such as adoption of a model ordinance developed by Metro;</u>

(d) <u>Amendments to a functional plan that establish new requirements for cities and counties shall be made enforceable in the functional plan pursuant to ORS 268.390(6);</u>

(6) <u>When it adopts an updated regional transportation system plan required by required by OAR 660-012, Metro shall demonstrate that the updated plan is consistent with framework plan amendments adopting a preferred scenario as provided in (3) above.</u>

Stat. Auth.: ORS 197.040; Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(8)
Stats. Implemented: Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(8)

OAR 660-044-0050

<u>Commission Review of Regional Plans</u>

<u>(1) The commission shall review Metro's framework plan amendments adopting a preferred land use and transportation scenario and amendments to functional plans to</u>

implement the framework plan amendments in the manner provided for periodic review under ORS 197.628 to 197.650.

(2) The commission's review of framework plan amendments adopting a preferred land use and transportation scenario shall determine whether the preferred scenario can reasonably be expected to achieve greenhouse gas emission reductions as set forth in the targets in OAR 660-044-0020, other requirements of this division, and any applicable statewide planning goals.

(3) The commission's review of amendments to functional plans shall determine whether the adopted functional plans are consistent with and adequate to carry out relevant portions of the framework plan amendments.

(4) The commission may conduct review of Metro's framework plan amendments adopting a preferred scenario in conjunction with review of a UGB update or an update to the regional transportation system plan.

Stat. Auth.: ORS 197.040; ORS 197.274(2); Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(8)
Stats. Implemented: ORS 197.274(2); Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(8)

OAR 660-044-0055

Adoption of Local Plans to Implement the Preferred Scenario

(1) Local governments shall amend comprehensive plans, and use regulations, and transportation system plans to be consistent with and implement relevant portions of the preferred land use and transportation scenario as set forth in Metro's functional plans or amendments. "Consistent" for the purpose of this section means city and county comprehensive plans and implementing ordinances, on the whole, conforms with the purposes of the performance standards in the functional plan and any failure to meet individual performance standard requirements is technical or minor in nature.

(2) Beginning one year from Metro's adoption of a preferred scenario, local governments shall, in adopting an amendment to a comprehensive plan or transportation system plan, other than a comprehensive plan or transportation system plan update or amendment to implement the preferred scenario, demonstrate that the proposed amendment is consistent with the preferred land use and transportation scenario.

Stat. Auth.: ORS 197.040; ORS 197.274(2); Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(8)
Stats. Implemented: ORS 197.274(2); Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(8)

OAR 660-044-0060

Monitoring

(1) Metro shall as part of reports required by ORS 197.301 prepare a report monitoring progress in implementing the preferred scenario including status of performance measures and performance targets adopted as part of the preferred scenario.

(2) Metro's report shall assess whether the region is making satisfactory progress in implementing the preferred scenario; identify reasons for lack of progress, and identify possible corrective actions to make satisfactory progress.

(3) The commission shall review the report and shall either find Metro is making satisfactory progress or provide recommendations for corrective actions to be considered or implemented by Metro prior to or as part of the next scheduled update of the preferred scenario.

Stat. Auth.: ORS 197.040; ORS 197.301; ORS 197.274(2); Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(8)
Stats. Implemented: ORS 197.301, Chapter 865 Oregon Laws 2009 (House Bill 2001) §37(8)

600 NE Grand Ave.
Portland, OR 97232-2736

Metro | Memo

Date: August 23, 2012
To: TPAC and interested parties
From: Josh Naramore, Senior Transportation Planner
Subject: 2015-18 MTIP Process and Schedule

Regional flexible funds are an element of the funds programmed within the Metropolitan Transportation Improvement Program (MTIP). The Metropolitan region is preparing to prioritize transportation projects and program activities to receive regional flexible funds available in the years 2016, 2017 and 2018. Recent changes to the ODOT Statewide Transportation Improvement Program (STIP) have accelerated the Metro process for the next regional flexible funds allocation process. Metro staff is seeking policy direction from the Joint Policy Advisory Committee on Transportation (JPACT) at their September meeting for the allocation of the regional flexible funds and direction on coordinating with the STIP process.

At the August 31 TPAC meeting Metro staff will be presenting the information included in the attached memo to JPACT**.** Staff will lead a discussion and seek TPAC input on how to frame the JPACT direction on the 2015-18 MTIP process. This material will be presented at the September 13 JPACT meeting.

To submit questions, comments, or request any additional information, contact Josh Naramore at 503-797-1825 or joshua.naramore@oregonmetro.gov.

600 NE Grand Ave.
Portland, OR 97232-2736
www.oregonmetro.gov

Metro | Memo

Date: September 6, 2012

To: JPACT members and alternates

From: Josh Naramore, Senior Transportation Planner

Subject: Direction on the 2015-18 MTIP and 2016-18 Regional Flexible Funds Allocation

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The Portland metropolitan region is preparing to prioritize transportation projects and program activities in developing the 2015-18 Metropolitan Transportation Improvement Program (MTIP). The Regional Flexible Funds Allocation (RFFA) process is the Metro and JPACT administered allocation conducted as part of the development of the MTIP. Recent changes to the ODOT Statewide Transportation Improvement Program (STIP) have accelerated the Metro process for developing the next MTIP and RFFA. Metro staff is seeking policy direction from the Joint Policy Advisory Committee on Transportation (JPACT) at their September meeting on the development of the MTIP, allocation of the regional flexible funds and direction on coordinating with the STIP process.

Background

The allocation process for 2014-15 funds represented a significant change to the regional process. The project proposals for new focus areas were developed through a collaborative process involving impacted stakeholders. A joint task force was created to advise JPACT and TPAC on project focus area needs, priorities and project prioritization factors during the stakeholder engagement process. The development of projects within the project focus areas began with stakeholder outreach to the populations, agencies, organizations, and businesses that made up the communities affected by and involved with each project focus area. In order to further the consideration of Environmental Justice (EJ) and underserved populations, a working group was convened to provide input on the needs of minority, low income, elderly and disabled populations and help evaluate projects from an equity perspective and how projects may or may not meet the needs of these populations.

The Oregon Transportation Commission's (OTC) and ODOT have made recent changes to the STIP process with the expectation to identify the best multimodal transportation project to address a problem while maintaining and preserving existing transportation assets. The STIP is being streamlined from a collection of programs tied to specific pools of funding dedicated to specific modes or specialty programs and divided into two broad categories, Fix-It and Enhance and a single application process. The changes are intended to identify the most effective projects based on community and state values. With revenue for maintenance and improvement of the transportation system limited, the STIP changes favor investments that effectively address a wide range of issues such as safety, mobility, accessibility, economic development, sustainability, energy, health, and community livability. The ODOT allocation process is part of both the development of the 2015-18 MTIP and STIP.

STIP Coordination Process

With the recent changes to the STIP process, Metro and ODOT staff have been working to coordinate the MTIP and STIP calendars. Additionally, there has been recent OTC direction on creation of an entity much like an Area Commission on Transportation (ACT) for the Portland metropolitan region for this STIP cycle. JPACT, as the federal metropolitan planning organization (MPO) for the region has an opportunity to provide policy direction in the coordinated development of the STIP projects. Metro staff is seeking JPACT input on the following questions about coordinating the MTIP with the STIP process:

1) Is the draft Metro 2015-18 MTIP schedule in **Attachment 1** the right approach to align with the STIP process outlined in **Attachment 2**?

2) How does JPACT want to provide policy direction or input to the ODOT Region 1 ACT like entity on project selection?
   - Potential emphasis areas could include bottlenecks, low-cost solutions, multimodal, safety, leveraging local funding and implementation of corridor plans.

2016-18 RFFA Policy Direction

Past RFFA processes allocated two years of funding. However, both the STIP and MTIP will be allocating three years of funding for fiscal years 2015-16, 2016-17, and 2017-18. As a result of an additional year of funding and with changes from the recently adopted MAP-21 federal legislation more funds will be available for the 2016-18 RFFA. Using the policy direction from the 2014-15 RFFA as a starting place Metro staff is seeking JPACT direction on the following questions and options for allocation of 2016-18 regional flexible funds.

3) Should we continue to utilize the 2014-15 policies and process summarized in **Attachment 3**?

4) How does JPACT want to allocate the additional funding for the 2016-18 RFFA?
   - An overview of available funding in the 2015-18 MTIP and STIP is provided in **Attachment 4**. Metro staff has developed potential options in **Attachment 5** to aid JPACT discussion.

At the September 13 JPACT meeting Metro staff will be presenting background information on the 2016-18 RFFA and STIP. To guide the discussion Metro staff has included the following information materials:

- Attachment 1 – Draft Metro 2015-18 MTIP Schedule
- Attachment 2 – 2015-18 STIP Schedule
- Attachment 3 – Overview of the 2014-15 RFFA and Lessons Learned
- Attachment 4 – Available Funding for the 2015-18 MTIP and STIP
- Attachment 5 – JPACT Options for 2016-18 RFFA

To submit questions, comments, or request any additional information, contact Josh Naramore at 503-797-1825 or joshua.naramore@oregonmetro.gov.

DRAFT 2015-18 MTIP Schedule

METRO

2015-18 MTIP Adoption

2012

Summer - Fall

Overview of proposed TIP process and funding programs

Fall - Winter

Review of existing data performance measures (part of the Congestion Management Process)
Policy update: Adopt desired outcomes of the TIP process October JPACT/Council
Release Regional Flexible Fund allocation solicitation packet

2013

Winter/Spring

Review region-wide programs (TOD, RTO, TSMO, Corridor Development, TriMet & SMART 5307)
Review TriMet 5-year strategic plan
RFFA applications due February 15
Begin evaluation of projects

June - September

Finish 30-day public comment period by July 30
Project narrowing process to proposed TIP (Aug TPAC, Sept JPACT)

October

Submit proposed TIP to ODOT for inclusion in Draft STIP by Oct 1
Region STIP Coordinators upload project list into PCSX by Oct 31

Nov - Dec

Draft STIP prepared for public review process

2014

Jan

OTC & JPACT release STIP & MTIP for public review

March 1

Public review of Draft TIPs complete

March - June

JPACT/Council act on any adjustments based on public comments (March TPAC, April JPACT)

Air quality conformity analysis and determination process

June – July

Final STIP prepared and reviewed with ACTs, MPOs, other stakeholders

August

OTC review and approve Final 2015-18 STIP

September

FHWA/FTA approval of STIP and air quality conformity of MTIP

2015-2018 STIP Enhance Project Application/Selection Process
Draft Timeframes

8/3/12

- **September 20, 2012** Application process begins
- **October 16, 2012** OTC meeting with ACT chairs
- **November 27, 2012** Applications must be submitted to specified region e-mail address by noon this day
- **Nov 27-Dec 5, 2012** Regions review applications for eligibility
- **December 6, 2012** Applications distributed to ACTs and MPOs for deliberation and 150 percent list development and prioritization
- **March 15, 2013** ACTs submit 150 percent recommendations to regions by close of business
- **March 18-July 19, 2013** Regions scope 150 percent lists
- **March 21, 2013** Regions provide their ACTs' 150 percent lists to TDD for Distribution to OTC, OFAC and Joint TE-OBPAC
- **June 19, 2013** OTC, OFAC and Joint TE-OBPAC Committee provide input on 150 percent lists
- **July 22, 2013** Regions provide scoping information to Area Managers and ACT chairs; ACTs and regions begin developing project recommendation lists
- **October 4, 2013** Regions provide their project recommendation lists to TDD for compilation and OTC consideration
- **Oct 7-Nov 13, 2013** OTC review of project recommendation lists and allocation of discretionary 20 percent
- **December 18, 2013** OTC releases draft 2015-2018 STIP for review
- **February 14, 2014** Draft STIP Public Review process complete
- **March 14, 2014** ACT/MPO/OTC etc. review of comments complete
- **April 18, 2014** Complete any necessary adjustments to draft STIP
- **April 21-Aug 15, 2014** Conduct air quality conformity determinations
- **September 30, 2014** Final STIP available for review
- **Oct 1-Nov 19, 2014** Review of final STIP
- **November 19, 2014** OTC review and approval of final 2015-2018 STIP
- **February 2015** USDOT review and approval of 2015-2018 STIP

2014-15 RFFA Process: Overview and Lessons Learned

The following reflects the policy direction that was adopted by JPACT and Metro Council for 2014-15 regional flexible funds allocation (RFFA) process and summarizes the two-step process:

Step 1: Regional Programs
Support of an initial funding target for existing regional programs, but with direction to develop a process for JPACT review of these programs prior to the final allocation of funding in the spring of 2011.

- *Regional Programs: $46.733 million*

-Transit Oriented Development – $5.95 million
-High capacity transit (HCT) bond - $26 million
-HCT development - $4 million
-TSMO/ITS - $3 million
-Regional Travel Options - $4.539 million
-Regional Planning - $2.244 million
-Corridor & Systems Planning - $1 million

- *Established funding for Metropolitan Mobility Preparedness : $1 million*

This allocation of funds was to develop projects in preparation for the 2010 proposed changes to the federal transportation authorization bill. The recently adopted MAP-21 did not include the 2010 proposed creation of a federal Metropolitan Mobility Program for which this set aside was intended to develop projects.

Step 2 – Community Investment Funds

- *Vehicle electrification: $500,000*

One time set aside of $500,000 for electric vehicle acquisition and infrastructure development. This project focus area supports the use of electric vehicles in the region.

- *Green Economy/Freight Initiatives target: 25 % ($5.5 million)*

This project focus area supports the development of the region's economy through investment in green infrastructure and key freight projects or programs.

- *Active Transportation/Complete Streets target: 75% ($16.5 million)*

This project focus area prioritizes infrastructure support for non-auto trips and ensuring safe streets that are designed for all users. Examples of project types include, but are not limited to:

2014-15 RFFA Lessons Learned

The following are some lessons learned and recommendations based on feedback received by Metro staff from stakeholders about the 2014-15 RFFA process.

RFFA Findings:

a. The local project nomination and narrowing process requirements were too minimal to ensure that all processes conducted at the local level met expectations.

b. Some of the RFF task force criteria were difficult to meet through project design.

c. Local processes for public engagement did not yield a lot of participation.

d. While the joint RFF task force enabled discussion between two groups that have few opportunities to reach understanding, it diluted the specific expertise in developing criteria for each focus area.

RFFA recommendations**:**

a. Further develop guidelines for local process for nominating and narrowing projects. (An example is to ensure that all processes include technical presentations to decision makers prior to the narrowing process.)
b. Allow staff refinement of criteria while it is being developed or existing criteria if used again next cycle.

c. Establish additional guidelines to be met during local engagement processes. Perhaps the addition of local open houses and web tools in addition to public meetings would improve performance.

d. If a task force is to be convened in the next cycle, it is recommended that the original conception of two task forces (or a task force/working group per focus area) be explored to improve the development of criteria and project priorities.

Funding Decisions and Available Funds 2015-18 MTIP and STIP

Fund Type	Current JPACT/Council Role *	2016-18 Funding Amount	Administering agency
Programmatic Funding			
Regional Flexible Funds	Final decision on allocation	$98.5 million	Metro/JPACT
Tri Met 5307 and 5307 Enhancements	Consulted on TriMet Transit Improvement Program. Approve spending in TIP	$105 million + $1 million	TriMet
SMART 5307 and 5307 Enhancements	Approve spending in TIP	$1.4 million + $20,000	SMART
Special Needs Transportation	Approve awards for inclusion in TIP	Changes from MAP-21	TriMet (STFAC)
ODOT Region 1 Enhance	Identify priorities from applications to inform Area Committee	$65.6 million	ODOT
ODOT Additional Statewide Enhance	Identify priorities from applications to inform Area Committee	$46.1 million	ODOT
ODOT Statewide Fix-It (need Region 1 break-out)	Briefed on project list. Approve allocations for inclusion in TIP	$729.3 million	ODOT
Discretionary Funding			
New Starts	Approve HCT System Plan prioritizing project development in the planned HCT corridors, any RFFA funding for project development or construction, UPWP (work plan & budget for priority corridor).	$300.0 million	FTA award (TriMet is local lead agency)
FHWA TIGER	Identified JPACT priorities from applications	$0 to $50 million	FHWA award
FHWA TCSP	Approve awards for inclusion in TIP	$0 to $3 million	FHWA award

* In addition to developing and approving the Regional Transportation Plan which provides overall policy direction and the eligible list of projects to receive funding.

JPACT Options for 2016-18 RFFA Process

Based on the RFFA funding summary from Attachment 3, JPACT will have $98.56 million to allocate as part of the 2016-18 RFFA. Using the 2014-15 RFFA process as a baseline the 2016-18 RFFA process will have an additional $37.78 million to allocate[1]. For the September 13 JPACT discussion, Metro staff has developed some options to help aid the discussion on ways to allocate the additional funding. These are illustrative options based on the existing 2014-15 RFFA policy direction and two-step allocation process.

Option 1 – Redistribution Across All Step 1 and 2 Programs

- Step 1 and Step 2 programs retain 2014-15 funding levels for 2016-18 - $60.78 million
- Additional $37.78 million would be distributed to any Step 1 or Step 2 program or category
- The framework for allocating the additional funds would be developed based on additional JPACT direction

Option 2 – Modified 2014-15 process

Step 1 – Maintain existing regionwide program funding levels and add Regional Safety Program

- Regionwide program remains the same from 2014-15 RFFA for 2016-18 - $26 million
- Allocate funding to the Regional Safety Program. A proposal for funding this program is being prepared for JPACT consideration later this fall. An allocation to this program would reduce the amount of funding for Step 2.

Step 2 - Maintain 25% / 75% split between Green Economy/Freight Initiatives and Active Transportation/Complete Streets categories. Allocate the additional $37.78 million to both categories based the same split.

- Green Economy/Freight Initiatives – Increase from $5.5 million to $14.945 million
- Active Transportation/Complete Streets – Increase from $16.5 million to $44.835 million
- Green Economy/Freight Initiative project recommendations would be developed by the Regional Freight TAC.
- Active Transportation/Complete Streets projects would be developed by the local coordinating committees. The Active Transportation Advisory Committee will use the Active Transportation Plan findings and opportunities to help develop local projects.

[1] This assumes maintaining the funding levels for both the Step 1 regionwide programs and Step 2 categories of Active Transportation/Complete Streets and Green Economy/Freight Initiatives, accounting for the third year of funding in the 2016-18 allocation and uses a 3 percent inflationary rate.

Option 3 – Maintain process from 2014-15 allocation process

Step 1 – Maintain existing funding for regionwide programs for 2016-18 - $26 million

Step 2 - Maintain 25% / 75% split between Green Economy/Freight Initiatives and Active Transportation/Complete Streets categories. Allocate the additional $37.78 million to both categories based the same split.

- Green Economy/Freight Initiatives – Increase from $5.5 million to $14.945 million
- Active Transportation/Complete Streets – Increase from $16.5 million to $44.835 million
- Project recommendations are derived from local coordinating committees.

Option 4 – Revisit 2014-15 RFFA policy direction

- If JPACT choose this option, Metro staff will need to develop a revised 2015-18 MTIP schedule and work program.

CONTEXTUAL INFLUENCES ON TRIP GENERATION

Final Report Draft

OTREC 2011-407

by

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for

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May 2012

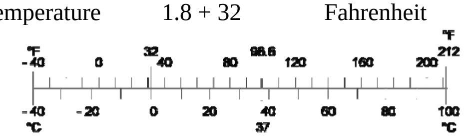
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

CONTEXTUAL INFLUENCES ON TRIP GENERATION

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EXECUTIVE SUMMARY

This study examines the ways in which urban context affects vehicle trip generation rates across a variety of land uses. An establishment intercept travel survey was administered at 78 establishments in the Portland, Oregon region during the summer of 2011. Data were collected from high-turnover (sit-down) restaurants (Mexican and pizza), 24-hour convenience markets, and drinking places. Combined with person and vehicle trip counts during the same time and built environment data, a method to adjust ITE vehicle trip rates locally has been developed.

Results from this study suggest that a trend exists in travel behavior: for all land uses, vehicle trip rates (per establishment area) decrease as neighborhood types become more urban. An exogenous variable representing urban context is useful in predicting vehicle trip rate adjustments (by establishment size) to ITE rates.

Comparisons between ITE Trip Generation vehicle trip rates and vehicle trip rates from this study rates indicate a need for a local adjustment for both convenience markets (open 24-hours) and drinking places. High-turnover (sit-down) restaurants appear to be predicted by the ITE methodology and rates fairly well, but we still introduce a vehicle trip rate adjustment to better match locally observed travel patterns.

The adjustment model provided in this study is applicable to ITE Trip Generation vehicle trip rates for the PM peak hour. The trip rate units are vehicle trips per hour per thousand square feet of gross floor area. Different rate adjustments are provided for each of the three land uses studied. The key model variable is mean Urban Living Infrastructure (ULI) score from the Metro Context Tool within a ½ mile buffer around establishments. ULI is a measure representing retail density and diversity.

The regression model has a good statistical fit (R^2 = 0.763). The model is relevant in two ways:

1. It allows vehicle trip adjustments to existing establishments in the Portland region to be calculated in a relatively straightforward manner.

2. It provides a guidance tool for planners and policy makers to develop strategies to reduce vehicle trips to shopping establishments in the future.

The ULI measure is highly correlated to many other built environment attributes and serves as a proxy for overall urban character. The provided ranges of built environment measures associated with ULI allow interpretation of the ULI tool in a more tangible way.

In this study, we also developed a method to estimate equivalent-vehicle trip rates using a person counts, automobile mode share, and vehicle occupancy at establishments. The method estimates actual vehicle counts well. It is useful since one of the main difficulties with vehicle trip generation data collection in urban areas is the ability to accurately count vehicle trips at establishments with on-street parking where it is hard to determine counting cordon locations. Future trip generation studies in urban areas can utilize this method where counting vehicle trips is complex.

1.0 INTRODUCTION

There is national interest in building data that expand upon the existing Institute of Transportation Engineers (ITE) trip generation rates to include sites located in a multi-modal context. Often criticized for their shortcomings, Institute of Transportation Engineers (ITE) Trip Generation (TG) rates were developed beginning in the 1960s and focused on single-use, vehicle-oriented in suburban sites in the United States. ITE TG rates were meant to provide engineers with off-the-shelf estimates for basic land uses and simple contexts to bypass expensive data collection costs (Institute of Transportation Engineers 2008, Gard 2007, Steiner 1998). Despite this intention, the ITE TG handbook is commonly applied erroneously to more urban contexts. For these applications, ITE recommends that local rates be established via data collection for any non-suburban, paid-parking area with limited transit service or pedestrian access: "If the site is located in a downtown setting, served by significant public transportation... the site is not consistent with the ITE data" (Institute of Transportation Engineers 2004).

Measuring local trip rates and calculating the impact of urban form on vehicle trip rates are expensive and intensive processes. Many local jurisdictions ignore warnings on the limited applications in the ITE TG Handbook and apply generic rates to inappropriate contexts, like high density areas with low actual vehicle trip rates (Nelson\Nygaard Consulting Associates 2005, Lerner-Lam et al. 1992, Badoe 2000, Fleet and Sosslau 1976). ITE acknowledges the limitations of the TG dataset as they relate to availability of transit, non-motorized transportation facilities, mixed land uses, and density. While the impacts of transit are discussed in the appendix of the ITE TG Handbook, the section begins with a disclaimer stating any information provided "is strictly for informational purposes... (and) provides no recommended practices, procedures, or guidelines." The ITE TG Handbook also recognizes the impact of pedestrian and bicycle infrastructure on reducing estimated vehicle trips, but the Handbook does not provide site-trip generation data upon which reduction factors are based (Institute of Transportation Engineers 2004). Efforts are underway by ITE to address those issues, but methodology and data will not likely be available soon. In the meantime, local governments burdened with long-range planning obligations are struggling with ITE rate applications in urban contexts like infill, mixed use, and Transit-Oriented Developments (TODs) (Rizavi and Yeung 2010, Nelson\Nygaard Consulting Associates 2005).

Despite evidence that a more compact urban form, access to transit and a greater mix of uses generates fewer and shorter vehicle trips, local governments are often compelled to use current ITE trip generation rates to evaluate transportation impacts and calculate transportation system development charges (TSDCs). This is due to: a) the expense of collecting local data, b) lack of alternative sources of information, c) the strong industry bias toward using ITE published rates and d) the absence of a consistent, empirically tested methodology for adjusting those rates for development occurring in different land use and transportation contexts.

When analysts ignore the impacts of transit, pedestrian infrastructure, bicycle facilities, and urban settings on vehicle trip generation, vehicle trips are overestimated. High vehicle trip estimates increase the amount of vehicle-oriented development, necessitating other automobile priority measures. More vehicle use, greater capacity, abundant parking supply, faster travel times, and fewer automobile alternatives are all related to overestimating vehicle trip rates.

Further, growth of new development is often stunted from high impact fees associated with overestimating vehicle trips.

Compounding these challenges, cities in Oregon are required to demonstrate that planning and zoning changes will not degrade the performance of state-owned transportation facilities compared to the levels of service documented in the Regional Transportation Plan under the Oregon Transportation Planning Rule, section -0060, and Oregon Highway Plan, Policy 1.F.6. These requirements can conflict with regional policies in Metro's 2040 Growth Concept that call for development of mixed-use centers and corridors to support jobs and freight reliability, a compact urban form and leverage transportation investments such as high capacity transit. Thus, there are gaps in the understanding about how best to evaluate, mitigate and plan for growth under these conditions.

This research project aims to address this issue and develop a method to adjust ITE's trip generation rates to better reflect the relationship between land use, transportation and travel demand for specific land use types located in various urban settings. The project collected local data (using counts and establishment surveys) on a few specific land uses (restaurants, 24-hour convenience markets, and drinking places) to develop trip generation rates that are sensitive to demographic, land use and transportation contexts. These new trip rates were compared to the ITE rates for the same land use category and establishment size and a methodology for adjusting the ITE rates was developed.

The benefits of better estimates of vehicle traffic for new developments extend beyond reducing the amount of required development for new or renovated sites. Other benefits to providing methods for reducing vehicle trips include:

- Decreases need for extensive roadway construction improvements near TODs.
- Improves ability for local governments to adjust requirements for trip generation appropriately for development.
- Lowers construction costs and impact development fees to builders and developers.
- Facilitates infill and mixed-use development to take root, leading to increased commerce and density.
- Provides better assessments of progress toward greenhouse gas (GHG) targets by making more realistic estimates of the contribution of land use change.

The remainder of this report is organized as follows. A literature review summarizes the current state of the knowledge with respect to the role of context on trip generation. Then, the data used in this study and the methods used to collect them are described. Next, we document the methodology developed to adjust ITE's trip generation rate for urban context and discuss the application of the approach in a planning context. Finally, the report concludes with a discussion of the implications of our study findings for planning and policy, the study limitations, and suggestions for future work. Supporting documentation is provided in the Appendices.

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

The research documented in this review includes academic work, white papers, and policies of state, regional, county and city level jurisdictions. A wide range of applications were found when considering changes to vehicle trip rates and reductions for various land uses and travel purposes. For the purpose of this review, findings were groups in those that provide more academic foundation to inform the foundation of the analysis methodology design to those with more practical purposes to consider the ways in which other areas are dealing with estimation of vehicle trip rates in urban contexts.

In this spectrum of vehicle trip generation literature, some academic papers have sought to identify and summarize quantitative relationships or elasticities of vehicle trips as they relate to factors like residential density or land use mix (Ewing and Cervero 2001, Ewing and Cervero 2010). Other academic and white paper reports working toward practical application determine vehicle trip reduction percentages of individual factors, such as proximity to transit (JHK & Associates, Pacific Rim Resources, and SG Associates 1996, Institute of Transportation Engineers 2004). While disaggregate built environment factors play a role in explaining vehicle trip generation rates, providing a methodology for application in practice is difficult. Many jurisdictions have developed fixed guidelines for adjustments in application.

This literature review begins with a summary of studies which aimed at evaluation of ITE Trip Generation rates. Following this summary, an additional review of guidelines for trip generation estimation or mitigation to investigate the ways in which jurisdictions are currently handling this issue. The next section discusses and compares external projects evaluating and proposing solutions for estimation of trip generation. Finally, academic literature is reviewed to determine common definitions for context and built environment that may significantly explain vehicle trip generation.

2.2 EVALUATION OF ITE TRIP GENERATION RATES

There have been many studies which evaluate the error in estimation of ITE Trip Generation rates compared to observed study values. These ranges of error, shown in Table 2-1, identify the large error range of results found from the variety of studies. To compare the error in ITE trip generation estimation, Equation 2-1is used. A negative rate indicates estimated vehicle trip counts being larger than those observed in the study.

Equation 2-1. ITE Trip Rate Error Equation

$$Estimated\ Error = \frac{Observed\ Vehicle\ Trip\ Rate - ITE\ Estimated\ Vehicle\ Trip\ Rate}{ITE\ Estimated\ Vehicle\ Trip\ Rate}$$

Table 2-1: Summary of ITE Trip Rate Error Collected from Literature Review[1]

	AM Peak			PM Peak			Automobile Mode Share		
Central Business District / Urban Core / Downtown	**-93**	**to**	**1109 %**	**-99**	**to**	**11 %**	**8**	**to**	**100 %**
Eating / Restaurant	*-93*	*to*	*-57 %*	*-99*	*to*	*-70 %*	*17*	*to*	*57 %*
Office	*-80*	*to*	*-22 %*	*-62*	*to*	*-21 %*	*56*	*to*	*95 %*
Residential	*-83*	*to*	*15 %*	*-80*	*to*	*11 %*	*14*	*to*	*85 %*
Restaurant	*-35*			*-26*	*to*	*-26 %*	*34*	*to*	*60 %*
Retail	*-17*	*to*	** 1109 %*	*-22*	*to*	*8 %*	*8*	*to*	*100 %*
Services	*-14*	*to*	*-14 %*	*-66*					
Shopping	*30*	*to*	*30 %*	*3*	*to*	*3 %*			
Mixed-Use Development	**-109**	**to**	**181 %**	**-170**	**to**	**61 %**			
Mixed	*-109*	*to*	*38 %*	*-80*	*to*	*61 %*			
Town Center	*-108*	*to*	*181 %*	*-170*	*to*	*-35 %*			
Transit-Oriented Development	**-90**	**to**	**20 %**	**-92**	**to**	**35 %**	**50**	**to**	**96 %**
Office							*50*	*to*	*96 %*
Residential	*-90*	*to*	*20 %*	*-92*	*to*	*35 %*	*53*	*to*	*93 %*
Development near transit	**-58**	**to**	**72 %**	**-36**	**to**	**51 %**	**28**	**to**	**90 %**
Office							*28*	*to*	*90 %*
Residential	*-58*	*to*	*72 %*	*-36*	*to*	*51 %*	*33*	*to*	*82 %*
Suburban Activity Centers and Corridors	**-37**	**to**	**-5 %**				**54**	**to**	**98 %**
Office	*-37*	*to*	*-20 %*						
Residential	*-5*	*to*	*-5 %*						
Shopping							*54*	*to*	*98 %*

* This retail shop located in Oakland, California had an observed AM peak trip count of 133 vehicle trips and an ITE estimated trip count of 11 vehicle trips.

The greatest range of error in estimation of vehicle trips tends to occur in Central Business District/Urban Core/Downtown areas. However, one retail shop studied in Oakland, California had an observed AM peak trip count of 13 vehicle trips and an ITE estimated trip count of 11 vehicle trips. Provided this establishment is an outlier, Mixed-Use Developments then show the

[1] Source include (Samdahl 2010, National Research Council (U.S.) 1990, Fehr & Peers 2008, Schneider 2011, Lee, et al. 2011, Kimley-Horn and Associates, Inc. 2009 June 15, Cervero and Arrington 2008, Cervero 1993, JHK and Associates 1987, Dill 2008, Lapham 2001, Colorado/Wyoming ITE Section Technical Committee - Trip Generation 1987, Jeihani and Camilo 2009, Sperry 2010)

greatest range of variation in error in estimation. Prediction of vehicle trip generation rates are by far the most complex when a dense, variety of land uses are accessible within one development. For these sites, although ITE provides a methodology to handle the interaction of land uses, it has not been shown to be the most effective method available to estimate vehicle trip generation to mixed use sites (Lee, et al. 2011), as discussed later in section 2.3.1. Retail and residential type developments tend to be both over and under estimated when using ITE Trip Generation rates. Standard deviations provided by ITE Trip Generation rates were not used in this assessment.

The automobile mode share is also provided in this table for those studies which counted person trips and calculated those persons taking a vehicle. The Central Business District/Urban Core/Downtown area provides the largest range of automobile mode share. However, even those sites studied in Suburban Activity Centers and Corridors contain as small as 54% automobile mode share.

2.3 APPLICATIONS IN PRACTICE

ITE Trip Generation Report and Handbook are a commonly referenced and utilized practical guideline. The study sites are often limited to vehicle-oriented, suburban locations with little to no transit, bike or pedestrian facilities, but jurisdictions which require traffic impact studies of some type often also provide some guidelines on how to approach a local adjustment for more mixed-uses, presence of quality transit (both rail and bus), bicycle or pedestrian amenities, or transportation demand management practices. This section details a review of 23 jurisdiction guidelines from around the United States and Canada. These sites range from the ultra-urban New York City, New York to the local jurisdictions of Bend, Oregon. The main purpose of this review was to identify trends in estimation of trip generation rates and traffic impact studies.

Twenty-two of the jurisdictions referenced ITE Trip Generation rates and methodologies as being appropriate in their local contexts, barring the presence of local rates or studies are not available[2]. Six of the jurisdictions methods allowed for bicycle, pedestrian or transit adjustments to be applied from mode share information, although only one of these studies directly required documentation of vehicle occupancy data to be applicable (City of Frisco 2005). Six of the jurisdictions provide some level of local vehicle trip generation rates. These areas tend to be more urban, or have a larger in span of authority (New York City, San Francisco, San Diego, Montgomery County, Mississauga Canada, Southern New Hampshire). Additionally, eleven of the jurisdictions provide some guidance of what conditions require a traffic impact study of some level, which may include limitations of vehicle trips generated, references to the areas land use plans or location of development near facilities with congestion or access problems. Provided development is below these standards, it becomes a case-by-case decision on the requirement of in depth analysis of impact. This focus provides some insight into areas of concern as they pertain to trip generation.

[2] The 23rd study did not specifically reference ITE Trip Generation methodologies as being appropriate or not appropriate. It appears that ITE methodologies may be acceptable, provided no better-fitting methodology is available.

Table 2-2. Summary of Traffic Impact Study Guidelines for 23 Jurisdictions[3]

Trip Generation Methodologies

- 15of 23: Allow use of ITE Trip Generation rates as a primary method.
- 7 of 23: Allow use of ITE Trip Generation rates as an alternative method (typically after the use of locally provided rates or comparable data collection).
- 4 of 23: Provide some maximum reduction applicable to trip generation methodologies.
- 3 of 23: Recommend using previously collected and stored trip generation rates. WSDOT
- 6 of 23: Provide local trip generation rates to be used as a primary source for estimation. Three of these include some combination between local rates and ITE rates using travel surveys to inform the transition between vehicle trips and person trips (mode share and vehicle occupancy).
- 6 of 23: Recommend comparable data collection to development type and location. This is also recommended with in ITE Trip Generation methodologies.
- 1 of 23: Allow for alternative methods to be used, upon approval.

Transit Adjustments

- 14 of 23: Allow some adjustment for transit use.
- 7 of the 14: Provide fixed trip credit or percent adjustment for transit accessibility.
- 6 of 14: Allow for application of mode share rates. One of these mentioned the need for documentation of vehicle occupancy.
- 2 of 14: Provide maximum transit reductions limitations.
- 2 of 14: Provide reductions based on location within Transit-Oriented Development (TOD) or Area (TOA).

Bike/Walk Adjustments

- 13 of 23: Allow some adjustment walking or bike travel.
- 6 of 13: Allow for application of mode share rates. One of these mentioned the need for documentation of vehicle occupancy.
- 3 of 13: Provide fixed trip credit or percent adjustment for walk/bike amenities.
- 1 of 14: Provide maximum reductions (combined with transit reductions) limitations.

Pass-by Adjustments

- 19 of 23: Allow some pass-by adjustments.
- 3 of 19: Provide a sample of acceptable pass-by reduction rates by land use.
- 4 of 19: Accept ITE Trip Generation Pass-by methods and rates as being acceptable.
- 2 of 19: Provide maximum pass-by rates limitations for specific land uses or applicable to trips generation estimates for development.
- 5 of 19: Provide maximum limitations for pass-by adjustments based on percent of adjacent street, peak hour traffic. Four of these allowed 10% of adjacent street traffic as a maximum; one allowed 2%.
- 2 of 19: Restrict pass-by applications to specific land uses (retail-type).

Mixed-Use or Internal Capture Adjustments

- 14 of 23: Allow some internal capture or mixed-use adjustments.
- 5 of 14: Accept ITE Trip Generation Internal Capture methods or data as being acceptable.
- 2 of 14: Provide maximum internal capture rate adjustments.
- 2 of 14: Provide fixed internal capture adjustments or guideline based on local context.

Miscellaneous Comments

- 7 of 23: Allow for reductions for transportation demand management (TDM) methods.
- 4 of 23: Provide some adjustment or special local rate by area-type or district.
- 11 of 23: Provide some guidance on a threshold of requirements before a Traffic Impact Study (TIS).

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[3] Sources include (Bedford County Department of Planning 2004, Baltimore City Department of Transportation 2007, Montgomery Planning 2010, Harris County, Texas 1991, City of Vancouver 2010, City of Sedro-Woolley 2004, City of Henderson, Department of Public Works 2009 February, Charlotte Department of Transportation 2006, City of Pasadena 2005 August 24, Georgia Regional Tranpsortation Authority 2002 January 14, Southern New Hampshire Planning Commission 2010, San Francisco Planning Department 2002, City of Bend 2009, San Diego Municipal Code 2003 May, City of San Diego 1998, Virginia Department of Transportation 2010 April, City of Rockville 2011, City of Los Angeles Department of Transportation 2010, City of Mississauga 2008, New York City 2010, San Francisco Planning Department 2002, State of Flordia Department of Community Affairs 2006, City of Salem 1995, City of Bellingham 2012, City of Bellingham 2012)

Table 2-3 provides summary of the vehicle trip generation thresholds before Traffic Impact Study (TIS) is required, while Table 2-4 list some example land use development sizes based on trip generation estimates to use in comparison.

Table 2-3. Trip Generation Thresholds Requiring Traffic Impact Study (TIS) †

Jurisdiction	Daily Threshold	PM Peak Threshold	Peak Hour Threshold
Bedford County, VA	500	-	-
Montgomery County, MD	-	-	30
Pasadena, CA	70	-	11
Sedro-Woolley, CA	500	-	50
Henderson, NV	-	-	100
Charlotte, WV	2,500	-	-
San Francisco, CA	-	50	-
San Diego, CA	500-1000	-	50-100
Mississauga, Canada	-	-	75
New York City, NY *	-	-	50

* Also provides thresholds for transit trips and pedestrian/bike trips generated for basis of required transit and pedestrian/bike impact studies.

† For sources, see page 7, footnote 3.

Table 2-4. Land Use Examples of Square Footage Gross Floor Area Required to Meet Trip Generation Thresholds

	Approximate Square Footage Gross Floor Area to Generate Vehicle Trips:	PEAK HOUR OF ADJACENT STREET TRAFFIC 10	50	75	100	WEEKDAY, DAILY 70	500	1000	2500
925	Drinking Place	880	4,400	6,610	8,820	-	-	-	-
932	High-Turnover (Sit-Down) Restaurant	900	4,480	6,730	8,970	550	3,930	7,870	19,660
851	Convenience Market (Open 24-Hours)	190	950	1,430	1,910	100	680	1,360	3,390
850	Supermarket	950	4,760	7,140	9,520	690	4,890	9,780	24,450
936	Coffee/Donut Shop without Drive-Through Window	250	1,230	1,840	2,450	-	-	-	-

* Square footage of gross floor area is calculated using average ITE Trip Generation rates.

2.3.1 Other Current Studies and Approaches

The MXD model (Fehr & Peers) and the 4D model (Environmental Protection Agency - EPA) are both examples of models which account for elasticities and impacts of contextual factors like density and diversity while estimating vehicle demand. Both models can be applied to local contexts, however, the cost of implementing and maintaining TDM often exceed the budget by local jurisdictions that do not have a modeling staff. Some research suggests that the use of the MXD model may result in a 26% error compared with actual surveyed counts, compared with a roughly 40% error using ITE TG Report rates and a 32% error using ITE TG Report rates and reductions (Walters 2009). The INDEX model with 4D enhancements (EPA) reported a 12% error compared with collected in areas of infill development (Hagler Bailly Services, Inc. and Criterion Planners/Engineers 1999).

URBEMIS is a national model used for calcualting air quality impacts of local projects, like new developments, by taking into account physical factors, like density, sidewalk connectivity and land use mix, and also temporary factors not conidered in this literature review, like travel demand management, and provides credits, or trip reductions, for specific land uses (Nelson\Nygaard Consulting Associates 2005).

The National Cooperative Highway Research Program (NCHRP) is currently funding two projects related to understanding the differences in travel behavior from these environmental differences. Neither study has officially been published, but general methodologies have been presented.

In the NCHRP 8-66, "Trip-Generation Rates for Transportation Impact Analyses of Infill Developments", focuses on defining reductions based on context for sites which allow or encourage infill development. In this study, the researchers may develop a reduction method based on person-trips by converting ITE data with assumed vehicle occupancy. Then the authors apply the relative ITE reduction rates to the known context types defined separately.

NCHRP 8-51, "Enhancing Internal Trip Capture Estimation for Mixed-Use Developments", attempts to identify characteristics of mixed-use development, which affect the level of internal capture trips, and investigates data collection framework and protocol for determining the magnitude of the internal capture effect to apply as reduction rates (Bochner 2010). Using this method, one researcher claims the trips generated show significant improvement of about 13-percent error from the ITE method with about a 35-59-percent error as compared with actual counts. (Sperry 2010). Although specifically focused on improving the accuracy of vehicle trip rates as they relate to Mixed-Use Developments, the resulting methodology may validate or compare with the total overall vehicle reductions found in the Contextual Influences study, which attempts to offer vehicle trip reductions also based on context.

2.4 DEFINING CONTEXT

During an ITE Trip Generation study, it is recommended to collect the context, or "location within an area", surrounding the establishment surveyed. Although ITE trip generation rates are not segmented by these area-types, it is recognized that these areas are inherently different in results (Institute of Transportation Engineers 2004).

While individual built environment measures have commonly been used to explain mode choices, this section first explores the explanation of travel behavior based on changes in area-types defined by either local planning agencies or individual studies (Section 2.4.1). Then, this section identifies those built environment variables which have been shown to impact mode choice in travel behavior (Section 2.4.2).

2.4.1 Area Types

2.4.1.1 Central Business District, Urban Core and Downtown Areas

The Central Business District (CBD) and Urban Core (UC) areas, defined as the core of the commercial district within the city, may contain many of the built environment characteristics that are significantly correlated with reductions in the number of vehicle trips generated at establishments. Factors such as dense employment and residential populations, high accessibility to transit and pedestrian amenities, greater connectivity through tighter intersection networks, and limited or paid parking availability, all work together to significantly reduce the amount of vehicle trips destined within the core. Jurisdictions studied in section 2.3 apply reductions or adjustment methods for downtown area-types more often than other area-types focused here.

This area-type is most associated with lower vehicle mode shares. For example, a study in San Francisco found vehicle mode shares to 3 pharmacies in urban core areas to be between 8% and 13%, while 17 similar establishments around suburban San Francisco had vehicle mode shares of between 54% and 98%. The urban core location had significantly higher land use mixes, off-street or paid parking, smaller site development set-backs and pedestrian access (Schneider 2011). Walking tends to have a greater mode share in the CBD-type areas. For commuting trips, research in Chicago and San Francisco also found that almost all residents in CBD areas walk to their destinations, instead of driving or taking transit (Seskin, Cervero and Zupan 1996).

Employment and population density in CBDs may also play an important role in transit ridership, reducing vehicular trips. High-density residential and workplace areas in locations of high-quality transit opportunities, measured in lower headways, increase the likelihood of taking transit. Researchers found that increasing employment density within a CBD by six-times, results in daily transit boarding's increasing by over 4.5 times (Seskin, Cervero and Zupan 1996). These effects of the built environment in downtown areas also appear to have influences on non-work travel behavior. A study Philadelphia compared three vehicle-oriented grocery stores with three pedestrian-oriented grocery stores. While holding the high-density, land-use mix, street network connectivity and sidewalk coverage constant, the researchers varied availability of parking lot sizes and setbacks to the store entrance. They found the automobile-oriented grocery stores had, on average, 21% of respondents that always drove to the site, while the pedestrian-oriented grocery stores had nearly 6.2% of respondents list that they always drove (Maley and Weinberger 2010).

2.4.1.2 Transit-Oriented Development

Transit-Oriented Developments (TODs) or Transit-Oriented Areas (TOAs) are one of the more researched areas. By definition, TODs include a transit center or station with high density and mix of residential and employment land uses radiating from a quarter to a half mile out. These areas are developed in an effort to increase the amount of transit and active (bike and pedestrian) travel in concentrated areas. The research identifying impacts of TOD design is inconclusive on the best combination of the built environment, such as land use mix, density and pedestrian amenities, to maximize vehicle trip reductions. The literature on TOD-type areas identifies residential and employment densities, pedestrian amenities and connectivity, accessibility to transit, high-quality transit, and trip purpose as having influence on vehicle mode shares.

Portland, Oregon has had much success in obtaining higher transit-ridership and vehicle trip reductions. One study attributes much of the success to the placement of TODs on corridors already developed for regional travel like a "necklace of pearls". The study concludes that traffic impact studies may overestimate the vehicle impact of TOD residential locations in locations close to rail by nearly 50-percent. In this study, Portland represented only a portion of the surveyed sites, and appears to have the lowest vehicle trip generation rates, nearing 40-percent below the ITE manual for residential sites located near light rail stations. This reduction in vehicle trips generated increases in the study sample as the density of dwelling units per acre increases in the development area (Cervero and Arrington 2008).

Travel behavior is relatively inelastic within a quarter mile from a transit station when comparing environmental characteristics like mixed land uses, traffic calming, pedestrian amenities, and density (Cervero and Arrington 2008). This suggests that mode choice remains relatively constant less than a quarter mile from a transit center or station even when other built environment factors change. It has been found that TOD implementation on regional and corridor levels may decrease residential vehicle trips an average of 44% compared to ITE Trip Generation estimates (Cervero and Arrington 2008). Proximity to light, heavy and commuter rail transit stations in Washington, DC, Portland, San Francisco, and New Jersey were studied at ranges from a quarter to a half mile. Within these buffers, the number of dwelling units ranged from 100-900, while the range of calculated trip reductions ranged between 30% and 60%. The range of reductions in this study reflected proximity to transit, household density, and transit type all reducing the vehicle trips generated at these locations (Cervero and Arrington 2008).

Additionally, Transit-Adjacent Developments (TAD), those developments that have a lack of pedestrian amenities and tend to have greater vehicle-oriented design characteristics, show a smaller reduction in vehicle mode shares compared with TOD locations. While TOD-type developments appear to service transit-users, the combination of mixed land uses, densities and pedestrian amenities increase the likelihood of other non-automobile modes in addition to transit.

For example, a dissertation examined factors of commuting around fixed-rail transit stations in Maryland, Florida, Oregon, California and New Jersey. The split of access modes for the two stations are shown in Table 2-5 and are distinctly different (Renne 2005).

Table 2-5. TOD and TAD Study Mode Shares *

Access Mode	TOD (Berkeley)	TAD (Fremont)
Automobile	7.4-percent	62.0-percent
Carpool	0.9-percent	6.3-percent
Walk	59.3-percent	7.8-percent
Bike	4.6-percent	1.0-percent
Transit	18.6-percent	10.2-percent

* (Renne 2005)

The higher driving rates for access mode at the Fremont station may be due to its park-n-ride design, priority for parking provision over infill development, pedestrian infrastructure, and density. Despite the differences in development in these two areas, the author noted Berkeley as having a higher share of transit commuting, walking, cycling, and households with one or no cars. Housing density near the Berkeley station is high. The author also notes a 740% increase in residential density and 990% increase in transit commuting trips from 1970 to 2000. Density around TODs is critical to their success. A 73-percent decline in walking and cycling around Fremont station suggests development of density and encouraged park-n-ride type facilities may overwhelm other pedestrian features that make the area easier to access by active modes (Renne 2005).

Another Portland study performing two surveys at specified TOD locations and found the commuting transit mode share near MAX stations declined significantly when walk access time exceeded 30 minutes for work or school trips (Dill 2008), showing increased importance of pedestrian accessibilities and accessibilities. Additionally, another study in California found that roughly one fifth of trips within a TOD to retail locations are taken by transit, while one tenth of total trips are walking (Lund, Cervero and Willson 2004).

In the study of TODs in Portland, Oregon, overall transit commuting shares ranged from approximately 6 to 22% in 2000, while other alternative modes of transportation in TODs of the region ranged from 4 to 37%. The growth of transit commuting mode share in the compared TODs averaged 32% over 30 years. All TODs had a higher non-automobile mode share than surrounding areas (Renne 2005).

High-quality transit service also impacts most choice in TOD-type areas. In Portland, TriMet worked to improve off-peak bus service within more dense or TOD-like corridors, increasing the non-work trips by transit. Between 1999 and 2003, TriMet increased service frequency of 10 bus lines to less than 15 minutes, increasing overall ridership by 9-percent. In addition to an 8-percent increase in weekday ridership, ridership increased by 14 and 21% for Saturday and Sunday. Frequent bus service accounts for about half of the weekly hours ridden and trips taken. The same report suggests that headways of 10 minutes are ideal and positively correlated with ridership on transit. Other factors impacting transit ridership include the extensiveness of the transit network and parking costs (Cervero and Arrington 2008).

Moreover, a large influencer of mode share relates to the trip purpose. A travel survey conducted by mail in Portland, found that less than 25% of respondents used transit for non-work trips in good weather once a week or more. The further from the downtown area the TOD was located, the lower the non-commute share of transit ridership (Dill 2008). In a San Francisco Bay Area study, the likelihood that transit will be taken for a non-chained trip versus a chained trip is 24.5% versus 4.2%. In locations near BART where there was a greater density and land-use mix, there is reflected an even greater demand for non-work chained trips (Lund, Cervero and Willson 2004).

2.4.1.3 Mixed-Use Developments

Mixed-Use Developments (MXD) are defined in the ITE Trip Generation Handbook as having more than two land uses, typically planned as a single real-estate project between 100,000-2,000,000 square feet in size with some trips between on-site land uses, and not located on major streets. No part of this definition includes access to transit for mixed-use developments (Institute of Transportation Engineers 2004). One of the main phenomena observed in MXD areas include internal capture, the ability to perform multiple activities at a single development due to the close proximity to a variety of land uses, and potentially greater pedestrian amenities.

Internal capture rates for four residential, mixed-use developments along the MAX corridor in Portland, Oregon, were found to have a 2 to 20% internal capture rate to or from retail locations during the PM peak hour. Daily rates include a 4 to 28% internal capture of trips to retail locations within these developments. The same study also found that when all pedestrian and transit trips are included in the trip generation of the residential sites along MAX transit corridors, the rates generated are still lower than the provided ITE TG Rates (Lapham 2001).

Additionally, the internal capture which occurs from infill development is also an area of more recent research. Infill may occur in any urban areas and increases densities and accessibilities, potentially effecting travel behavior. A large study in California, surveying 13 residential, office and retail infill locations observed differences in vehicle trip generation between -99% to 30% compared to ITE Trip Generation estimations. Those sites that observed positive percent differences (generating greater trip rates than provided by ITE) include retail or grocery store locations and mid-rise residential condominiums (Kimley-Horn and Associates, Inc. 2009). These values are incorporated into the estimated adjustments to ITE Trip Generation rates in Table 2-1. Relationships between this variation in trip generation rates and the built environment are not addressed in the current state of the research. However, the data collected from this study was analyzed using currently available methods in a study from UC Davis. From this study, no current methodology was identified as a clear “winner” for estimating vehicle trip generation at smart growth locations due to the complexity of interactions between the built environment and travel choices (Lee, et al. 2011).

2.4.1.4 Suburban City Centers and Corridors

Although ITE Trip Generation rates are typically collected at suburban-type locations (Institute of Transportation Engineers 2004), there is some evidence that suggests that even these locations are difficult to estimate with accuracy, especially as these centers and corridors become more established (see Table 2-1). Medium-dense suburban locations, for example, near transit corridors with lower single-family housing percentages and smaller parcel sizes tend to promote walking and biking of shorter trips (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption 2009).

Although suburban type neighborhoods often had a reputation for vehicle oriented design, some researchers found in some suburban areas have the ability to transition into transit-oriented neighborhoods easily, helping to reduce vehicle travel. In a study in Toronto, Canada, increasing transit accessibility and utilizing the medium density of the neighborhood (developed between 1986 to 2001), the automobile-driver share of morning peak period trips dropped from 43 to 37%, while transit and non-motorized modes rose from 50 to 54% and 3 to 5%, respectively. In this example, changes in accessibility and encouraging density around transit stops further the vehicle trips taken (Crowley, Shalaby and Zarei 2009).

2.4.2 Built Environment

While the last section focused on studies which have classified the study sites into already known contexts, an alternative way to define the area-type is by using disaggregate measures of the built and transportation environment. For the purpose of this study, contextual factors researched and discussed include macro-scale measures. While micro-scale measures, such as presence of tree shade and pedestrian barriers to the roadway, may influence the decision to take a specific route, it is the macro-scale variations, such as intersection density and land use mix, which facilitate the ability to take an alternative mode instead of an automobile. This section introduces built environment attributes that are shown in the literature to have an impact on automobile trips. These elements of the built environment are often grouped into categories reflecting the "D"s of development: Density, Diversity, Design, and Distance to Transit (Cervero and Kockelman 1997, Ewing and Cervero 2001), and therefore are placed into these categories in this section.

2.4.2.1 Density

Employment and residential density both influence mode choice. One study suggests the main benefit to greater densities is to make destinations closer to origins, although the authors do not see the significance in an increase in transit usage when residential density increases (Lund, Cervero and Willson 2004). Another study found relevance in the employment and residential density. Some research suggests that by doubling the residential density, the household vehicle miles traveled maybe reduced by 5%, and in some locations as much as 25% when additional factors, like proximity to transit and mixed land use, are also improved (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption 2009). Overall, the literature suggests increased density is correlated with reductions in the number of vehicle trips taken. In a synthesis of influences on the built environment, the aggregate (linear) elasticity of density and vehicle trips is -0.05, suggesting that as density increases by 10%, the number of vehicle trips decreases by 5% (Ewing and Cervero 2001).

2.4.2.2 Diversity (Land Use Mix)

Diversity, or land use mix, may be measured in a variety of ways. Simple measures include percent of commercial land use to total land, or percent single-family detached dwellings to total dwellings. More complex measures include measures of entropy, gravity or dissimilarity (D'sousa, et al. 2012). For transit, the results of one study suggest that although density is often used to justify the development of transit, it is the land use mix which tends to support transit use (Seskin, Cervero and Zupan 1996). In vehicle trip generation studies, areas with mixed uses tend to have greater reductions in vehicle trip generations. For example, Fehr & Peers conducted a trip generation study in Sacramento and San Francisco Bay Area within the following mixed-use developments: (1) a medium-sized, dense suburban area; (2) a medium-sized, medium/high density downtown area with high employment; and (3) a large, low density, suburban residential area. They found that the downtown area (2) had roughly 12% fewer vehicle trips compared with ITE estimates. The areas in the suburbs (1) and (3), tended to have 45% fewer trips than ITE estimates. This same study calculated the internalization of trips and found that for all three mixed-use types, roughly 30, 25, and 7% reductions in internalization of trips compared with ITE TG was possible even at low densities when mixed land uses are present (Samdahl 2010).

Another study focusing on non-motorized trips found that the greater density of discretionary businesses located within an area promotes non-motorized trips, and land use mix measured within a quarter mile of a traveler's residence tend to be correlated with additional observed reductions in motorized discretionary travel (Guo, Bhat and Copperman 2007). In a synthesis of influences on the built environment in 2001, the aggregate (linear) elasticity of diversity or mix and vehicle trips is -0.03, suggesting that as diversity increases by 10%, the number of vehicle trips decreases by 3% (Ewing and Cervero 2001).

2.4.2.3 Distance to Transit

The ITE Trip Generation Handbook provides some guidance on typical transit accessibility reductions based on other built environment characteristics, such as density or pedestrian facilities. As the distance from transit increases, the ridership or demand of transit decreases. In addition, the handbook suggests that distance to rail generates different demand from distance to bus. The ITE TG Report provides information suggesting rate reductions between 2.5 to 10-percent for locations within a quarter mile of bus transit corridors. For locations within a quarter mile of light rail transit or near transit centers, the range of reductions increases to 5 to 20-percent. Higher levels of reductions are allowed with greater values of floor area ratios (i.e. property intensity correlated with activity densities) or greater mixed land use (Institute of Transportation Engineers 2004).

A San Francisco Bay Area study surveyed more than 1,000 large employment sites to examine possible connections between commuter's use of rail and location near stations. This study found a greater correlation between transit use and proximity to stations for work sites located within a quarter mile of a transit station, and decreasing correlations for sites located within a quarter to a half mile and more so for a half mile and beyond stations. The greatest commuter use of rail was from stations located in downtown areas such as Oakland, Berkeley and San Jose (Dill 2003). In a 2004 study, the defining measure of distance to transit includes the proximity measure of a quarter to a third mile near a transit station, or a half mile for areas with extensive pedestrian-friendly facilities, to best capture travel behavior around the site. In the same study, the authors suggests that station headways under 15 minutes or rail headways of 20-50 minutes are enough to impact the vehicle ridership of transit station areas (Lund, Cervero and Willson 2004).

A meta-study conducted by Ewing and Cervero (2010) suggested that the proximity to transit was relatively inelastic, although slightly negative reducing vehicle trips, related to vehicle trips, but positively elastic relating to walking and transit usage. In addition, they found that there is a correlation between the destination accessibility (jobs within one mile) for automobile with a positive correlation toward walking. The slight negative correlation of job accessibility for transit (within 30 minutes) and vehicle and walking usage may reflect an inelastic correlation.

2.4.2.4 Design

The design of an area may be reflected by many different factors, but the type of built environment often correlates with pedestrian or bicycling use as well as transit attractiveness. In NCHRP Report Number 16 on transit and urban form, the authors found that suburban neighborhoods tend to have more automotive shares for non-work trips than "historic" neighborhoods, most likely due to the mix of land uses and density available from their built block types. Additionally, there is a modest negative correlation between transit ridership and the average block size (in acres) within one-mile of either the home-end or non-home-end of a trip. This means that as blocks increase in size, there is a decrease in the likelihood that a station area resident rides transit. In addition, the relationship between transit ridership and the amount of one- and two-side sidewalks are modestly positive. This suggests that transit usage is more attractive when more pedestrian amenities are available. The same study suggests that the number of “conflict points” on a pedestrian route surrounding a transit station is negatively correlated to accessing transit by foot (Seskin, Cervero and Zupan 1996). Additional factors which small positive impacts on the walkability of neighborhoods include the presence of Street Trees, Street Lights, Street Furniture (Lund, Cervero and Willson 2004). These impacts are small compared with the distance to transit stations, density or diversity of land uses.

An additional measure of design is intersection density or block size, characteristics that often reflect the street network. For example, the density and network connectivity of bikeway and pedestrian facilities within a mile of a traveler’s residence appears to have a statistical significant and positive effect on the number of non-motorized trips taken (Guo, Bhat and Copperman 2007). Moreover, the relative location of both employment and residential land uses with respect to transit stations used by many jurisdictions was summarized as varying between a quarter to half mile in distance, a distance that "most people" would walk to work. Another factor of connectivity for destination access, therefore, is the proportion of total intersections that have more than four-way access which relates to pedestrian connectivity. The higher the street connectivity, the higher the likelihood residents near the station will take transit. The same survey showed the home-end correlation being negative with vehicle trips, suggesting either a unique characteristic of the neighborhood surveyed or that residents which live within walking distance of a rail station lacking street connectivity does not deter in transit ridership, supporting the strength of the variable for proximity to transit in overpowering other built environment characteristics (Lund, Cervero and Willson 2004). In a synthesis of influences on the built environment, the aggregate (linear) elasticity of design, such as street network density, and vehicle trips is -0.05, suggesting that as design increases by 10%, the number of vehicle trips decreases by 5% (Ewing and Cervero 2001).

2.4.2.5 Other Factors

2.4.2.5.1 Parking

The ability to park at the destination end of a trip taken is often a key player in selecting a mode choice. For example, there is a significant difference in transit ridership when the destination is located in an area with limited or paid parking compared with free parking (Cervero 2007). In another study, when studying transit, fewer than one out of twenty residents located near transit areas take transit to work if they can park for free at work; if free parking is not available, the transit-commuting share jumps to nearly 45 percent (Lund, Cervero and Willson 2004). While parking is discussed in this study as being a potential player in defining the built environment, parking generation rates and supply is not the focus of this study and remains an important area of future research.

2.4.2.5.2 Socio-economic Characteristics, Attitudes and Self-Selection

The literature also suggests that the built environment does not necessarily have the greatest correlations with reductions in vehicle trips generated. When controlling for socio-economic characteristics, the built environment, although often significant, has less explanatory power than demographic type information (Ewing and Cervero 2010). In fact a more significant player in explaining travel behavior tends to be attitudes, instead of the built environment and socio-economic characteristics (Kitamura, Mokhtarian and Laidet 1995).

Additionally the self-selection of individuals to travel choices also plays a key role in more accurate estimation of vehicle travel behavior. For example, reduced vehicle trips in TOD areas is often thought to come in part from the self-selection of residents, the mix of retail and residential land uses allowing for increased trip-chaining and reduced need for vehicle trips due to facilities provided (Cervero and Arrington 2008). Another study suggests that self-selection characteristics of a pedestrian may have a higher impact on actual pedestrian mode splits (Lund, Cervero and Willson 2004).

Traditional data collected using ITE Trip Generation methods do not, however, include information relating to socioeconomic characteristics, attitudes or self-selection. Although these factors appear to be significant in the literature, the application of information and results pertaining to analysis considering these factors would remain difficult in comparing or adjusting to ITE Trip Generation methods, and therefore, are not the focus of this study.

2.4.2.5.3 Destination (Trip Type and Length)

The “destination” can be defined as the trip type taken, such as work or non-work trips, and the trip length. Both of these descriptions relate more closely to the type of land use being studied, the demographics of the surrounding area, and willingness to travel by various modes. A survey of public and private organizations in Oregon provided rates expected from improvements in alternative transportation systems. The vehicle trip reductions provided for pedestrian and cycling trips are 2 to 10%for home-based work trips and home-based other trips and 2 to 5% for non-home-based other trips less than 0.5 miles. For trips between 0.5-2.5 miles in length only 2 to 5% of reductions for cycling would be allowed for all trip types, and for trips between 2.5-5 miles, 0 to 2% of reductions for cycling would be allowed for home-based trips. In this survey, pedestrian and bicycling reductions act independently to reduce vehicle trips (Clark 1997).

For non-work trips, the TOD neighborhood type has the highest ability to capture non-automobile modes of transportation due to the density and land use mix. Rail (5.3%), walk (3.9%), bus (2.9%), and bicycle and taxi (tied at 0.4%) are the most important non-automobile modes within a TOD for non-work trips (Lund, Cervero and Willson 2004). Once work commute sections are within one-quarter mile of a rail station, factors like mixed land uses, traffic calming, pedestrian amenities, and even density seem to matter little. These features are more likely to affect the non-work short trips (Cervero and Arrington 2008).

2.5 CONCLUSIONS

There does not appear to be any land use in which ITE Trip Generation rates and methodologies predict with a consistent level of accuracy. It is clear that developments in central business district, urban core and downtown areas tend to have the greatest variation in automobile mode share and the most substantial range of error when compared with ITE rate estimates. Additionally, mixed-use areas with very high levels of internal capture are also problematic. These developments contain more than one land use, sometimes with residential and commercial mixed uses, but not always. Transit-oriented or accessible areas and developments are also problematic, but there is less information about the impact of specific land uses in these areas. Additionally, despite the locations from ITE data sets to be characteristically suburban and vehicle-oriented, that does not leave developments in suburban centers and corridors to be exempt from inaccurate estimation using ITE rates and methods.

A portion of this error between ITE estimates and observed data counts may be due to small sample sizes within ITE's estimates requiring average rates to be used despite many vehicle trip generation relationships to be non-linear. Additionally, error may be due to variations in socioeconomic characteristics. There are no current methodologies for estimation or adjustment to ITE rates which account for socioeconomic characteristic variation for the purposes of traffic impact assessment. This is mainly due to the lack of information about patrons of establishments, neither from previous ITE studies, nor for future development assessments. As a result, the built and transportation environment remain the standard for attempting to account for variation in ITE Trip Generation rates.

There has recently been a lot of activity investigating methodologies to more accurately estimate trip generation. Of them, there is no one methodology that works best for all cases and they all have varying challenges in implementation. Lee et al (2011) provides an evaluation of the most current methodologies: ITE Mixed-Use, EPA MXD model, NCHRP 8-51, MTC Survey, and URBEMIS. Of these five methods, both the EPA MXD method and the URBEMIS method provide a greater level of sensitivity to changes in the built environment, but at the expense of far greater data needs making it difficult to modify or supply the models with information modifying them to represent local behavior. Additionally, methods such as MTC Survey have not been evaluated in methods external to California.

Guidelines in trip generation estimation provided by jurisdictions in the United States often list ITE rates and methodologies as being the primary or secondary method approved for application in estimation. Many of the same jurisdictions also provide guidelines on suggested methods of adjustment to ITE using fixed rates or applied mode shares to adjust estimated rates to fit the local needs. Additionally, of the few that allow documented mode share information to be applied for trip rate adjustments, only one also requests documentation on vehicle occupancy, a key factor in adjusting person trips by alternative modes (transit, bike, and walk) to and from vehicles. Few jurisdictions have compiled local trip generation studies to compile local rates and or adjustments, Portland locations included. Those that do provide local rates, however, tend to vary their rates by district-based or area-based boundaries.

These district-based rates are location specific and difficult to relate, then, to external areas, such as Portland. Identification of the built and transportation environment variables which significantly explain the most variation in observed vehicle trip generation becomes an important element in predicting travel behavior. Although socio-economic information provides greater explanatory power, it is also not typically captured within traffic impact studies at individual establishments and therefore will not be approached within the analysis. Additionally, built environment measures typically studies tend to be highly-correlated with each other, making it difficult to incorporate more than one variable in a regression alone. Processes such as factor and cluster analysis allow many variables to be incorporated in order to identify indices of composite measures or groupings of similar areas. However, these methods may require more observations (at the establishment level) to be able to be correctly applied and may be considered, in some cases, subjective.

Therefore, the focus of this study is to identify those built and transportation environment measures which explain the most variation in vehicle trips generated at establishments in the local contexts of Portland, Oregon to provide a parsimonious local adjustment to ITE Trip Generation rates and methodologies.

3.0 DATA & METHODS

This chapter presents the study design, data collection processes, and sample used to develop an adjustment method to ITE vehicle trip rates based on area type. The chapter is organized as follows:

1. Survey Site selection and definitions of area types.
2. Survey instrument design and sample description.
3. Count data collection methods and sample description.
4. Built environment data methods.

Data collected from this study are then compared to ITE Trip Generation Manual information to forms the basis of a method to adjust ITE rates locally.

3.1 SITE SELECTION & ESTABLISHMENT TYPES

To analyze trip generation at different types of urban environments, establishments were included in the study based on characteristics of the surrounding built environment. Environmental variables were analyzed[4] to ensure that selected sites represented the entire spectrum of the urban landscape found in the Portland metropolitan region. Five unique classifications resulted. They can be generally described in the following area type terms:

- Central Business District neighborhoods (near downtown Portland)
- Urban Core neighborhoods (such as inner Northeast and Southeast Portland neighborhoods)
- Neighborhood and Regional Centers (similar to those Regional Centers defined by Metro)
- Suburban Town Centers and Corridors (typically areas farther from the Central Business District but more densely developed than suburban residential areas)
- Suburban Areas (the least densely developed areas)

Individual establishments representing the five area types were recruited to participate in the study. Greater numbers of establishments were sought in more urban area types (Central Business District, Urban Core, Neighborhood/Regional Centers) as we hypothesize that these are likely to have greater non-motorized and transit trips. We anticipate that establishments in more automobile-oriented area types (Suburban Town Centers, Suburban Areas) have higher automobile mode shares and trip rates similar to those found in the ITE manual. Agreement with ITE rates requires fewer observations (a smaller sample size) to support statistical analyses.

Given the resource limitations for this study, only a few ITE land use types are examined. Land uses chosen for the study include a) Land Use 932: High-Turnover (Sit-Down) Restaurants

[4] A K-means clustering analysis was performed in the stats package in R using built environment measures to determine classifications of area type. Variables in the cluster analysis included intersection density, population density, employment density, block size and floor-area ratio.

(pizza and Mexican restaurants were used in this study), b) Land Use 851: Convenience Markets (Open 24-Hours) without gas stations and c) Land Use 925: Drinking Places. These land use types, which are ubiquitous around the region, are chosen for analysis since they are located in urban infill, mixed use, and TODs where overestimation of vehicle trips is most problematic.

Most establishments in the study belong to regionally owned and operated franchises. Local establishments are overrepresented in the sample because they were more willing to participate than national corporate franchises. Choosing local establishment potentially creates limitations in the study: establishments were generally smaller (most under 3,000 sq. ft. gross floor area) and may cater to a more local cultural demographic. Table 3-1 summarizes the number of establishments that participated in the study. Figure 3-1 shows the spatial distribution of the 78 survey establishments throughout the Portland region. Area types change from more urban to more suburban as distance from the Central Business District increases.

Table 3-1. Establishments Surveyed by Area and Land Use Type

Area Type	# Restaurant Locations	# Convenience Locations	# Bar Locations	Total
Central Business District	12	4	3	19
Urban Core Neighborhoods	10	5	6	21
Neighborhood and Regional Centers	6	6	4	16
Suburban Town Centers	5	7	0	12
Suburban Areas	6	4	0	10
Total	39	26	13	78

3.2 SURVEY DATA

This section details the methods used for survey data collection and provides a description of the survey sample.

3.2.1 Survey Instruments

Data were collected in 2011 from June through early October. Because of the relatively small sample size, we controlled for weather by only collecting data on days with favorable conditions. Data collection events occurred from 5:00PM to 7:00PM on Mondays, Tuesdays, Wednesdays, and Thursdays, as they are considered “typical” travel days. The 5:00PM to 7:00PM time window was chosen to overlap with ITE’s Trip Generation weekday, peak hour (4:00PM to 6:00PM) as well as the peak hour of generators for some land uses. According to many store managers, most restaurants do not experience much customer traffic during the 4:00PM to 5:00PM hour.

Information collected at each location included: (1) customer intercept surveys, including socio-demographic status and travel information; (2) counts of persons entering and leaving the establishments and of automobiles leaving (where possible); (3) establishment information, including site-specific attributes such as gross square footage, number of employees, parking capacity, and other site design characteristics; and (4) archived information about the built and environment.

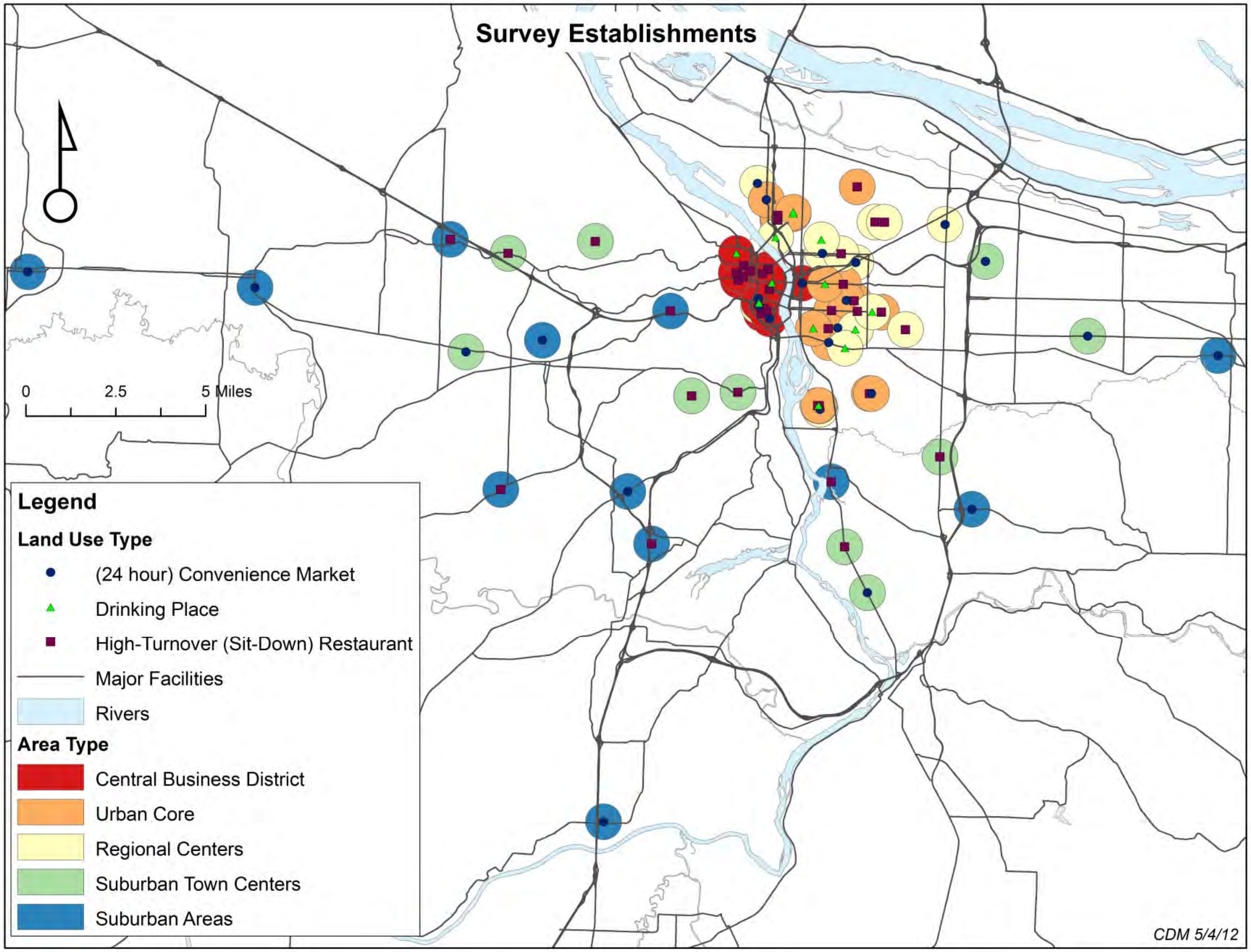

Survey Establishments
0
2.5
5 Miles
Legend
Land Use Type
(24 hour) Convenience Market
Drinking Place
High-Turnover (Sit-Down) Restaurant
Major Facilities
Rivers
Area Type
Central Business District
Urban Core
Regional Centers
Suburban Town Centers
Suburban Areas
CDM 5/4/12

Figure 3-1. Locations of Survey Establishments

3.2.1.1 Customer intercept survey

The surveys were administered by intercepting customers as they leave the establishment. Two survey options were offered to customers: (1) a five-minute survey administered via handheld computer tablets, and (2) a shortened version of just four questions. The five-minute survey collected information on demographics, travel mode(s), consumer spending behavior, attitudes towards transportation modes, the trip to and from the establishment, and map locations of home and work Appendix A contains a paper version of the five-minute survey instrument.

The short survey was offered as an alternative to customers refusing the five minute survey. It does not collect as much detailed information, but it does help obtain a larger sample. This survey collected four: mode of travel, amount spent on that trip, frequency of visits to the establishment, and the respondent's home location. Gender was recorded by the survey administrator. See Appendix B for the short survey instrument

3.2.1.2 Establishment information

Site-level characteristics were collected during field data collection events. These characteristics include vehicle parking spaces, parking configuration, and site amenities for pedestrians and cyclists. Building square footage was collected from managers and Google Earth.

3.2.2 Sample Description

An average of 24.2 surveys was collected at each establishment, for a total of 1884 surveys (697 long surveys and 1187 short). The overall response rate was 52% for all surveys. More detail on sample size is provided in Table 3-2.

Table 3-2. Survey Sample Size

Land Use	Establishments (N)	Long Surveys (N)	Short Surveys (N)	Response Rates		Total
				Long Survey	Short and Long Survey	
Drinking places	13	107	108	30%	50%	215
Convenience	26	281	710	14%	61%	991
Restaurants	39	309	369	24%	52%	678
Total	78	697	1187	19%	52%	1884

Table 3-3 shows the demographic information of long survey respondents. In addition, the sample demographic characteristics are compared to US Census data for the Portland metro area. Household income, vehicle ownership, and household size are closely aligned with Census information. Men and younger people were slightly overrepresented in our sample.

Table 3-3. Survey Demographics Compared to U.S. Census Data

Variable	Survey observed*	2010 Census (Oregon)
Median household income per year	$50,000 - $99,000	$48,457
Average household income per year	$50,000 - $99,000	$62,964
Median Age	25-34	38
Male respondents	56.80%	49.50%
Average # vehicles per household	1.60	1.80
Average # bicycles per household	1.70	N/A
Average # transit passes per household	0.50	N/A
Average # adults per household	2.20	N/A
Average # children per household	0.25	N/A
Average household Size	2.45	2.50
Physical limitations	6.90%	13.00%

*Note: demographic data from long survey only. N = 697

3.2.2.1 Mode share

Table 3-4 shows automobile mode share is consistently higher in suburban areas than in more urban settings. Automobile mode share decreases as locations become more urban. Note that no drinking places were surveyed in suburban locations.

Table 3-4. Automobile Mode Share

Area Type	Drinking Place	24-hour Convenience Store	High Turnover (Sit-Down) Restaurant
Central Business District	26%	34%	35%
Urban Core	46%	51%	64%
Regional Centers	52%	60%	70%
Suburban Town Centers	N/A	70%	85%
Suburban Areas	N/A	72%	86%

Table 3-5 shows mode shares in more detail. Higher proportions of walking and bicycling occur at establishments in the Central Business District, Urban Core, and Regional Center area types than in suburban area types. Transit mode shares are highest in the Central Business District, but there is not as consistent a trend in transit mode shares between urban to suburban area types as there are trends with other travel modes. Non-automobile mode shares appear highest in the areas of the region that offer the most variety of convenient travel choices.

Table 3-5. Percent Mode Shares by Area Type and Land Use

Area Type & Land Use	Automobile Mode Share	Walk Mode Share	Bicycle Mode Share	Transit Mode Share
Convenience	58%	27%	7%	6%
Central Business District	34%	49%	10%	10%
Urban Core	52%	31%	9%	6%
Regional Centers	60%	26%	7%	5%
Suburban Town Centers	70%	18%	3%	7%
Suburban Areas	72%	14%	8%	3%
High-turnover Restaurant	63%	22%	8%	6%
Central Business District	35%	42%	7%	16%
Urban Core	65%	20%	13%	2%
Regional Centers	70%	24%	6%	1%
Suburban Town Centers	85%	6%	1%	6%
Suburban Areas	86%	5%	0%	8%
Drinking Place	43%	27%	22%	7%
Central Business District	26%	40%	19%	15%
Urban Core	46%	20%	25%	8%
Regional Centers	52%	30%	18%	1%
Suburban Town Centers*	N/A	N/A	N/A	N/A
Suburban Areas*	N/A	N/A	N/A	N/A
Overall	58%	25%	9%	7%
Central Business District	34%	43%	9%	14%
Urban Core	57%	23%	15%	5%
Regional Centers	61%	26%	10%	3%
Suburban Town Centers	79%	11%	2%	7%
Suburban Areas	78%	10%	5%	5%

*Drinking places were not surveyed in suburban area types

Figure 3-2 shows the resulting automobile mode share for all establishments surveyed in a spatial context. As shown, automobile mode shares are generally lower in establishments closer to the city center. There is variation in automobile mode share in the inner east side of Portland where area type varies between Urban Center and Neighborhood/Regional Center. For a more detailed map of mode shares of survey establishments, see Appendix C.

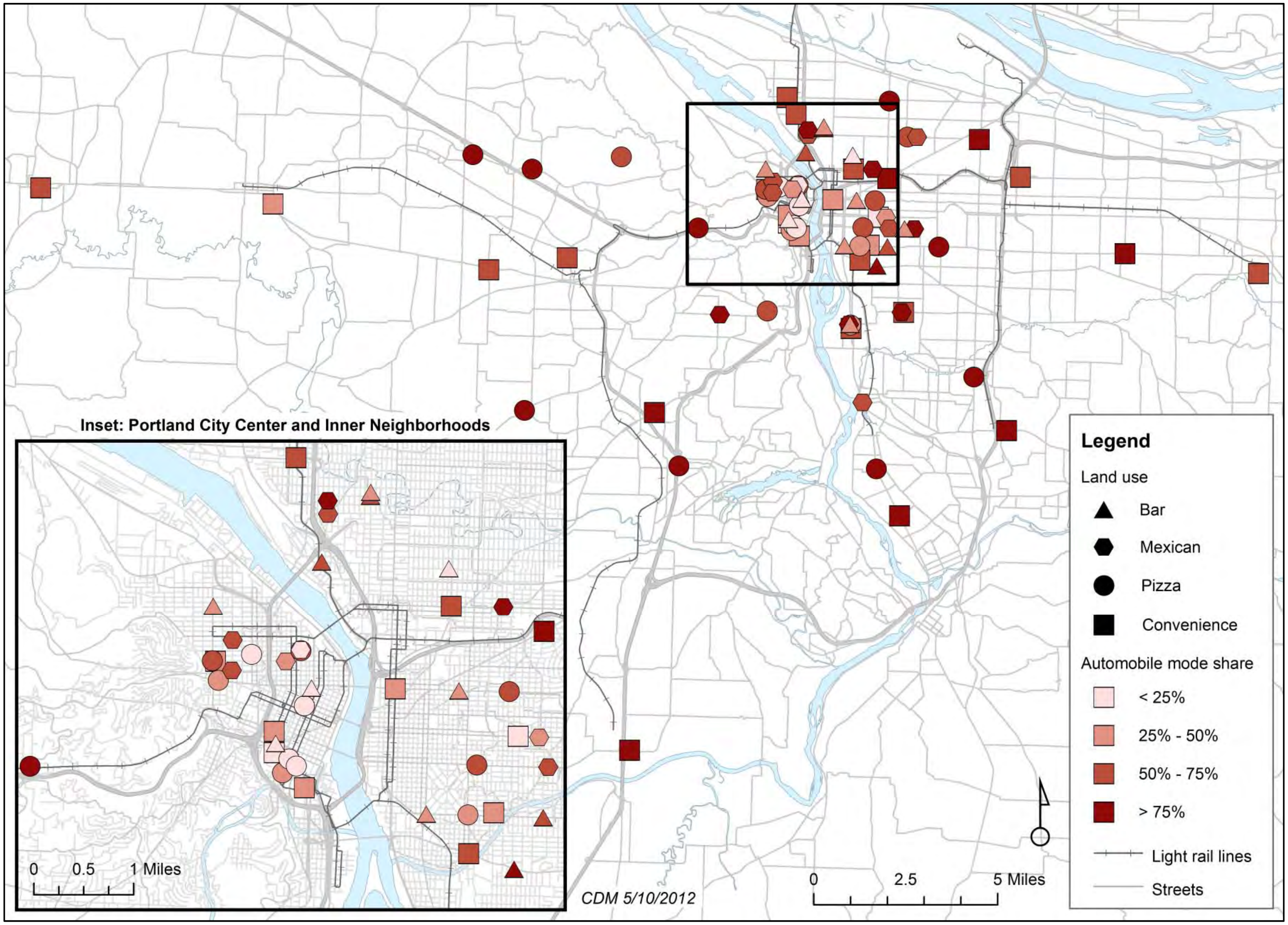
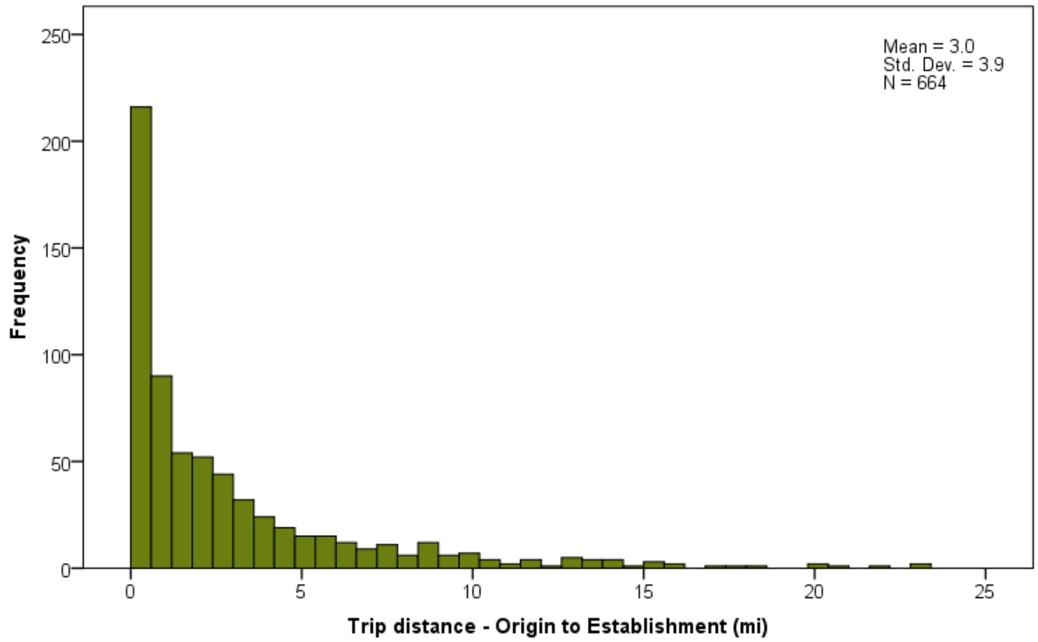


Figure 3-2. Automobile Mode Share of Survey Establishments

3.2.2.2 Trip length distribution



Note: trip distance to establishment only available for long survey responses

Figure 3-3. Trip Lengths, Origin to Establishment

In Figure 3-3, the trip length distribution (network distance) of origin to establishment trips is shown from long survey data. Most trips were less than five miles in length. Average trip lengths by mode and area type are provided in Table 3-6. There is no consistent pattern for trip length as area type changes from urban to suburban.

Table 3-6. Average Trip Length Distribution by Area Type (miles)

Area Type	Vehicle		Rail	Bus	Bike	Walk	All	N
	Driver	Passenger						
Central Business District	4.9	4.2	10.6	3.8	2.2	0.6	2.5	163
Urban Core	4.2	2.4	1.7	4.6	2.7	0.9	3.0	227
Regional Centers	2.9	3.0	3.1	3.0	2.2	0.7	2.1	158
Suburban Town Centers	5.7	1.7	8.9	9.0	0.9	0.5	5.1	77
Suburban Area	4.7	3.5	9.2	4.2	1.3	0.5	3.9	72
All	4.3	2.7	10.0	5.0	2.4	0.8	3.0	697
N	305	49	23	26	75	203	681	

Note: N for travel mode is less than N for area type due to respondents that chose “Other mode”, skipped, or opted out of the question.

3.2.2.1 Vehicle occupancy

Table 3-7 shows the average observed vehicle occupancy from long survey responses tabulated by land use and area type. Convenience stores had the lowest vehicle occupancy and high-turnover restaurants had the highest. There appears to be little variation in vehicle occupancy across area types.

Table 3-7. Average Vehicle Occupancy from Long Survey

Area Type	Drinking Place	24-hour Convenience Store	High Turnover (Sit-Down) Restaurant
Central Business District	1.5	1.0	1.8
Urban Core	1.5	1.1	1.8
Regional Centers	1.8	1.3	1.8
Suburban Town Centers	N/A	1.2	1.5
Suburban Areas	N/A	1.1	1.8

3.2.2.2 OHAS Comparison

The vehicle occupancy and automobile mode share data collected from the survey are compared to data from another regional survey of travel behavior, the Oregon Household Activity Survey (OHAS). Table 3-8 and

Table 3-9 show that automobile mode shares and vehicle occupancies observed in this study are lower than those observed in OHAS data.

Adjustment for potential survey bias was not applied to the survey sample. OHAS data are collected at the households of participants, unlike data from this study that are collected at establishments.

Table 3-8. OHAS Comparison: Automobile Mode Share

Land Use	TGS Survey	Oregon Household Travel Survey Data (OHAS, 2011)[5]
Convenience Market (Open 24-Hours)	58.5%	84.8%
High-Turnover (Sit-down) Restaurant	62.9%	79.0%
Drinking Place	43.3%	79.0%

[5] OHAS Trip purpose comparing Convenience Market (Open 24-hours) includes "Routine Shopping (Groceries, Clothing, Convenience Store, Household Maintenance)". OHAS trip purpose comparing High-Turnover (Sit-down) Restaurants and Drinking Places is aggregated by "Eat Meal Outside of Home" trip purposes.

Table 3-9. OHAS Comparison: Vehicle Occupancy

Land Use	PSU Survey	Oregon Household Travel Survey Data (OHAS, 2011)[5]
Convenience Market (Open 24-Hours)	1.2	1.6
High-Turnover (Sit-down) Restaurant	1.8	2.0
Drinking Place	1.6	2.0

3.3 COUNT DATA

This section details the methods used to collect person trip counts and vehicle trip counts from establishments. It also describes the resulting trip count data.

3.3.1 Method

Surveyors counted persons entering and exiting the establishment at every entrance to the store. The number and gender of people refusing to participate in the survey was recorded in order to later calculate response rate and bias in the survey data. Counts of vehicles and bicycles exiting the site were recorded when feasible (typically when the site had parking adjacent to the store entrance). Vehicles and bicycles were only counted when exiting because many establishments were in shopping centers and mixed-use developments. Counting vehicles entering a mixed-use development site could potentially introduce error from counting vehicles that went to non-survey establishments. By counting vehicles and bicycles exiting, we ensure that these trips came to the site before leaving.

3.3.2 Sample description

3.3.2.1 Trip counts and establishment type

Observed person trips exiting establishments varied across establishment types. In Figure 3-4 we see that convenience stores had the highest person trip rates of any particular land use type. We can also see that customer traffic appears to be greater during the 6-7 PM hour than customer traffic during the 5-6 PM hour for all land uses except convenience stores.

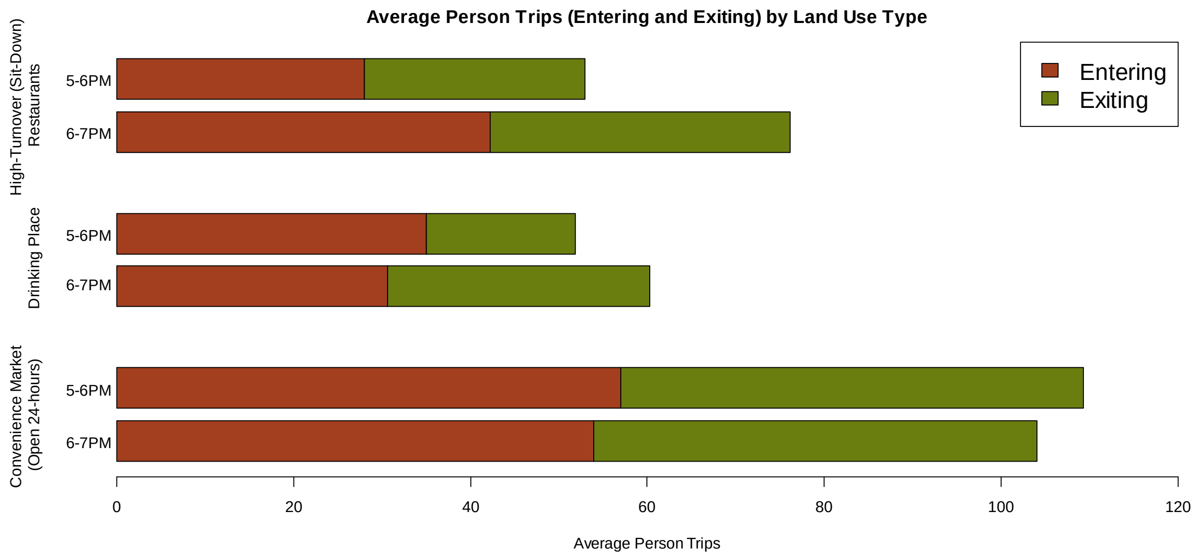


Figure 3-4. Observed Person Trips by Establishment Type

Figure 3-5 shows the mean observed vehicle trips exiting different establishment types. Vehicle trips do not appear to vary substantially between the 5-6 PM and 6-7 PM hours. We see that convenience stores have the most observed vehicle trips on average. Exiting vehicle trip counts were obtained for just 44 of the 78 establishments studied. Many study sites, especially those in urbanized neighborhoods, contained on-street and complex parking situations and did not allow vehicle counts to be obtained during data collection.

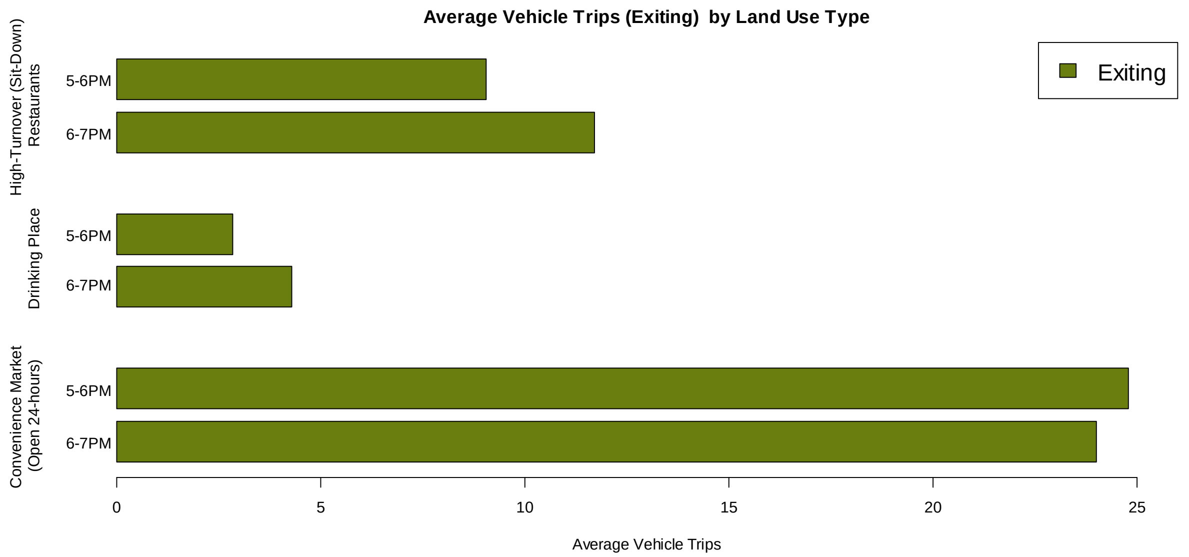


Figure 3-5. Observed Vehicle Counts by Establishment Type

Table 3-10 shows a summary of person and vehicle trips aggregated to land use. The survey locations were on average not very big (most between 1800 and 3200 square feet in area). Convenience stores had the most customer traffic during the 5:00 – 7:00 PM hour.

Table 3-10. Observed Person and Vehicle Trip Counts by Land Use Type

ITE Land Use		Convenience Market (Open-24 Hours)		Drinking Place		High-Turnover (Sit-Down) Restaurant	
ITE Land Use Code		851		925		932	
Sample Size (N)		26		13		39	
		Mean	*Std. Dev.*	Mean	*Std. Dev.*	Mean	*Std. Dev.*
Average Gross Floor Area of Establishment (Sq. Ft.)		2529	*278*	3197	*2881*	1747	*871*
Person Trips	Enter	57.0	*29.6*	35.0	*15.3*	28.1	*18.2*
	Exit	52.3	*29.2*	16.8	*5.6*	24.9	*12.0*
Vehicle Trips	Exit	48.8	*21.4*	7.1	*9.4*	20.8	*18.9*

3.4 BUILT ENVIRONMENT DATA

Built environment information was gathered from the US Census Bureau and Metro in order to support an ITE rate reduction method based on area type. This information was collected within a ½ mile radius (Euclidean distance) from each establishment point, hereby referred to as the establishment buffer. The measures that were included in this study are described below in more detail.

3.4.1 Metro Context Tool

The Context Tool, developed by Metro, is a set of GIS raster indices[6] of built environment dimensions including: bicycle access, people per acre (population and employment density), transit access, urban living infrastructure (ULI), sidewalk density, and block size. Only the ULI index is used in the analysis presented here. Other built environment measures used in this study are described in the next section.

ULI serves as a measure of the density and diversity of retail and service destinations. Figure 3-6 illustrates the ULI Context Tool across the Metro region. The measure is based on the different retail and service land uses that accommodate everyday non-work living needs[7]. The greater the ULI index, the greater the number of businesses of these types nearby. The highest ULI values are in places like downtown Portland, where many different retail and service establishments exist in close proximity.

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[6] Rasters are calculated using Kernel Density Tool (1/4 mile distance) in Spatial Analyst Toolbox in ArcGIS 10.0.
[7] Businesses comprising attractions in the ULI Context Tool (and their corresponding NAICS 2007 code) are the following: retail bakeries (311811), breweries (312120), nursery/garden center/farm supply stores (444220), supermarkets and other grocery (except convenience) stores (445110), all other specialty food stores (445299), beer/wine/liquor stores (445310), men's clothing stores (448110, women's clothing stores (448120), children's and infants' clothing stores (448130), family clothing stores (448140), sporting goods stores (45110), book stores (451211), department stores (except discount department stores) –but only including large supermarket-type department stores (452111), gift/novelty/souvenir stores (453220), motion picture theaters (except drive-ins, 512131), child day care services (624410), fitness and recreational sports centers (713940), drinking places (alcoholic beverages, 722410), full-service restaurants (722110), limited-service restaurants (722211), cafeterias/grill buffets/buffets (722212), snack and nonalcoholic beverage bars (722213), and dry cleaning and laundry services (except coin-operated, 812320).

The ULI index is developed by calculating the densities of retail and service businesses within a ¼-mile of each raster cell and then classifying them into a one through five index. The classification is performed using Jenks' natural breaks algorithm, an optimization method to determine the best arrangement of values into classes by minimizing the sum of squared differences within classes. Jenks' natural breaks is a common method to display classified data on chloropleth maps by finding actual breaks in the data instead of using an arbitrary classification scheme like equal intervals. The range of observations comprising each index value varies as a result.

Figure 3-7 provides an example. Business densities around establishments, the underlying calculation of ULI, are plotted against vehicle trip rates at establishments. The ULI index of survey establishments is shown in the shaded background of the plot. This chart illustrates an increased range in business density as the ULI score increases. Only two establishments fall into a ULI index of 5, located mostly in the central business district of Portland, and many of the locations fall into ULI indexes of 2, 3, and 4. Figure 3-6 also provides an example: very few areas in the Metro region besides downtown Portland have ULI scores of 5, and the majority of the region has a ULI of 1. Most of the areas with medium density business (ULI of 2, 3, and 4) are located along major corridors, centers or suburban downtowns.

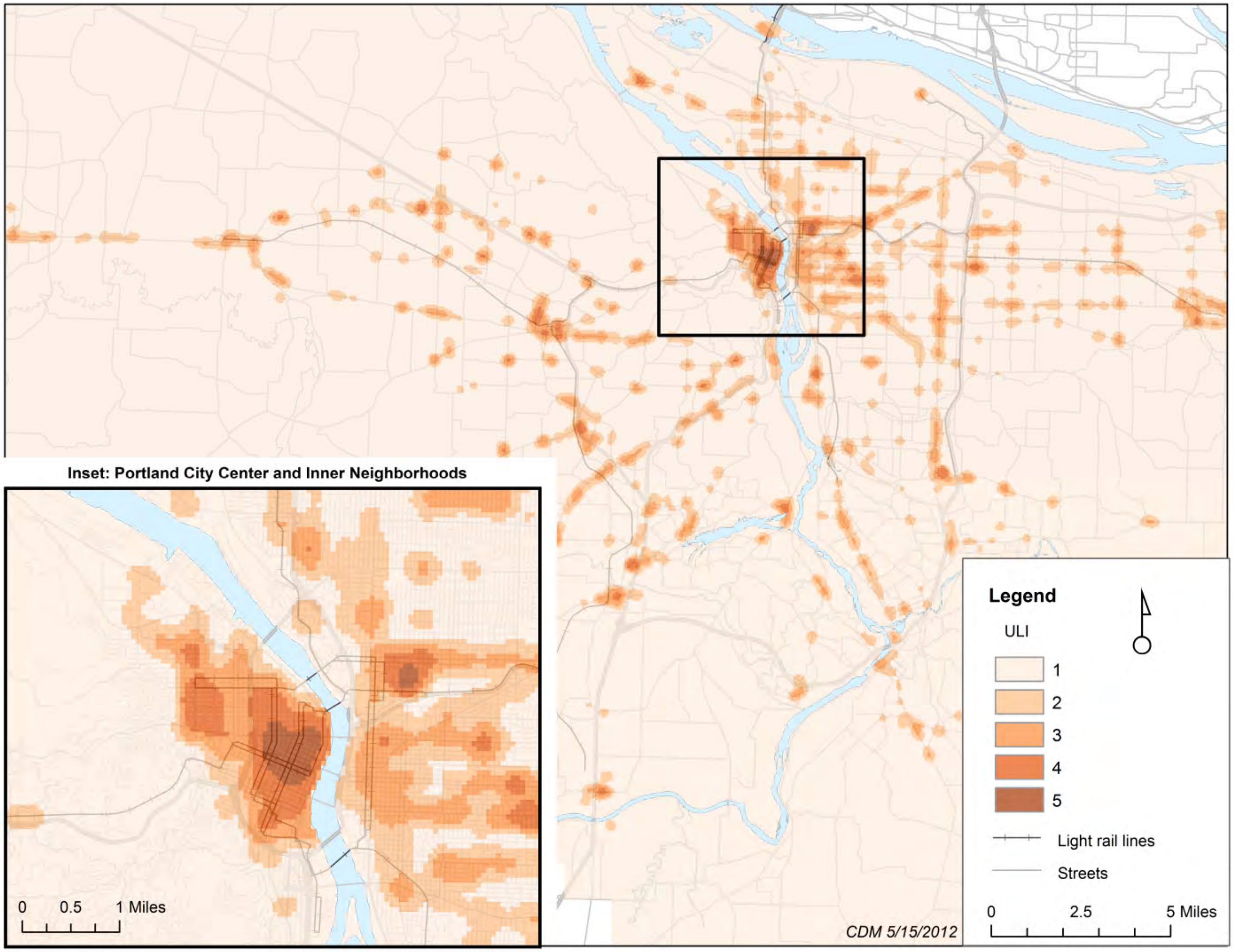

Figure 3-6. Urban Living Infrastructure Context Tool

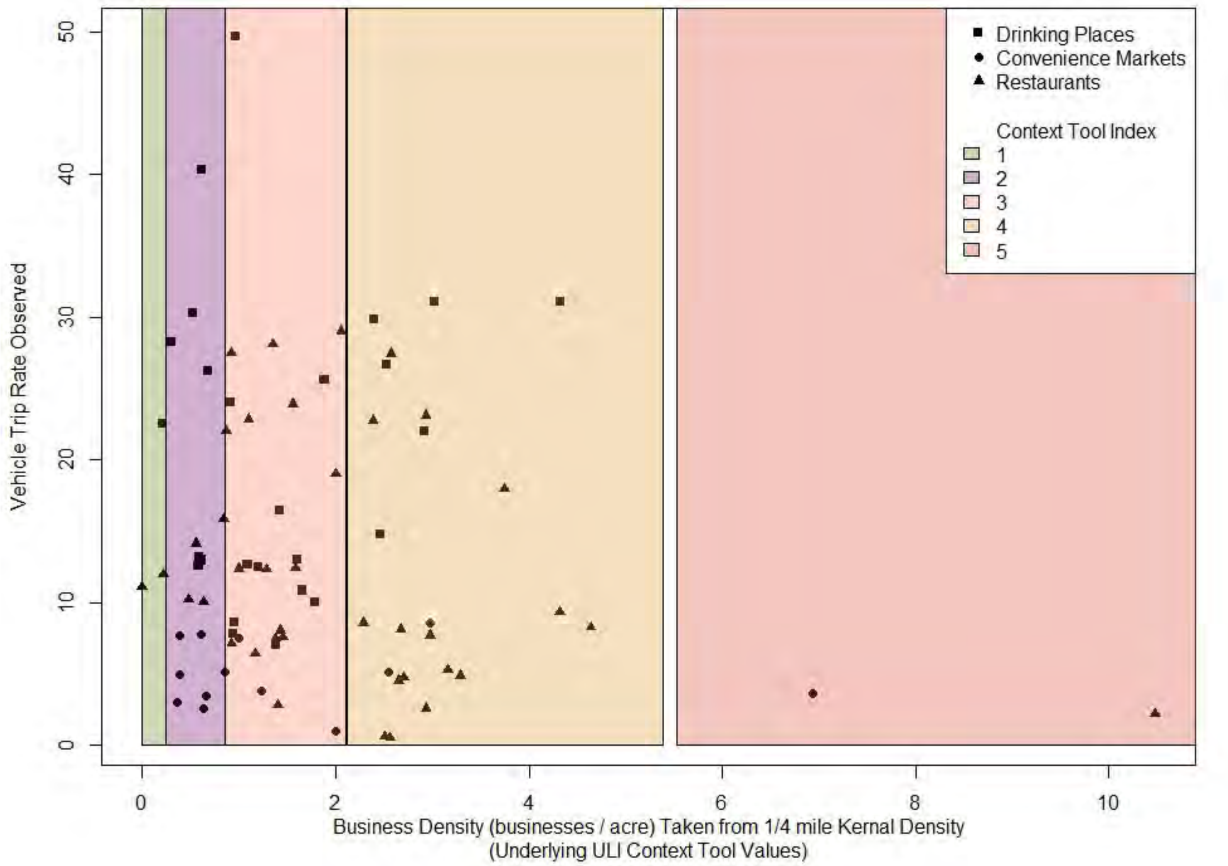

Figure 3-7. ULI Business Density (raw data), Context Tool Index Ranges and Observed Vehicle Trip Rates

We use ULI in our analysis by calculating the average ULI score within a half mile radius of the establishment. This average provides a representation of area surrounding the establishment. An example is illustrated in Figure 3-8. The ULI score found at this establishment point is 3, while the average ULI score within the establishment buffer is 2.19.

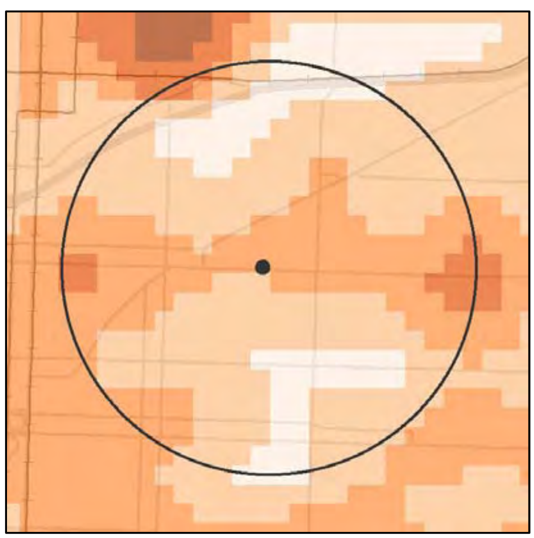

Figure 3-8. Example Establishment with ½-mile Buffer and ULI Context Tool

ULI is also highly correlated with other built environment attributes that are associated with higher rates of non-automobile travel, such as measures of density, street configuration, block size, bicycle and pedestrian networks and transit service. As such, ULI is an indicator of the character of a particular neighborhood: a place with a high ULI score is very likely to also have a more gridded street network with small blocks, higher densities of housing and employment, higher-quality transit access, and amenities that make walking and cycling more convenient. Figure 3-9 shows the observed mode shares within average ULI ranges of survey establishments. Clearly, ULI is strongly associated with non-automobile travel. Establishments with the highest ULI scores have the highest proportion of people who walked. Additionally, transit appears to have a greater mode share for those locations with a ULI of 3, areas often located along corridors and neighborhood centers.

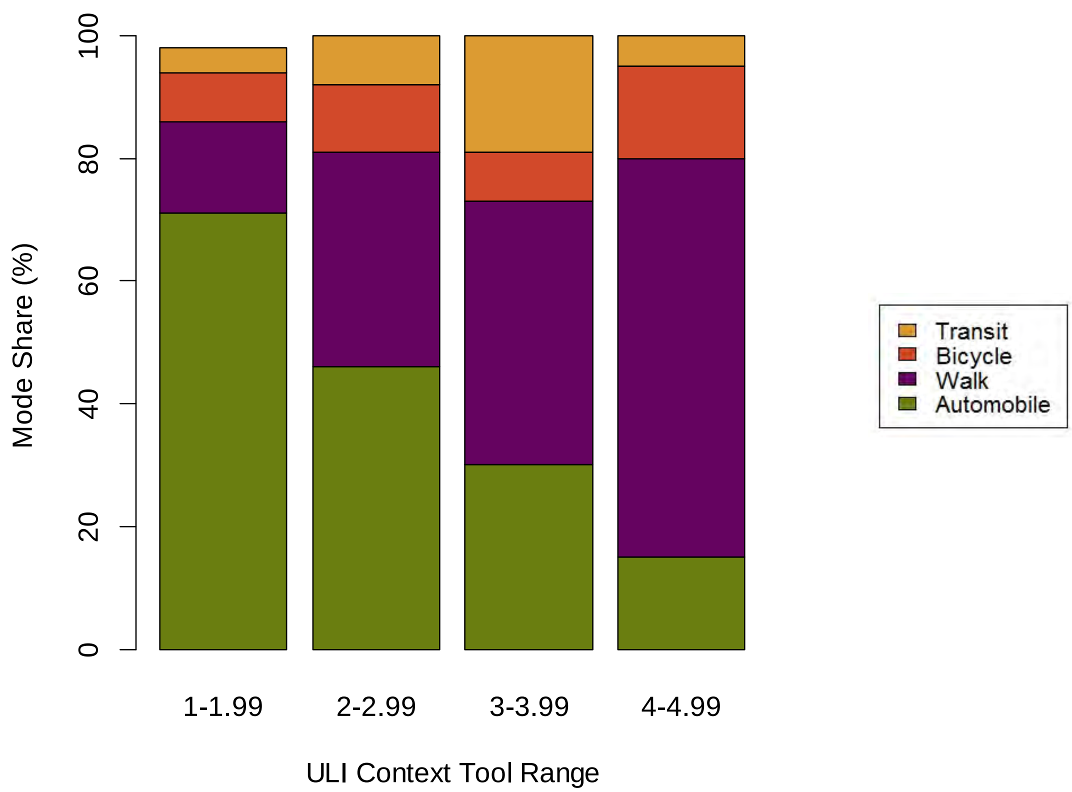

Figure 3-9. Average Mode Share by ULI Range (Metro Context Tool)

3.4.2 Other built environment data

In addition to the ULI measure discussed previously, several additional built environment features that are influential in travel choices were considered in our analysis. These built environment features were also measured at a ½ mile buffer around each establishment.[8] These measures are listed in Table 3-11 and are described below.

[8] Water features were excluded from all calculations when water fell within the ½ mile buffer

Table 3-11. Built Environment Measures List and Data Source

Measure	Units	Data Source*
Number of Transit Corridors	# Trimet lines within ½-mile	Light-rail and Bus Stop layer (RLIS, 2010)
People Density	Residents and employees per acre	ESRI Business Analyst (2010) and Multifamily/Household layers (RLIS, 2010)
Number of High-Frequency Transit Stops	# stops within ½-mile with headways under 15 Minutes	Bus Stop layer (RLIS, 2010) and TriMet schedules (2011)
Employment Density	Employees per acre	ESRI Business Analyst (2010)
Median Floor-to-Area Ratio	Unitless ratio	LiDAR, Zoning, Building, Tax lot layers (RLIS and Metro Internal)
Lot Coverage	Percent	Tax lot and Building Layers (RLIS, 2010)
Length of Bike Facilities	Miles	Bike Route layer (RLIS, 2010)
Access to Rail	Presence of rail station within ½-mile	Light-rail Stop layer (RLIS, 2010)
Intersection Density	Intersections per million square feet	Lines file (TIGER 2009)
Median Block Perimeter	Miles	Faces file (TIGER 2009)

* RLIS: Regional Land Information System, Portland Metro.

Number of Transit Corridors: This is a count of the transit routes accessible within the establishment buffer.

People Density: This value is a measure of total residential and employment population within the establishment buffer divided by its buffer area in acres.

Number of High-Frequency Transit Stops: This is the number of high-frequency bus-transit stops within the establishment buffer and indicates the level of quality transit available. A high-frequency transit stop is defined by having service headways of 15 minutes or less (including at least four stops) between 4:30 and 5:30PM. Data for the peak hour studied (5:00-6:00PM) are not available.

Employment Density: This measure is the number of employees within the establishment buffer divided by its buffer area in acres.

Median Floor-to-Area Ratio (FAR): This measure identifies the median ratio of building structure floor area to buildable land area of the tax lot parcel (FAR) for the establishment buffer. FAR provides an indication of development intensity. These data are a layer still under development by Metro and are not publicly available. The measure is constructed by combining LiDar imagery with estimates of floor height from zoning codes and data. Using this estimated number of floors for each building, the FAR is calculated by dividing number of floors by the total area available within that parcel of land. The median value is used because it is a more robust measure than the average FAR.

Lot Coverage: This measure represents the percent of tax lot parcel area covered by the corresponding building footprints, which represents proxy for parcel setbacks. This measure is calculated for all parcels within the establishment buffer.

Length of Bike Facilities: The availability of bike facilities is measured in miles of bicycle facility links (facility links listed as a bike facility) within the establishment buffer.

Access to Rail: This binary variable indicates the access to a light-rail station within the establishment buffer. A value of one indicates the presence of at least one rail station within the buffer, and a value of zero indicates no station.

Intersection Density: This is the number of intersections per 1,000,000 square feet within the establishment buffer divided by its area.

Median Block Perimeter: This is the median perimeter distance, measured in miles, of census blocks geographies within the establishment buffer. The median is selected as a more robust measure of the typical block size near the establishment. The median value is a more robust descriptive measure than mean when the variation of values is not evenly distributed around the mean.

4.0 ANALYSIS

Based on the descriptive analysis discussed in the previous chapter, we detail here the methods and assumptions employed to compare study findings with ITE. We aim to develop a consistent method for adjusting ITE trip generation estimates to control for urban context. This is based upon relationships between built environment characteristics and mode shares found from analysis of data collected from specific establishments across the Portland region.[9]

This chapter is organized as follows:

1. Testing key assumptions in our analysis. We show that person trip rates do not vary by context, but rather the distribution of trip rates by different travel modes.
2. Comparison of ITE trip rates to data collected in this study.
3. ITE adjustment method.
4. Implications for planning the built environment.

4.1 ASSUMPTIONS TESTING

One critical assumption in this study is that person trip rates for a specific establishment type (land use category) and size (gross floor square footage or similar measure) do not vary across urban contexts. Rather, the distribution of those person trip rates across various modes of transportation varies by the urban built environment. If this hypothesis is true, it suggests that automobile and non-automobile trips may be substitutable across contexts (person trip rates are constant) rather than complements (non-automobile trips may be additional trips). If non-automobile trips are complementary (vary across contexts), the ability to compare ITE vehicle trip rates with collected data proves difficult. In that case, the error between observed and estimated vehicle trip rates cannot be distinguished from non-automobile trip rates. See Figure 4-1 for an illustration.

In order to test the hypothesis illustrated in Figure 4-1, person trip rates (entering and exiting the establishments) are compared across the various area types described in Section 3.1, controlling for differences in land use type and establishment size.

The average person trip rate (trips per square foot gross floor area) from the PM peak hour (5:00 – 6:00 PM) across land use types was tested for significant variance across contexts. Tests were performed for: (1) all land uses combined across contexts (pooled data) and (2) specific land use types across contexts (data segmented by establishment type). The null hypothesis (H_0) stated that average person trip rates are equal across contexts, and the alternate hypothesis (H_1) stated that average person trip rates are not equal across contexts. Hypothesis testing was performed via one-way analysis of variance statistical means testing at 95% confidence. The results of the hypothesis testing are shown in Table 4-1.

[9] Statistical analyses were performed with SPSS, Version 19.0 (IBM Company, 2010) and R, version 2.6 (The R Foundation for Statistical Computing, 2008). Spatial analysis was conducted in ArcGIS 10.0 (ESRI, 2011).

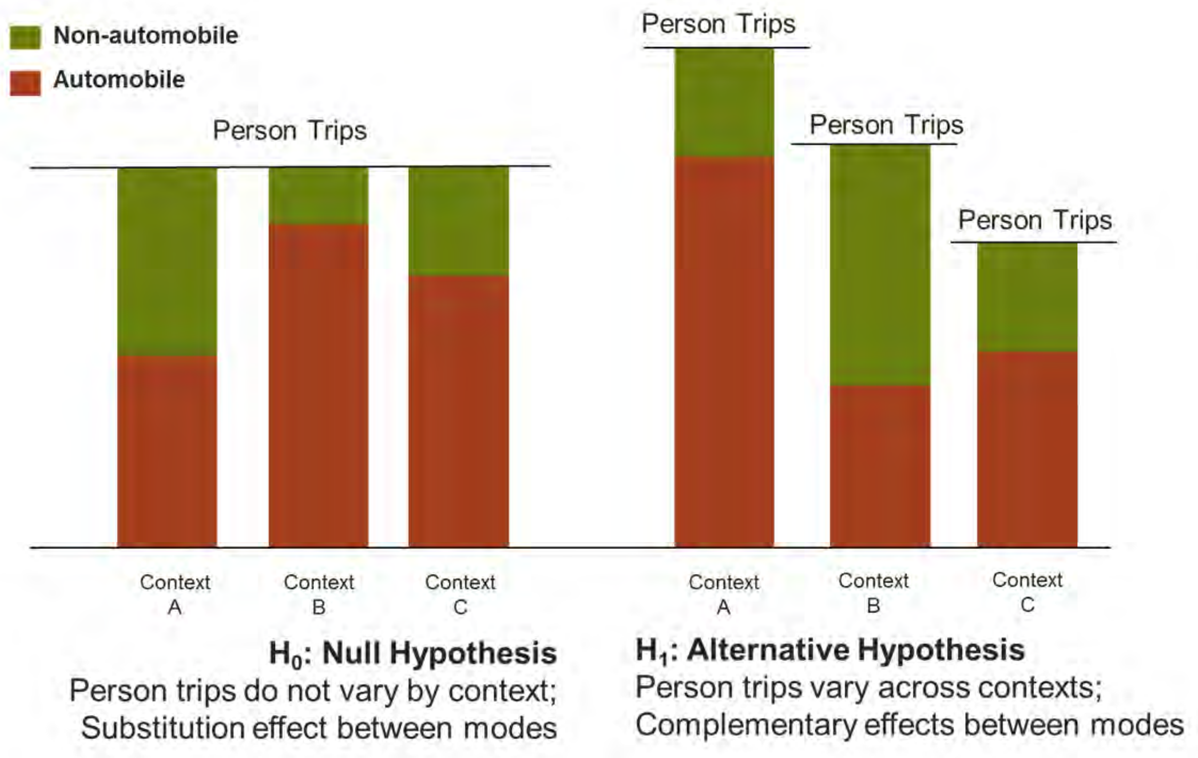

Figure 4-1. Do Person Trip Rates Vary Across Contexts?

Table 4-1. Hypothesis Testing ($\alpha = 0.05$)

Scenario (across contexts)	Result	p-value	Interpretation
All land uses combined	H_0	0.652	Person-trip rates similar across contexts
24-hour convenience stores	H_0	0.695	Person-trip rates similar across contexts
High-turnover restaurants	H_0	0.323	Person-trip rates similar across contexts
Drinking places	H_0	0.189	Person-trip rates similar across contexts
High-turnover restaurants + drinking places*	H_0	0.616	Person-trip rates similar across contexts

*Note: land uses combined due to similarities between brew-pubs and restaurants.

The results show that average person trip rates do not differ significantly across different context types, suggesting that non-automobile travel may be a substitute for automobile trips. Person trips do not vary significantly for establishments of a specific size and type.

4.2 COMPARISON OF TGS WITH ITE

This section details a comparison between the Trip Generation Study (TGS) data and the ITE Trip Generation data. To compare TGS person trips to ITE vehicle trips for each establishment, we need estimates of the number of vehicles entering and exiting sites. In Equation 4-1, we estimate vehicle trip rates from survey data[10].

Equation 4-1. TGS Vehicle Trip Rate

$$VEH\ TRIP\ RATE_{TGS} = \frac{(P_{IN} + P_{OUT})_{TGS}(\%AUTO)_{TGS}}{VEH\ OCC_{TGS}} \times \frac{1}{1000\ Sq.Ft.Area}$$

Where: P_{IN} = Person count entering the establishment,
P_{OUT} = Person count existing the establishment,
$\%AUTO_{TGS}$ = automobile mode share from the survey, and
$VEH\ OCC_{TGS}$ = Average vehicle occupancy for the survey

Comparison of TGS to ITE vehicle trip rates for the weekday peak hour of the facility (5– 6PM) can be seen in Figure 4-2, Figure 4-3, and Figure 4-4[11,12]. TGS vehicle trips are consistently below ITE rates and ITE data points for convenience stores and drinking establishments. Figure 4-4 shows that for high-turnover, (sit-down) restaurants, the TGS vehicle trips and ITE trip rate are in agreement. Table 4-2 shows a comparison of ITE and TGS vehicle trip rates. Convenience markets are the least correlated with ITE. Although high-turnover (sit-down) restaurants agree the most with ITE trip rates, a local refinement on application in various contexts may assist in explaining the variation observed at establishments with greater gross floor areas.

ITE lists the criteria recommended to adopt the ITE Trip Generation methodology for local use and TGS results (see Table 4-3). All criteria must be met to consider application of ITE Trip Generation data in local context. Otherwise, it is recommended that a local rate or equation be developed (Institute of Transportation Engineers 2004, 21). From Table 4-2 and Table 4-3, we recommend a local adjustment to ITE rates for convenience stores and drinking establishments. We do not have sufficient evidence to recommend adjusting ITE rates for high-turnover (sit-down) restaurants in the Portland region.

We hypothesize that the differences between ITE and TGS are largely due to differences in the travel modes customers use to access/egress these sites. As discussed in section 4.1, this is supported by the fact that person trip rates are similar across area types. This points to the need to adjust ITE rates for urban context, as differences in vehicle trips across context are largely due in part to the built environment attributes that support transit and non-motorized modes. The next section introduces the model used for adjusting ITE vehicle trip rates.

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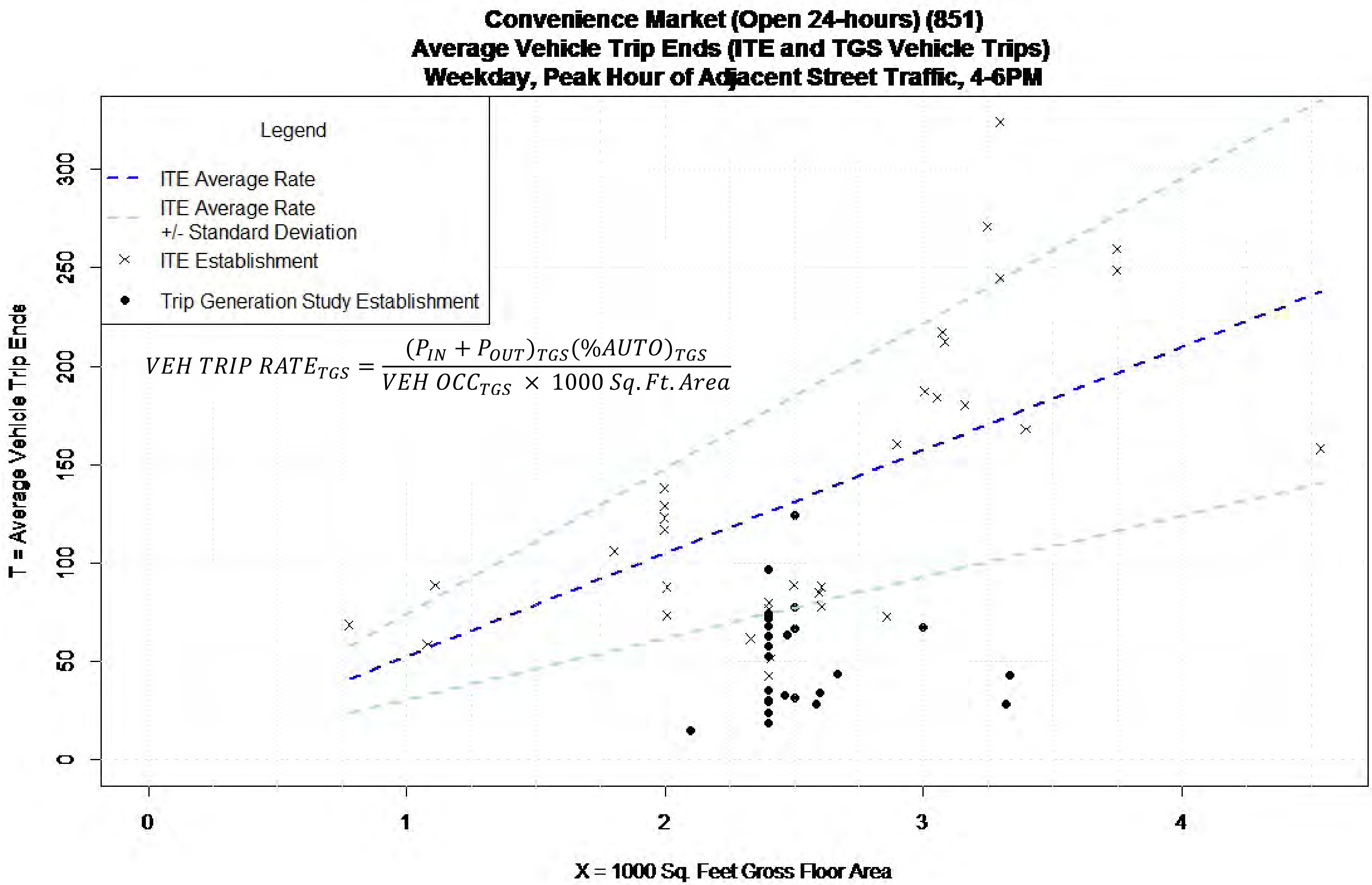
[10] For an explanation on the development of Equation 1, see Appendix F.

[11] No sites were evaluated during the peak hour of the generator, and limited data were available to determine the number of seats provided by restaurant-type establishments for comparison.

[12] No regression models are provided by ITE for any of these land uses due to weak correlation between establishment size and vehicle trips produced for adjacent street traffic during PM peak hours.



Convenience Market (Open 24-hours) (851)
Average Vehicle Trip Ends (ITE and TGS Vehicle Trips)
Weekday, Peak Hour of Adjacent Street Traffic, 4-6PM
Legend
ITE Average Rate
ITE Average Rate +/- Standard Deviation
ITE Establishment
Trip Generation Study Establishment
$VEH\ TRIP\ RATE_{TGS} = \frac{(P_{IN} + P_{OUT})_{TGS}(\%AUTO)_{TGS}}{VEH\ OCC_{TGS} \times 1000\ Sq.Ft.Area}$
T = Average Vehicle Trip Ends
0
50
100
150
200
250
300
0
1
2
3
4
X = 1000 Sq. Feet Gross Floor Area

Figure 4-2. Convenience Market (Open 24-hours) (LU 851): TGS Vehicle Trips and ITE Data

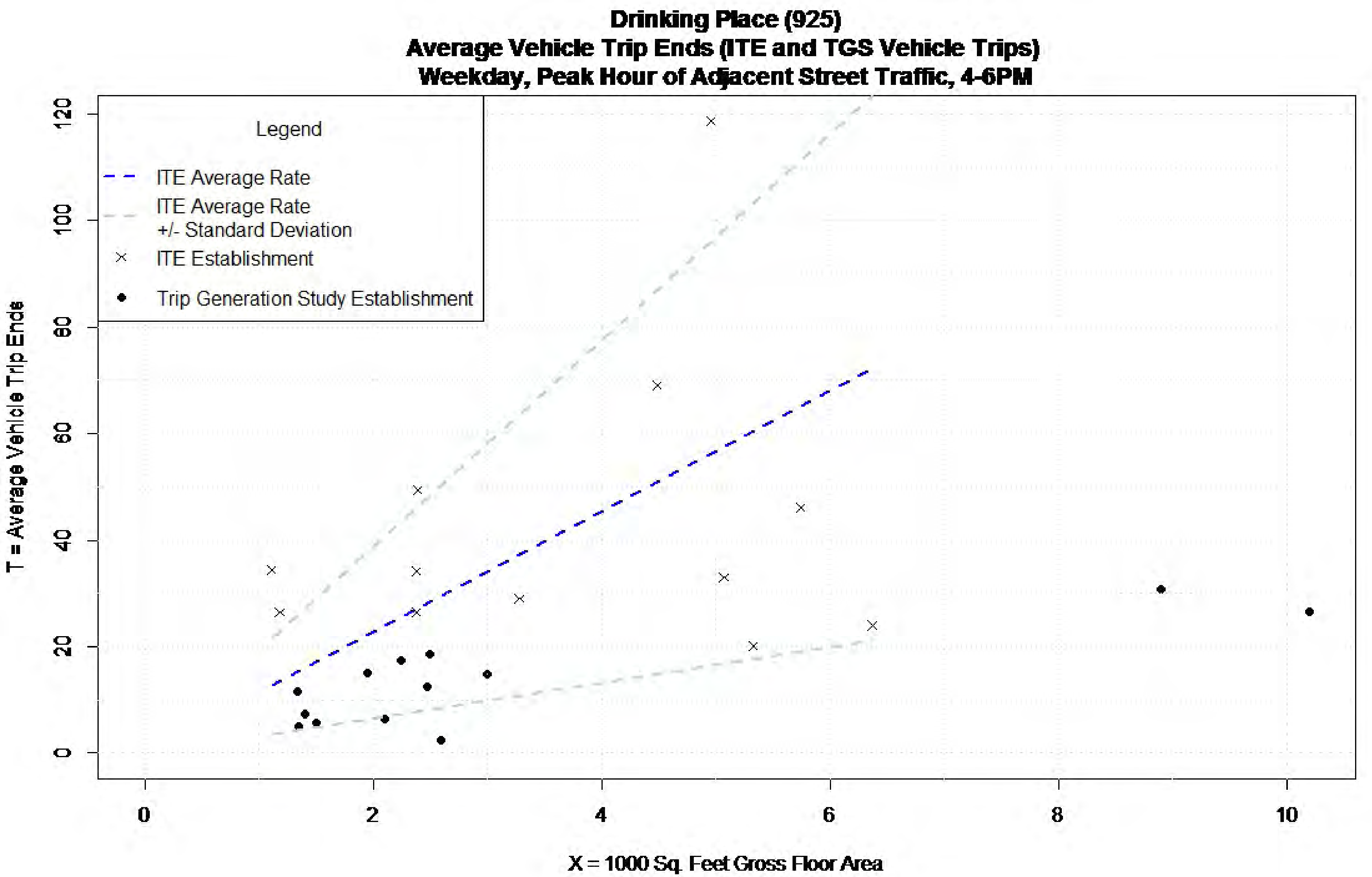
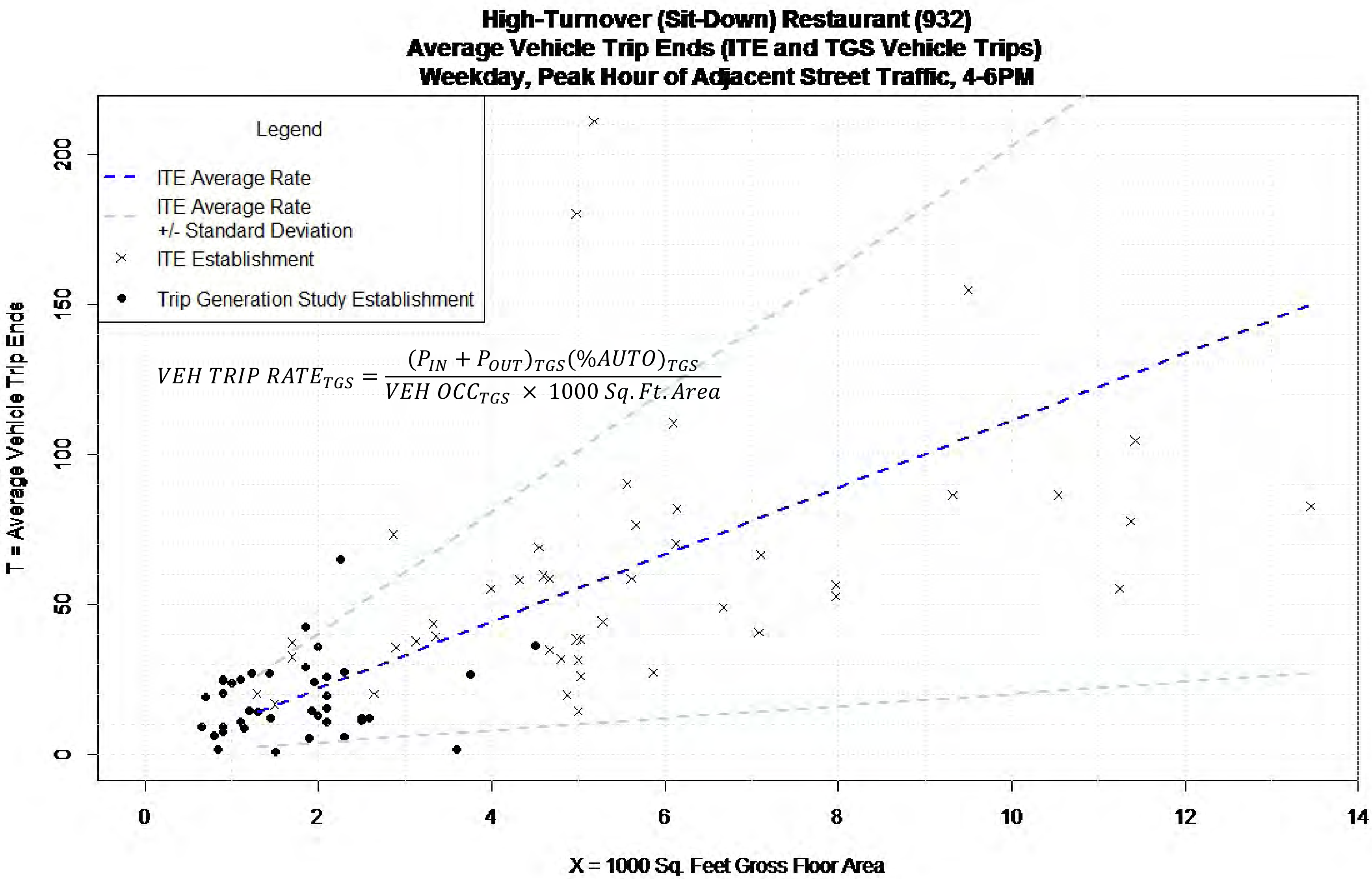


Figure 4-3. Drinking Places (LU 925): TGS Vehicle Trips and ITE Data



$$VEH\ TRIP\ RATE_{TGS} = \frac{(P_{IN} + P_{OUT})_{TGS}(\%AUTO)_{TGS}}{VEH\ OCC_{TGS} \times 1000\ Sq.Ft.Area}$$

Figure 4-4. High-Turnover (Sit-Down) Restaurants (LU 932): TGS Vehicle Trips and ITE Data

Table 4-2. Comparison of Vehicle Trip Rates - ITE versus TGS rates

ITE Land Use	**Convenience Market (Open-24 Hours)**		**Drinking Place**		**High-Turnover (Sit-Down) Restaurant**	
ITE Land Use Code	851		925		932	
Sample Size (N)	26		13		39	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
TGS vehicle trip rate (vehicles per 1000 Sq. Ft. area)	20.8	*10.8*	4.9	*2.3*	12.3	*8.3*
ITE Vehicle trip rate (vehicles per 1000 Sq. Ft. area)	52.4	*21.4*	11.3	*9.1*	11.2	*8.0*
Vehicle trip rate difference (TGS - ITE)	-31.6	*10.8*	-6.4	*2.3*	1.2	*8.3*

Table 4-3. ITE Criteria for Local Rate Development

ITE Criteria	LU 851: Convenience Market (Open 24-Hours) (N=26)	LU 925: Drinking Place (N=13)	LU 932: High-Turnover (Sit-Down) Restaurant (N=39)
1.) A trip generation study (with at least three locations) provides a vehicle trip rate that falls within one standard deviation of the mean provided by ITE.	TGS_{RATE} (20.8) does not fall within one standard deviation ITE_{RATE} (31.0 - 73.8)	**TGS_{RATE} (4.9) falls within one standard deviation ITE_{RATE} (3.3 - 19.4)**	**TGS_{RATE} (12.3) falls within one standard deviation ITE_{RATE} (2.0 - 20.3)**
2.A.) At least one study site has a rate that falls above the ITE weighted average or equation, and one that falls below; <u>OR</u>	0 locations fall above, 26 location fall below	0 locations fall above, 13 locations fall below	**17 locations fall above, 22 locations fall below**
2.B.) All study locations fall within 15% of the ITE average rate or equation. ((TGS_{RATE} - ITE_{RATE}) / ITE_{RATE}) < ±15%	1 of 26 location falls within 15%	0 of 13 locations fall within 15%	7 of 39 locations fall within 15%
3.) Locally collected studies fall within the scatter of rates provided by ITE	Appear slightly below	Appear below	**Appear within scatter**
4.) "Common sense" indicates appropriate use of ITE rates for location application.	Vague	Vague	Vague
Conclusion	Local rate or adjustment is recommended.	Local rate or adjustment is recommended.	Use of ITE methods may be appropriate.

Note: bold indicates a met criterion

4.3 LOCAL ITE RATE ADJUSTMENT FOR URBAN CONTEXT

In this section, we introduce a method to estimate an adjustment to ITE vehicle rates for the land uses: high-turnover (sit-down) restaurants (LU 932), convenience markets (LU 851), and drinking places (LU 925) based upon urban context. Using ordinary least squares regression, we have estimated several models of the adjustments to ITE rates (for the weekday, PM peak hour of the facility) using a variety of model specifications with a number of built environment measures and controlling for land use type. The model with the best performance is shown in Equation 4-2 below and makes use of the Urban Living Infrastructure (ULI) measure as a proxy for context (see Section 3.4 for a complete discussion of ULI).

ULI is a measure of local access to a number of retail and service establishments that accommodate a variety of non-work activities. This measure is highly correlated with other built environment attributes also known to be associated with higher rates of non-automobile travel, such as measures of density, street configuration, block size, bicycle and pedestrian networks and transit service. However, many of these measures are correlated with one another and cannot be used together in a single model. Thus, in this preferred model, ULI serves as a proxy for these other built environment characteristics, yet provides a simple and straightforward method for adjusting ITE trip rates for different urban contexts. See the following section (4.4) for a detailed discussion of these other built environment measures and their relative contributions to vehicle trip rates, as they are also important to consider for planning and policy.

The difference in the ITE vehicle trip rate for convenience markets is nearly five times larger than those for high-turnover restaurants and drinking places. Additionally, the average TGS vehicle trip rate for drinking places is significantly lower than the ITE vehicle trip rate and the average TGS trip rate for restaurants is higher than the provided ITE vehicle trip rate (see Table 4-2 for more details). However, the sample size for each land use is too small to develop a segmented model, and so we estimate a pooled model that uses binary variables to indicate the land use type.

The model below predicts the difference between ITE vehicle trip rates and TGS vehicle trip rates, or the local adjustment to ITE trip rates for the weekday, PM peak hour of the facility.[13] The model fit as indicated by Adjusted R^2 is 0.763.

From the coefficients in the resulting model, the land use indicators contribute more to the adjustment than the ULI variable representing context. However, once land use is controlled for, significant differences in trip generation can be attributed to context. For example, an increase in the average ULI score by one unit results in a 29% reduction in the ITE vehicle trip rate for drinking places and high-turnover (sit-down) restaurants and a 6% reduction for convenience markets.

Using this equation, we can see the range of possible adjustments for different contexts. For example, in locations with an average ULI of 1.0 (the lower bound of ULI), the ITE trip rate for

[13] Drinking establishments are the base case for this model, so the "Restaurant" and "Convenience" terms equal zero if calculating an adjustment to a drinking place. Significance level for Restaurant is at 99%, Convenience at 99.9%, ULI at 98%.

restaurants should not be increased more than 4.7[14], resulting in a new vehicle trip rate of 15.2 vehicle trips (per PM peak hour, per 1,000 square feet of gross floor area). Similarly, estimates of vehicle trip rates for convenience markets located in the same area would be 23.7 vehicle trips (a 45% reduction from the ITE vehicle trip rate), and drinking places 8.7 vehicle trips (a 77% reduction from ITE).

Equation 4-2. ITE Vehicle Trip Rate Adjustment Model

$$\boldsymbol{ADJ} = 0.643 - 3.29 * \boldsymbol{ULI} + 7.41 * \boldsymbol{Restaurant} - 26.04 * \boldsymbol{Convenience}$$

$$\boldsymbol{ADJ} = VEH\ TRIPS_{TGS,LU} - VEH\ TRIPS_{ITE,\ LU} \equiv \text{Difference in vehicle trip rates}$$

$$\boldsymbol{ULI} \equiv \text{Average of ULI values within establishment buffer}$$

$$\boldsymbol{Restaurant} = \begin{Bmatrix} 1, & \text{if ITE Land Use} = 932\text{: High-Turnover (Sit-Down)Restaurant} \\ 0, & \text{if ITE Land Use} \neq 932\text{: High-Turnover (Sit-Down)Restaurant} \end{Bmatrix}$$

$$\boldsymbol{Convenience} = \begin{Bmatrix} 1, & \text{if ITE Land Use} = 851\text{:Convenience Market (Open 24-hours)} \\ 0, & \text{if ITE Land Use} \neq 851\text{:Convenience Market (Open 24-hours)} \end{Bmatrix}$$

$$\boldsymbol{Adjusted\ R^2} = 0.763$$

Table 4-4 and Figure 4-5 provide some additional guidance on the range of observed values for which this equation is valid. Table 4-4 shows the ranges observed in this study. Figure 4-5 illustrates the results of Equation 4-2 plotted for each of the three land uses (see Appendix E for more detail).

Table 4-4. Range of Observed Values in Data Used for Model Estimation

ITE Land Use and Code		Average ULI Score	Establishment Size (sq. ft.)	Estimated Vehicle Trip Rate (trips per 1000 sq. ft. per hour)
851	Convenience Market (Open 24-hours)	1.10 – 3.29	2,100 – 3,334	7.1 – 49.7
925	Drinking Place	1.25 – 3.27	1,340 – 10,200	1.0 – 8.5
932	High Turnover (Sit-Down) Restaurant	1.02 – 4.20	650 – 4,500	0.5 – 29.0

[14] Computed from Equation 4-2, 0.643 – 3.29 * (1.0) + 7.41 * (1) – 26.04 * (0) = 4.7

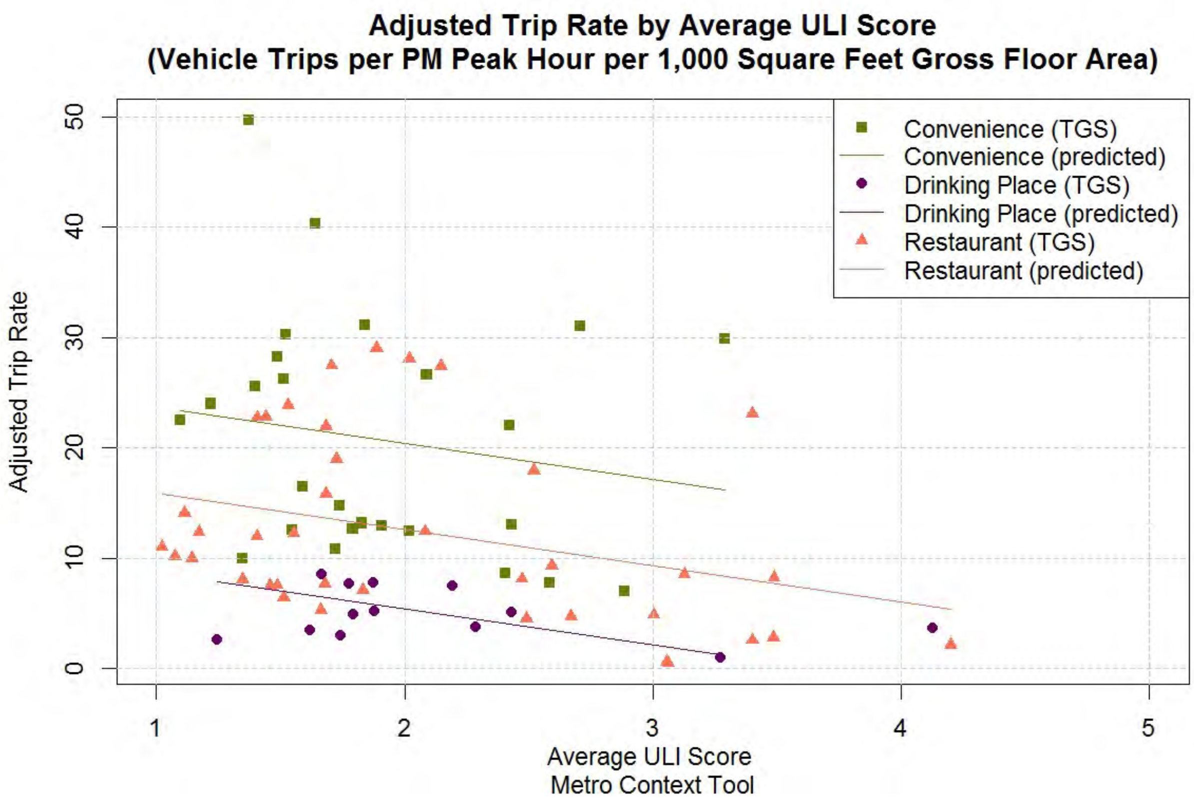


Figure 4-5. Graphical Representation of the Vehicle Trip Rate Adjustment Model

4.4 IMPLICATIONS IN PLANNING & POLICY

The model shown in Equation 4-2 is based on the ULI variable from the Metro Context Tool. It is important to note that ULI is highly correlated with many other built environment measures and may not be directly sensitive to policy. In this section, we relate ULI to several additional built environment variables. Understanding these relationships is useful since ULI may not always be the most sensitive built environment measure for policy decisions. If planners seek to make long-term changes to neighborhoods, this section will help identify important characteristics associated with lower automobile mode shares, based upon our findings.

Table 4-5 shows a list of the built environment measures highly correlated with ULI and their respective model performance in an ordinary least squares regression model predicting an adjustment to the ITE vehicle trip rates. Each row in this table represented a separate regression considered; the first row is the identical model presented in Equation 4-2. Each model considered contains the same two land use measures to identify whether the establishment is a restaurant or convenience market and one built environment measure representing context.

Table 4-5. ITE Rate Adjustment Models Using Built Environment Measures

Built Environment Measure (units)	Correlation with ULI	Adjusted R^2	Model Variable Coefficient	Convenience Market Coefficient	Restaurant Coefficient	Intercept Coefficient
Average ULI Score (unitless)		0.763	-3.29**	-26.04***	7.41***	0.64
Number of Transit Corridors (count)	0.78	0.767	-0.09***	-25.48***	7.62***	-4.31*
People Density (residents and employees per acre)	0.89	0.766	-0.07***	-26.19***	7.24***	-3.41
Number of High-Frequency Bus Routes (count)	0.84	0.766	-0.05***	-26.07***	7.19***	-3.62
Employment Density (employees per acre)	0.84	0.764	-0.08**	-26.13***	7.16***	-4.24*
Median FAR (ratio)	0.90	0.761	-0.53**	-25.92***	8.01***	-4.76*
Lot Coverage (%)	0.92	0.760	-0.17**	-26.6***	6.97**	-0.86
Length of Bike Facilities (mi.)	0.86	0.760	-0.79**	-26.24***	7.55***	-0.75
Rail Access (binary)	0.47	0.756	-3.99**	-24.31***	8.09***	-5.19**
Intersection Density (number per 1,000,000 sq. ft.)	0.77	0.755	-0.57*	-26.77***	6.65**	-0.85
Median Block Perimeter (mi.)	-0.41	0.750	1.33	-26.21***	6.93**	-8.59***

***p-value ≤ 0.01
** p-value ≤ 0.05
*p-value ≤ 0.10

The land use measures are highly significant in all models, indicating that identifying land use type in this pooled model structure is very important when determining an adjustment to ITE vehicle trip rates. However, predicting an ITE vehicle trip rate adjustment based on land use type indicators alone is not very sensitive to planning or evaluations of policy. Therefore, the additional independent variables are investigated individually to identify potential influences of the built environment on travel behavior.

All of the models shown in the table have good statistical fit (adjusted $R^2 > 0.75$). Four models perform better than the ULI model (Number of transit corridors, people density, number of high-frequency bus routes, and employment density), but ULI was selected because it is a more robust measure of the overall built environment than any of the other independent contextual variables and has more explanatory power while remaining significant. For example, the Number of Transit Corridors model has an adjusted R^2 of 0.767, higher than that of the ULI model at 0.763. But in application, an increase of two transit corridors within the half-mile establishment buffer equates to a trip rate adjustment of only 0.2 vehicle trips per 1000 sq. ft. per hour. An increase of average ULI score from 1 (most suburban) to 2 (neighborhoods and corridors) provides a larger adjustment of -3.3 vehicle trips per 1,000 sq. ft. per hour.

When we examine the underlying data that comprise the ULI index measure (as discussed previously in section 3.4.1 and Figure 3-7), it becomes clear that as the ULI scores increase, the densities of retail and service establishments serving urban populations also increases, as shown in Table 4-6. This means that the ability to increase an ULI score by *one unit* is much easier to achieve in suburban areas with ULI scores of 1 or 2 than in more urban areas like the Central Business Districts that have ULI Index measures of 4 or 5. Furthermore, comparing the ULI Index with other built environment measures is useful in order to relate these findings to planning and policy decisions. Table 4-7 summarizes measures of the built environment are associated with ULI. All measures in the table are correlated with ULI (Pearson's correlation of greater than 0.4; bold measures have a correlation of greater than 0.6). For an average ULI index value calculated within an establishment buffer, this table shows the associated mean values of other built environment attributes found in the same buffer.

Table 4-6. Retail and Service Establishment Densities Associated with ULI Index

ULI Index	Density of Establishments associated with ULI			Range
1	0.0	-	0.2	0.2
2	0.2	-	0.9	0.7
3	0.9	-	2.1	1.2
4	2.1	-	5.4	3.3
5	5.5	-	12.6	7.1

Table 4-7. Built Environment Measures Correlated with Observed Average ULI Score

ilt Environment Measure	Average ULI Score									
	1 - 1.99 N = 47		**2 - 2.99 N = 19**		**3 - 3.99 N = 10**		**4 - 4.99 N = 2**		**ALL N = 78**	
	Mean	***S.D.***	Mean	***S.D.***	Mean	***S.D.***	Mean	***S.D.***	Mean	***S.D.***
t Corridors (count)	9	*6*	26	*29*	72	*35*	98	*11*	24	*31*
sidents and employees per acre)	16	*6*	38	*24*	90	*25*	158	*9*	34	*35*
requency Transit Routes (count)	19	*15*	58	*39*	125	*51*	200	*63*	47	*52*
ity (employees per acre)	6	*6*	24	*22*	66	*25*	37	*5*	21	*31*
a-Ratio (ratio)	0.8	*0.6*	2.9	*1.9*	12.0	*2.9*	16.3	*1.9*	3.1	*4.4*
	20%	*6%*	33%	*6%*	50%	*8%*	66%	*2%*	28%	*13%*
cilities (mi.)	5.2	*1.5*	7.3	*2.3*	11.3	*0.8*	13.3	*0.6*	6.7	*2.8*
on (Binary)	30%	*46%*	53%	*51%*	90%	*32%*	100%	*0%*	45%	*50%*
ty (number per 1,000,000 sq. ft.)	6	*3*	10	*2*	12	*1*	14	*0.3*	8	*3*
meter (mi.)	2.5	*1.2*	1.6	*0.4*	1.6	*0.4*	1.5	*0.0*	2.1	*1.1*

ires are highly correlated with ULI (Pearson's correlation > 0.6).

5.0 DISCUSSION

The documentation of the findings and methodology provided here can aid local communities in assessment of new development as well as planning for the desired outcomes over the long term. Results from this study reveal a trend: for all land uses tested here, vehicle trip rates decrease as neighborhood types become more urban. Specifically, findings strongly support the need for a local adjustment for both convenience markets and drinking places. High-turnover restaurants appear to be better aligned with the ITE rates, but a vehicle trip rate adjustment is recommended to better match locally observed travel patterns.

The adjustment model provided in this study is applicable to ITE Trip Generation vehicle trip rates for the PM peak hour. The trip rate units are vehicle trips per hour per thousand square feet of gross floor area. Different rate adjustments are provided for each of the three land uses studied. The key model variable is average Urban Living Infrastructure (ULI) score from the Metro Context Tool within a ½ mile buffer around establishments. ULI is a measure representing retail density and diversity.

The regression model has a good statistical fit (R^2 = 0.763), and is relevant in two ways:

1. It allows vehicle trip adjustments to existing establishments in the Portland region to be calculated in a relatively straightforward manner.

2. It provides a guidance tool for planners and policy makers to develop strategies to reduce vehicle trips to shopping establishments in the future.

Thus, controlling for urban context is critical in determining the impact of different development types on the transportation system and to avoid over-planning the system for the automobile. The findings also suggest that strategies and investment priorities to encourage more compact, mixed-use areas with more transportation choices will support the use of non-automobile modes. More accurate trip generation estimates aid in more realistic assessments of traffic impacts of new development and avoid creating regulatory and/or financial barriers to compact form and infill development.

Because the ULI model variable is not directly sensitive to policy decisions, we have provided ranges of measurement for the built environment features associated with ULI scores seen in this study. The ULI measure is highly correlated to many other built environment attributes and serves as a proxy for overall urban character. The provided ranges of built environment measures associated with ULI allow interpretation of the ULI tool in a more tangible way. That is, if policy changes are directed at changing the ULI of a particular place with the intent of reducing automobile trip making, we have provided other measures of the built environment that are correlated with ULI that can help guide planning decisions in more detail.

In this study, we also developed a method to estimate equivalent-vehicle trip rates using a person counts, automobile mode share, and vehicle occupancy at establishments. The method estimates actual vehicle counts well. It is useful since one of the main difficulties with vehicle trip generation data collection in urban areas is the ability to accurately count vehicle trips at establishments with on-street parking where it is hard to determine counting cordon locations. Future trip generation studies in urban areas can utilize this method where counting vehicle trips is complex.

5.1 APPLICATIONS & LIMITATIONS

This section discusses the limitations of this study. They mostly result from small sample sizes of establishment locations, limited survey responses, and issues with regression analysis.

5.1.1 Establishment Sample Size

The most relevant limitation of this study is the establishment sample size. ITE requires only three or four points to develop a rate for a land use (as see in Table 5-1), and in that respect, this study exceeds the standards of sample size set forth by ITE. In this analysis, however, the aim was to provide a robust method for contextual adjustments and establishment sample size for each type of land use did not allow for adjustments to be predictable. Therefore, the observations were used in a pooled model with dummy variables to represent land uses. With a greater sample size of each land use, individual models may be useful in explaining the variation found across contexts related to each land use.

Table 5-1. ITE Vehicle Trip Rate Standards

Type of Rate	Required Sample Size*	Acceptable
Weighted Average Rate	3	Standard deviation < 110% of the weighted average mean
Regression Equation	4	$R^2 > 0.75$

Source: (Institute of Transportation Engineers 2004, 20-21)
*ITE states that "five sites are preferable"

A larger sample size of establishments would also facilitate a more robust analysis of context. In the case of our results, 78 observations did not provide a large enough sample to perform a factor analysis (FA). FA allows multiple built environment metrics to be included in the analysis, and yields indices that provide an aggregate definition of context while still allowing results to be unpacked into individual built environment measures. Because we could not use FA, one built environment measure was used in analysis, ULI. ULI represents other correlated variables, but requires a post-regression breakdown of correlated variables for interpretation.

5.1.2 Survey Sample Size

The urban nature of many sites restricted the ability to count vehicles entering and exiting the sites. On-site parking lots are rarer in urban areas and it is difficult to determine the extent of on-street parking that serves a particular establishment. Counting vehicles in shared parking lots is insufficient as an accurate measurement of vehicle traffic to one establishment. Our analysis required vehicle trip observations, so we developed a method to estimate them through observed person counts, vehicle occupancy, and automobile mode shares. While the method introduced is quite accurate, it is still a source of error in the model. Due to limited observations of vehicle occupancy at individual sites, we used aggregated vehicle occupancy for the land use in many cases.

We also suspect that the observed high non-automobile mode share may be partially due to response bias. It is possible that people who drive were less likely to participate in the study. For example, customers who arrived by automobile modes may have been less likely to respond to the survey because of time constraints. Similarly, customers who have a larger group size (or greater vehicle occupancy) may also be less likely to respond.

5.1.3 Model Results

Our methodology resulting from our regression analysis provides a good statistical fit. Although we were limited by our sample size of each individual land use, a pooled model with land use variables provided methodology for adjustment to ITE vehicle trip rates. The land use variables provided significant explanatory power due to the nature of variation in vehicle trip rate characteristics across the different land uses. ULI, a measure of living infrastructure or business activity, remained significant in explaining additional variation in vehicle trip rates across Portland. In fact, a *one unit* change in ULI results in a 3.3 vehicle trip rate reduction, in addition to the adjustment provided by the land use variable. This difference in ULI, or context, represents a 29% difference compared to ITE vehicle trip rates for restaurants and drinking places, and a 6% difference in convenience markets. Moreover, the local variation in vehicle trip rates for each land use, indicated by the land use variables, provides a local adjustment to ITE vehicle trip rates.

In addition, since ULI is highly correlated with many other built environment variables, observing the associations of these variables, as shown in Table 4-7, may provide additional insight for planners working to evaluate or generate policies to plan for smart growth in their area.

5.2 FUTURE WORK

Future work includes validation of the adjustment method, including more land uses, analysis of the relationships between parking supply and travel behavior, and analysis of micro-scale or site-level variables. This section details these topics and the plans to include each as a supplemental chapter to this report to be submitted at a later date.

5.2.1 Validation

The primary objective of future work to support this report is for validation of TGS methodology for the Portland region. This process includes data collection (vehicle trip counts, building floor area, and ULI) at establishments similar to those selected in this study. The selection process includes overlaying the potential choice set of establishments spatially onto the original site-selection neighborhood type designations performed initially for this project. A variety of locations must be selected for a range of contexts. Validation data collection is currently in progress through June 2012. Sample sizes for validation are supplied in Table 5-2 below (data are current for the week of April 30, 2012). Validation will be included in a supplementary chapter.

Table 5-2. Validation Sample Size by Land Use Type

ITE Land Use and Code	Sample Size
851 – Convenience Market (Open 24-hours)	18
925 – Drinking Place	6
932 – High-Turnover (Sit-Down) Restaurant	13

5.2.2 Additional Land Uses

The authors recognize the limitations of just three land use types studied in this project. Incorporating additional land uses in developing is critical to implementing accurate vehicle trip rate adjustments to the region. The following list documents potential ITE land uses (LU) for future data collection and analysis:

- Supermarket (ITE LU 850)
- Coffee/Donut Shops with or without Drive-Through Windows (ITE LU 936 – 938)
- Bread/Donut/Bagel Shops with or without Drive Through Windows (ITE LU 939 – 940)
- Banks, Walk-in and Drive-in (ITE LU 911 – 912)
- Pharmacy/Drugstore with or without Drive-Through Window (ITE LU 880 – 881)
- Apartments and Townhouses (ITE LU 220 – 224)

Data from a large supermarket chain in the Portland area are currently being gathered. The adjustment method will be tested on this land use. This analysis will also be incorporated into a supplementary chapter to this report.

5.2.3 Micro-scale Analysis

Macro-scale built environment measures can explain variation in travel behavior on an aggregate level, but understanding the relationships between micro-scale or site-level characteristics and variations in travel behavior is also important. Jurisdictions, urban designers, and planners are interested in how provision of certain micro-scale amenities affects travel. Micro-scale attributes include things like bicycle parking supply, tree canopy cover, sidewalk width, and the like. Data collection of micro-scale built environment characteristics at the study locations of this project is currently underway. Site-level analysis may provide a better understanding of travel characteristics and could potentially enhance vehicle trip rate adjustments.

The model introduced in this report suggests that with retail density and diversity (ULI), many other built environment factors interact to make places that lend themselves to higher levels of non-automobile travel. Planning decisions to develop places that generate fewer vehicle trips must address the issue of parking supply along with other built environment characteristics described in this report. Parking data from the survey establishments of this study are being gathered to investigate parking provision. A future step in the research is to investigate the associations between parking supply, urban contexts, and travel behavior with respect to a micro-level analysis.

APPENDIX A. LONG SURVEY

Question	Text To Read to Respondent	Answers
Q55. Age	*What best describes your AGE?*	[ ] under 18, [ ] 18-24, [ ] 25-34, [ ] 35-44, [ ] 45-54, [ ] 55-64, [ ] 65-74, [ ] 75 and over
Q52. HH	*Please provide the following information for your household:* *Number of Adults*	[ ] 0, [ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
	Number of Children	[ ] 0, [ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
	Number of Automobiles	[ ] 0, [ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
	Number of people with BICYCLES	[ ] 0, [ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
	Number of Transit Passes	[ ] 0, [ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
Q57. Decision	*When did you decide that you would visit [LOCATION]?*	[ ] passing by, [ ] after leaving home, [ ] today before leaving home, [ ] yesterday, [ ] before yesterday, [ ] do not know
Q2. Origin	*We would like to ask you some questions about your travel here today, Can you tell me the nearest intersection or address from where you came from?*	____________________________________ ____________ ____________________________________ ____________ ____________________________________ ____________
Q30. Beginning of Day	*Is this the place where you began your day?*	[ ] yes, [ ] no
Q3. Origin Type	*The best description of this location is one of the following:*	[ ] Home, [ ] Work, [ ] School, [ ]Restaurant, [ ] Coffee shop, [ ] Service errand, [ ] Other: __________________
Q8. Origin Mode	*How did you travel to [establishment]?* **Explain that we want travel modes in the order used. Remind respondent for walk trips if >1 block.**	
	Segment 1: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	
	Segment 2: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	
	Segment 3: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	
	Segment 4: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	
	Segment 5: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	
	Segment 6: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	
Q9-Q14. Veh Occ	**IF VEHICLE CHOSEN:** *For trip segment [#], how many people were in the vehicle?*	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more

Question	Text To Read to Respondent	Answers
Q58. Parking cost	**IF VEHICLE CHOSEN:** *How much did you pay for PARKING in traveling to [LOCATION]? (Enter zero if you have a parking pass)*	$_________
Q60. Transit Cost	**IF TRANSIT CHOSEN:** *How did you pay for your public transportation in travelling to [LOCATION] today?*	[ ] cash only, [ ] ticket at kiosk, [ ] transit pass, [ ] free zone
Q63. Mode Attitudes	*Now, we will ask you about your attitudes towards different transportation options in traveling to [LOCATION]. Please evaluate the following on a scale from 1 (strongly disagree) to 5 (strongly agree), even if you do not use these modes:*	
	Car parking here is easy and convenient	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5
	Bike parking here is easy and convenient	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5
	Biking here is safe and comfortable	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5
	Walking here is safe and comfortable	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5
	Taking transit here is convenient	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5
Q38. Shopping frequency	*In order to understand more about why you came here, we will ask a few questions about your consumer habits. Can you tell me how frequently you come here?*	[ ] rarely, [ ] once a month, [ ] a few times per month, [ ] once a week, [ ] a few times a week, [ ] daily
Q62. Time spent	*Could you tell me the approximate amount of TIME you spent here at [LOCATION]*	________ Minutes
Q39. Money spent	*Could you tell me the approximate amount of money you spent here at [LOCATION]?*	$_________
Q53. Group size	*How many people in your group did this purchase pay for?*	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
Q31. Destination location	*We are going to ask you a series of questions about where you will be going after [Location]. Can you tell me the nearest intersection or address you will be going NEXT?*	________________________ ________________________ __ ________________________ ________________________ __ ________________________ ________________________ __
Q32. Destination type	*The best description of this location is one of the following:*	[ ] Home, [ ] Work, [ ] School, [ ]Restaurant, [ ] Coffee shop, [ ] Service errand, [ ] Other: ___________________
Q8*. Destination mode	*How will you travel to the next location from here?* **Explain that we want travel modes in the order used. Remind respondent for walk trips if >1 block.**	
	Segment 1: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	

Question	Text To Read to Respondent	Answers
	Segment 2: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	
	Segment 3: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	
	Segment 4: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	
	Segment 5: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	
	Segment 6: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:______________	
Q36. Home location	**IF HOME NOT ALREADY GIVEN IN ORIGIN/DESTINATION QUESTIONS:** *Can you tell me the nearest intersection or address for your HOME?*	________________________ ________________________ __ ________________________ ________________________ __ ________________________ ________________________ __
Q37. Work location	**IF WORK NOT ALREADY GIVEN IN ORIGIN/DESTINATION QUESTIONS** *Can you tell me the nearest intersection or address for your WORK?*	________________________ ________________________ __ ________________________ ________________________ __ ________________________ ________________________ __
Q54. Limitations	*Do you have any medical limitations that prevent you from walking, bicycling or driving?*	[ ] yes, [ ] no
Q56. HH Income	*What best describes your total annual HOUSEHOLD INCOME?*	[ ] less than $25,000, [ ]$25K - $49,999, [ ] $50K - $99,999, [ ] $100K - $149,999, [ ] $150K - $199,999, [ ] $200K or more
Q40. Gender	*What gender do you most identify with?*	[ ] male, [ ] female
Q71. Follow up	*Finally, would you like to participate in follow-up research about travel & consumer choices?*	Name:__________________ ____________________ Phone/email: ________________________ ________
END	*We appreciate your time in completing this survey. Thank you, and have a great day!*	

APPENDIX B. SHORT SURVEY

Contextual Influences on Trip Generation Survey II
Location: ____________________
Date: ________________

Thank you for taking this 30 second survey about your travel choices and consumer behavior. The information you provide will inform Portland State University research about transportation, environment and behavior. Your participation in this study is voluntary, your information will be kept confidential and you can opt out at any time. (Circle M for male respondents and F for Female respondents.)

Questions:

1. How did you get here? (multiple modes allowed)

   (Walk; Bicycle; MAX/WES; Bus; Streetcar; Vehicle driver; Vehicle passenger; Other--write in)

2. Can you tell me the nearest intersection or address to/of your home?

3. Can you tell me how frequently you come to this plaid pantry?

   (Rarely; Once / month; A few times / month; Once / week; A few times / week; Daily)

4. Could you tell me the approximate amount of money you spent here during this visit?

APPENDIX C. MODE SHARES

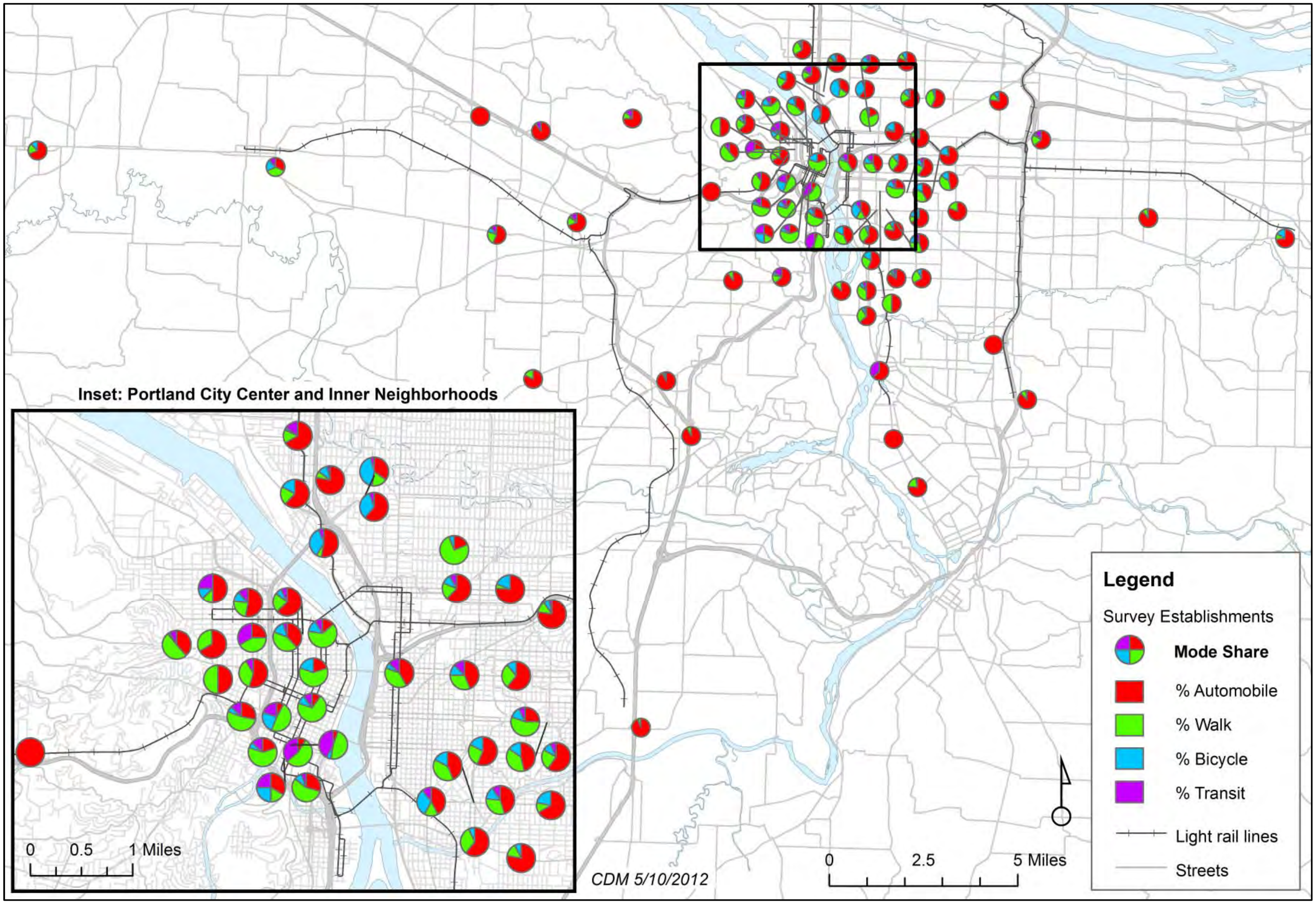


Figure 5-1. Survey Establishment Mode Shares

APPENDIX D. CONVERTING PERSON COUNTS TO VEHICLE TRIPS

Vehicle trip estimation method

To develop a method to adjust ITE vehicle trip rates, we used vehicle trips from our data collection effort. But vehicle trips exiting sites were obtained for just 44 of the 78 establishments studied. Many study sites, especially those in urbanized neighborhoods, contained on-street and complex parking situations and did not allow vehicle counts to be obtained during data collection. We describe the method used to develop vehicle-equivalent trips from person counts and vehicle occupancy.

At all study establishments, person counts entering and exiting the establishment were collected. Both the short-form and long-form survey collected mode choice, and the long-form survey gathered vehicle occupancy data from those who traveled by automobile. Vehicle occupancy was not collected in the short survey. Because vehicle occupancy data were only collected within the long-form survey, it has a smaller sample size. Therefore, for establishments with less than ten observations for vehicle occupancy, average vehicle occupancy observed for that particular land use was used in the vehicle-equivalent trip estimate type (see Table 3-8 and Table 3-9)

Vehicle trip estimation method to exiting trips

In Equation 5-1 we estimate vehicle trips exiting establishments.

Equation 5-1. Conversion to vehicle trip equivalents method for exiting trips.

$$VT_{CNTS,OUT} \approx VT_{EST,OUT} = \frac{(P_{OUT})(\%AUTO)}{V_{OCC}}$$

Where: P_{OUT} = Person count existing the establishment,
$\%AUTO$ = Automobile mode share from the long- and short-form surveys,
V_{OCC} = Average vehicle occupancy from the long-form survey,
$VT_{CNTS,OUT}$ = Vehicle trips counted from patrons exiting establishment, and
$VT_{EST,OUT}$ = Vehicle trips estimated from patrons exiting establishment.

Verification of estimation method

Since only exiting vehicle counts were counted at establishments, we test our method by comparing estimated exiting vehicle trips with observed exiting vehicle trips. A plot of estimated exiting vehicle trips is plotted against observed exiting vehicle trips is shown in Figure 5-2. Estimated vehicle trips are close to observed vehicle trips. Ideally, the points would follow the 1:1 unit line plot. The graph shows that results are not very far from the unit line.

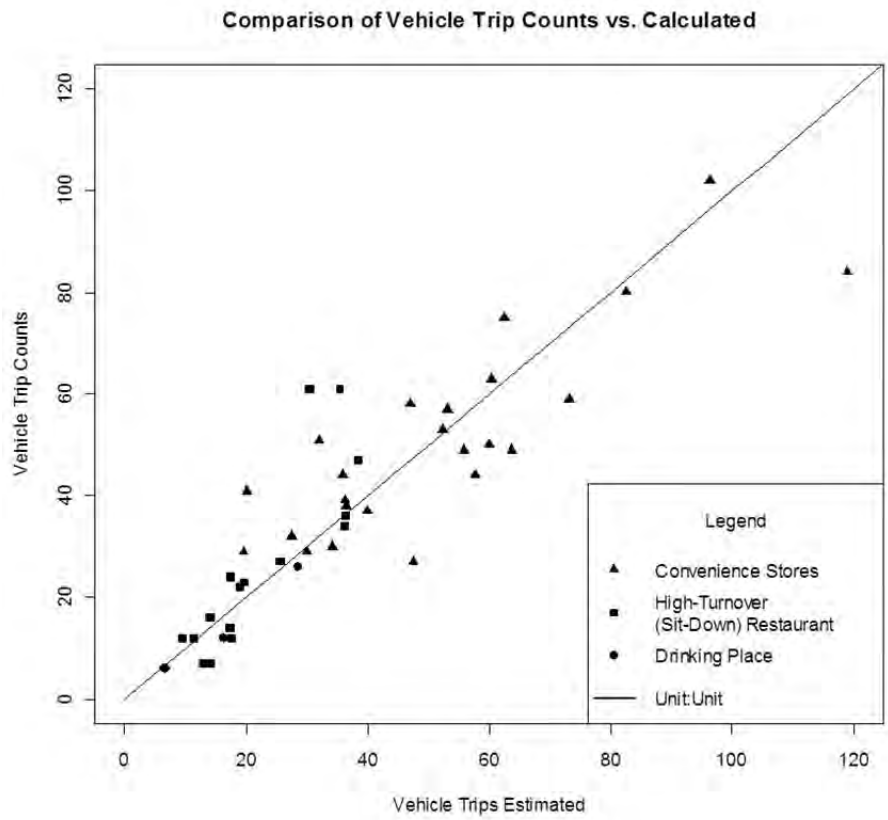


Figure 5-2. Comparison of vehicle trip counts to calculated

Table 5-3. Estimated vehicle trips compared to observed

Type	Mean Square Error	Weighted Average*	Sample Size
All Land Uses	128.3	1.02	44
Convenience Markets	155.9	0.98	24
High-Turnover (Sit-Down) Restaurants	117.4	1.17	16
Drinking Place	6.1	0.87	4

*Weighted averages less than one mean vehicle trips are overestimated (estimated vehicle trips > actual vehicle trips); values greater than one mean vehicle trips are underestimated.

Table 5-3 shows the comparison between estimated exiting vehicle trips and observed exiting vehicle trips. Weighted averages indicate the accuracy of the estimation method (Equation 5-1). Restaurants tend to have underestimated vehicle trips when compared with observed counts (weighted average > 1.0). Drinking places tend to have overestimated vehicle trips, but that may be due to smaller sample size. Overall, the weighted average between observed and estimated vehicle trips for all land uses is very close to 1.0, suggesting that converting person trips to vehicle trips using observed mode share and vehicle occupancy is a valid approach. This method could be applied elsewhere, since estimating vehicle trips in highly urbanized areas is difficult.

APPENDIX E. ADJUSTED VEHICLE TRIP RATE GRAPHICS

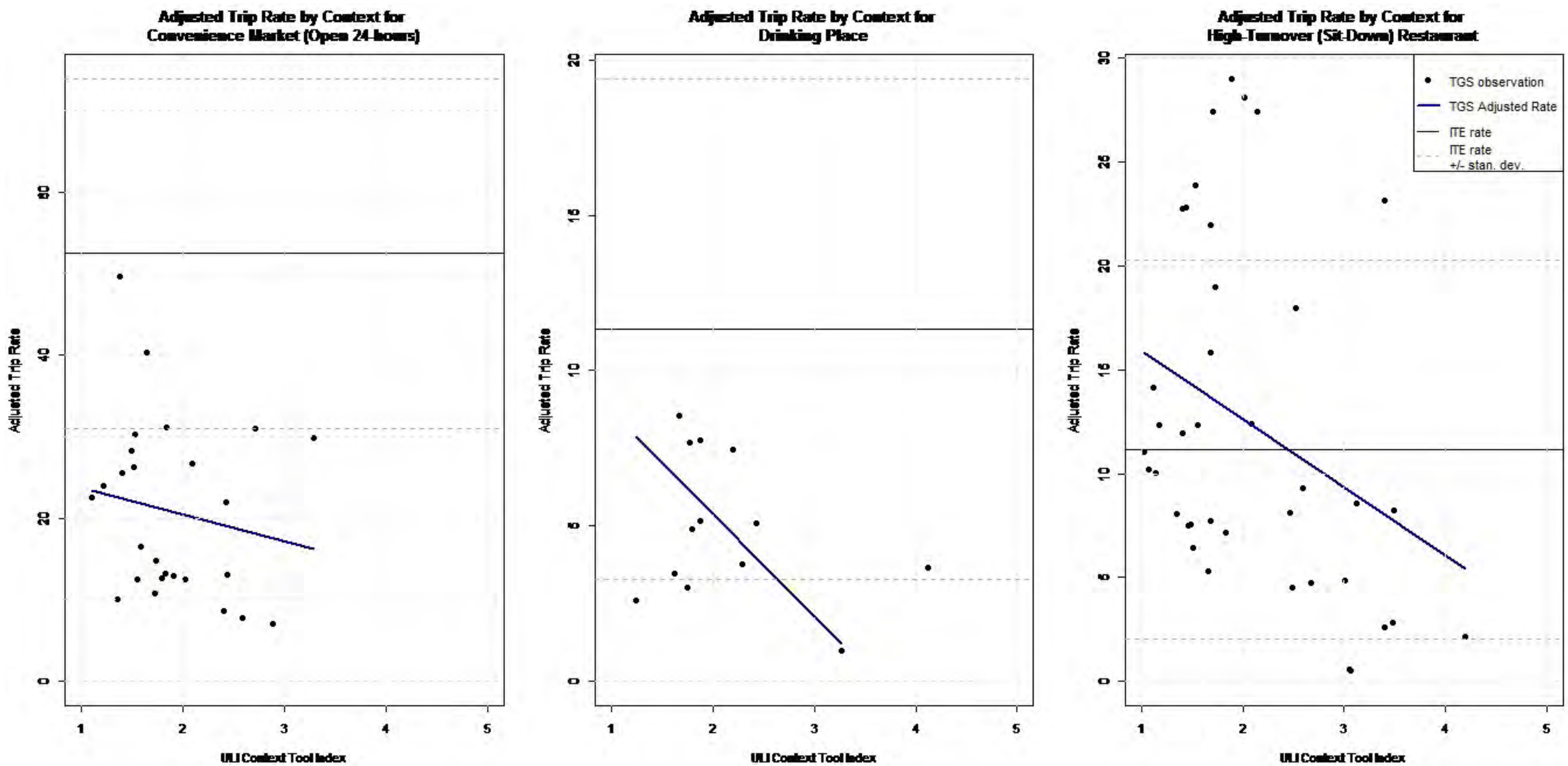


Figure 5-3. Adjusted Vehicle Trip Rate by Mean ULI Score and Land Use

APPENDIX F. BIBLIOGRAPHY

Badoe, Daniel. "Transportation - Land-use Interaction: empirical findings in North America, adn their implications for modeling." *Transportation Research. Part A: Policy and Practice* (National Academiy for the Sciences), 2000: 263.

Baltimore City Department of Transportation. "Procedures and Requirements for Conducting a Traffic Impact Study in Baltimore City." Baltimore City, Maryland, 2007.

Bedford County Department of Planning. "Bedford County Traffic Impact Study (TIS) Guidelines." Bedford, VA, 2004.

Bochner, Brian. *NCHRP 08-51: Enhancing Internal Trip Capture Estimation for Mixed-Use Developments.* Transportation Research Board. 2010 йил 01-October. http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=927 (accessed 2011 йил 03-March).

Cervero, Robert. *Ridership Impacts of Transit-Focused Development in California (UCTC No. 76).* Working Paper, Berkeley, CA: The University of California Transportation Center, 1993.

Cervero, Robert. “Transit-Oriented Development's Ridership Bonus: A Product of Self-Selection and Public Policies.” *Environment and Planning A* 39 (2007): 68-85.

Cervero, Robert, and G. B. Arrington. *TCRP Report 128: Effects of TOD on Housing, Parking, and Travel.* Washington, D.C.: Transit Research Board, 2008.

Cervero, Robert, and G. B. Arrington. “Vehicle Trip Reduction Impacts of Transit-Oriented Housing.” *Journal of Public Transportation* 11, no. 3 (2008): 1-17.

Cervero, Robert, and Kara Kockelman. "Travel Demand and the 3Ds: Density, Diversity, and Design." *Transportation Research: D* 2, no. 3 (1997): 199-219.

Charlotte Department of Transportation. "Land Development Rezoning and Traffic Impact Study Review Process." Charlotte, Carolina, 2006.

City of Bellingham. "Development Guidelines & Improvement Standards: Section 11-2.02 Traffic Studies: Project Trip Generation and Design-Hour Volumes." Bellingham, WA, 2012.

City of Bellingham. "Development Guidelines & Improvement Standards; Section 11-2.13 Traffic Studies: Technical Requirements of Final Report." Bellingham, Washington, 2012.

City of Bend. "Bend Code - Chapter 10-10 - Development Code." City of Bend, Oregon, 2009.

City of Frisco. “Article IV: Site Development Requirements; Seciton 10: Traffic Impact Analysis and Mitigation.” City of Frisco, Texas, 2005.

City of Henderson, Department of Public Works. “Traffic Impact Analysis Guidelines.” City of Henderson, Nevada, 2009 February.

City of Los Angeles Department of Transportation. "Traffic Study Policies and Procedures (December 2010)." Los Angeles, California, 2010.

City of Mississauga. "Traffic Impact Study Guidelines." Mississauga, Canada, 2008.

City of Pasadena. “Transportaiton impact Review Current Practice and Guidelines.” City of Pasadena, California, 2005 August 24.

City of Rockville. "Comprehensive Transportation Review (21 March 2011)." Rockville, Maryland, 2011.

City of Salem. "Development Bulletin 19: Transportation Impact Analysis (20 January 1995)." Salem, OR, 1995.

City of San Diego. "Traffic Impact Study Manual (July 1998)." San Diego, CA, 1998.

City of Sedro-Woolley. "Traffic Impact Study Guidelines (14 July 2004)." 2004.

City of Vancouver. "City of Vancouver Traffic Study Requirements." City of Vancouver, WA, 2010.

Clark, David. “Estimating Future Bicycle and Pedestrian Trips From a Travel Demand Forecasting Model.” *Institute of Transportaotn Engineers, 67th Annual Meeting.* Boston: Institute of Transportation Engineers, 1997. 1-8.

Colorado/Wyoming ITE Section Technical Committee - Trip Generation. "Trip Generation for Mixed-Use Developments." *Institute of Transportation Engineers Journal* 57, no. 2 (February 1987): 27-32.

Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption. *Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions.* Special Report 298, Board on Energy and Environmental Systems, Transportation Research Board, National Academy of Sciences, 2009.

Crowley, David, Amer Shalaby, and Hossein Zarei. "Access Walking Distance, Transit Use and Transit-Oriented Development in North York City Center, Toronto, Canada." *Transportation Research Record: Journal of Transportation Research Board* (Transportation Research Board) 2110 (2009): 96-105.

Dill, Jennifer. “Transit Use and Proximity to Rail: Results from Large Employment Sites in the San Francisco, California, Bay Area: Paper No. 03-4352.” *Transportation Research Record*, 2003: 19-24.

Dill, Jennifer. “Transit Use at Transit-Oriented Developments in Portland, Oregon, Area.” *Transportation Research Record: Journal of the Transportation Research Board* 2063 (December 2008): 159-167.

D'sousa, Ed, et al. *Neighborhood Environment for Active Transport--Geographic Information System--version 5.1*. Manual, University of Minnesota Center for Transport Studies, 2012.

Ewing, Reid, and Robert Cervero. "Travel and the Built Environment: A Meta-study." *Journal of the American* 76, no. 3 (2010): 265-294.

Ewing, Reid, and Robert Cervero. “Travel and the Built Environment: A Synthesis.” *Transportation Research Record: Journal of the Transportation Research Board* (Presented at the Transportation Reserach Record 1780) 1780 (2001): 87-114.

Fehr & Peers. "Summary of Research Demonstrating that Smart Growth Reduces Traffic." Internal - Referenced in Samdahl, Donald. Travel Demand Research for Downtown Kent. Kent, Washington: Fehr & Peers, 2010., 2008.

Fleet, Christopher, and Arthur Sosslau. "Trip Generation Procedures: An Improved Design for Today's Needs." *Institute of Transportation Engineering Journal* 46, no. 11 (November 1976).

Gard, John. “Innovative Intermodal Solutions for Urban Transportation Paper Award: Quantifying Transit-Oriented Develpment's Ability to Change Travel Behavior.” *Institute of Transportation Engineers Journal* 80, no. 11 (2007): 42-46.

Georgia Regional Tranpsortation Authority. “GRTA DRI Review Package Technical Guidelines.” 2002 January 14.

Guo, Jessica, Chandra Bhat, and Rachel Copperman. "Effect of Built Environment of Motorized and Nonmotorized Trip MAking: Substitutive, Complementary or Synergistic?" Edited by National Academy of the Sciences. *Transportation Research Repord: Journal of the Transportation Research Board* (Transportation Research Board) 2010, no. 1 (January 2007): 1-11.

Hagler Bailly Services, Inc. and Criterion Planners/Engineers. *The Transportatoin an dEnvironmental Impacts of Infill Versus Greenfield Development: A Comparative Case Study Analysis: EPA Pub. Number 231-R-99-005*. Environmental Protection Agency, 1999.

Harris County, Texas. "Chapter 5, Article II of the Land Development Code: Traffic Impact Analysis Guidelines." Harris County, TX, 1991.

Institute of Transportation Engineers. *Trip Generation Handbook: An ITE Recommended Practice, 2nd Ed.* Washington, D.C.: Institute of Transportation Engineers, 2004.

—. *Trip Generation: An Information Report , 8th Edition.* Washington, D.C.: Institute of Transportation Engineers, 2008.

Jeihani, Mansoureh, and Ricardo A Camilo. *Trip Generation Studies for Special Generators (MD-09-SP808B4J).* Research Report, Maryland: State Highway Administration, Maryland Department of Transportation, 2009.

JHK & Associates, Pacific Rim Resources, and SG Associates. *DRAFT Final Report: Accessibility Measure and Transportatoin Impact Factor Study.* Salem, Oregon: for the Oregon Department of Transportaton/Oregon Department of Land Conservtion and Development, Transportation and Growth Management Program, 1996.

JHK and Associates. *Development-Related Ridership Survey I.* Washington, D.C.: Washington Metropolitan Area Transit Authority, 1987.

Kimley-Horn and Associates, Inc. *Trip Generation Rates fo rurban Infill Land Uses in California; Phase 2: Data Collection.* California: Caltrans, 2009.

Kitamura, Ryuichi, Patricia L. Mokhtarian, and Laura Laidet. "A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area." *Paper presented at the Annual Meeting of the Transportation Research Board.* Washington, D.C., 1995.

Lapham, Michael. *Transit-Oriented Development - Trip Generation & Mode Split in the Portlan dMetropolitan Region.* Portland, Oregon: Portland State University, 2001.

Lee, Richard, et al. *Evaluation of Operation and Accuracy of Five Available Smart Growth Trip Generation Methodologies (UCD-ITS-RR-11-12).* Research Report, Davis, CA.: Institute of Transportation Studies, University of California, Davis, 2011.

Lerner-Lam, Eva, Stephen P. Celniker, Gary W. Halbert, Chester Chellman, and Sherry Ryan. "Neo-Traditional Neighborhood Design and Its Implications for Traffic Engineering." *Institute of Transportation Engineers* 62, no. 1 (1992).

Lund, Hollie M., Robert Cervero, and Richard W Willson. *Travel Characteristics of Transit-Oriented Developmen in California.* California: Caltrans Transportation Grant "Statewide Planning Studies" FTA Section 5313(b), 2004.

Maley, Donald W, and Rachel Weinberger. "Food Shopping in the Urban Environment: Parking Supply, Destination Choice and Mode Choice." *Transportation Research Board, 90th Annual Meeting.* Washington, D.C.: National Academy of the Sciences, 2010.

Montgomery Planning. *Local Area Transportation Review.* Montgomery County, Maryland.: The Maryland National Capital Park and Planning Commission, 2010.

National Research Council (U.S.). "NCHRP Report 323: Travel Characteristics at Large-Scale Suburban Activity Centers: Status of Current Research." *Transportation research circular*. (Transportation Research Board, National Research Council), 1990: 52-56.

Nelson\Nygaard Consulting Associates. "Crediting Low-Traffic Developments: Adjusting Site-Level Vehicle Trip Generation Using URBEMIS." San Francsico, California, 2005.

New York City. *City Environmental Quality Review (CEQR): Chapter 16.* New York City, NY: Mayor's Office of Environmental Coordination, 2010.

Renne, John Luciano. "Transit-Oriented Development: Measureing Benefits, Analyzing Trends, and Evaluating Policy." *Urban Planning dissertation.* New Brunswick, New Jersey: Rutgers, The State University of New Jersey, 2005.

Rizavi, Amir, and Alfred Yeung. "Urban Commuting Trends - Comparing Trip Generation Practices." *Institute of Transportation Engineers.* Vancourver: Institute of Transportation Engineers, 2010.

Samdahl, Donald. *Travel Demand Research for Downtown Kent.* Memorandum submitted to the City of Kent WA, June 28, 2010, Kent, Washington: Fehr & Peers, 2010.

San Diego Municipal Code. "Land Development Code: Trip General Manual." San Diego, California, 2003 May.

San Francisco Planning Department. *Transportatoin Impact Analysis Guildelines for Environmental Review.* San Francisco, California: City and County of San Francisco, 2002.

Schneider, Robert J. *Understanding Sustainable Transportation Choices: Shifting Routine Automobile Travel to Walking and Bicycling (UCTC-DISS-2011-01).* Dissertation, Berkeley, CA: University of California Transportation Center, 2011.

Seskin, S. N., Robert Cervero, and Jeffrey Zupan. *NCHRP Report No. 16: Transit and Urban Form.* Washington, D.C.: National Academy Press, 1996.

Southern New Hampshire Planning Commission. "Trip Generation Study." New Hampshire, 2010.

Sperry, Benjamin R. "Comparing Methodologies to Estimate Internal Trip Capture at Mixed-Use Developments." *Institute of Transportation Engineers, Annual Meeting.* Institute of Transportation Engineers, 2010.

State of Flordia Department of Community Affairs. "Transportation Concurrency Requirements and Best Practices: Guidelines for developing and maintaining an effective transportation concurrency management system (September 2006)." Tallahassee, FL, 2006.

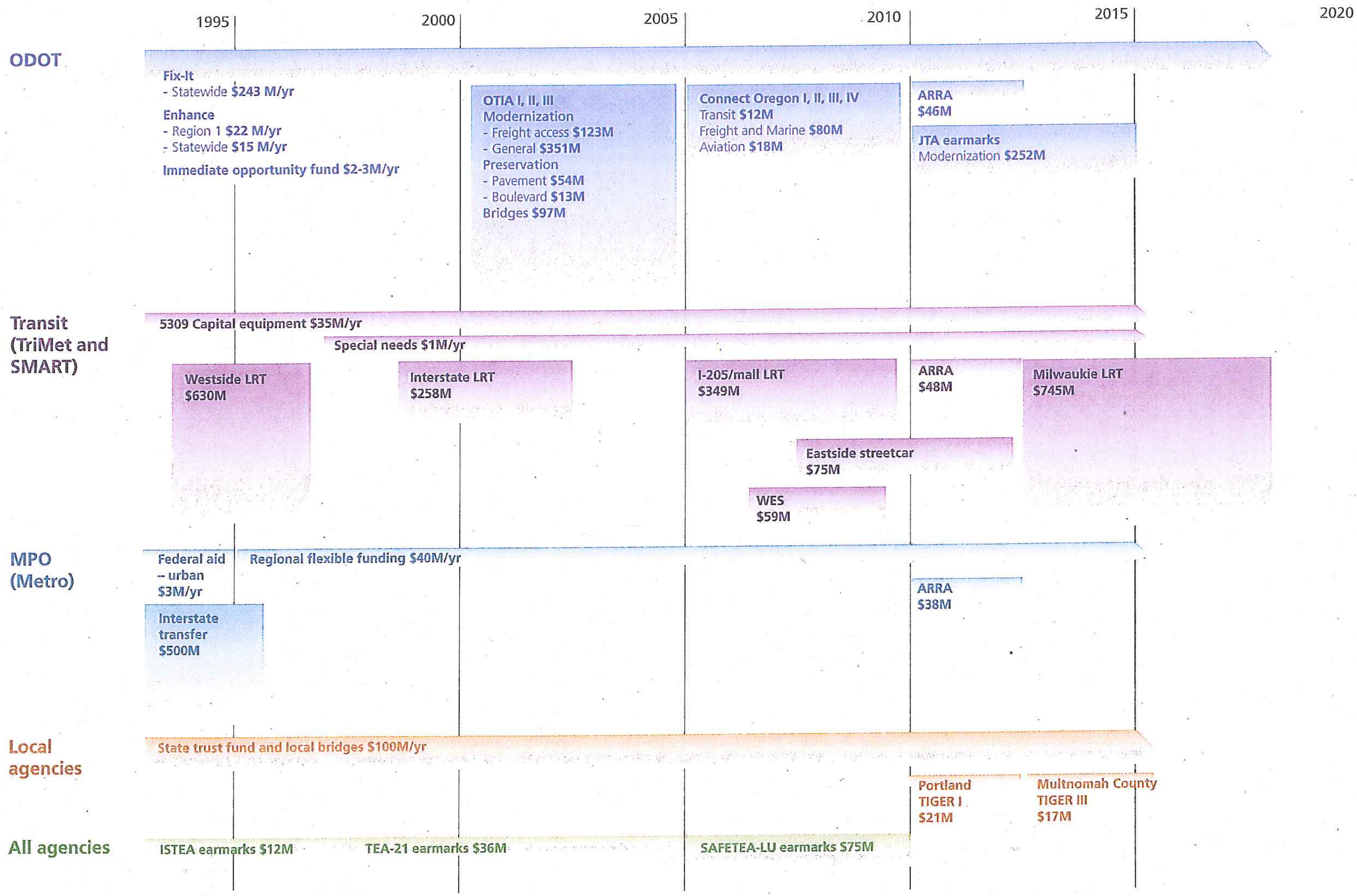
Steiner, R. L. "Traditional Shopping centers." *Access: Research at the University of California Transportation Center* 12 (1998): 8-13.

Virginia Department of Transportation. "Traffic impact Analysis Regulations Small Area Plan Amendments: 24VAC30-155-60.D.1: Traffic Impact Statement." Virginia, 2010 April.

Walters, Jerry. *Statewide Improvements of Tools for Regional & local Smart-Growth Planning.* Caltrans: Fehr & Peers, 2009.

Materials following this page were distributed at the meeting.

Federal and state capital investments in the Portland metropolitan area



KEY

ARRA American Recovery and Reinvestment Act
ISTEA Intermodal Surface Transportation Efficiency Act
JTA Jobs and Transportation Act
LRT Light Rail Transit
MPO Metropolitan Planning Organization
OTIA Oregon Transportation Investment Act
SAFETEA-LU Safe, Accountable, Flexible, Efficient Transportation Equity Act: A legacy for Users
TEA-21 Transportation Equity Act for the 21st Century
TIGER Transportation Investments Generating Economic Recovery
WES Westside Express Service

August 30, 2012
13046

2015-18 Metropolitan Transportation Improvement Program (MTIP)

August 31, 2012 TPAC

Ted Leybold & Josh Naramore

Metro | Making a great place

What is the MTIP?

The process of establishing project priorities within the limits of available funds to accomplish the goals of the state and metropolitan transportation plan.

- Implements 2035 RTP and OTP
- Fiscally constrained
- Region's CIP

Metro | Making a great place

Who develops the MTIP?

- The MPO (Metro)
- Developed in cooperation with state DOT and Public Transportation Service providers.
- Part of the STIP

Metro | *Making a great place*

What is required in developing the MTIP?

- Implement Public Involvement Policy
- Reflect priorities of the 2035 RTP
- Utilize the Congestion Management Process
- Coordination with ODOT, TriMet & SMART
- Selection of performance targets (new from MAP-21)
- Burdens and benefits analysis to Environmental Justice populations
- Air quality conformity
- Demonstration of fiscal constraint

Funding Sources programmed in the MTIP

- ODOT Administered Funds
- Regional Flexible Funds
- Transit Funding
- Local Funding

ODOT Administered Funds

- Fix-It
- Region 1 Enhance
- Statewide Enhance
- Immediate Opportunity Fund

Regional Flexible Funds

- Region wide programs
  - Transit Oriented Development
  - System Management & Operations
  - Travel Options (demand management)
  - Corridor Planning
  - In lieu of dues MPO support
- Community Investment categories
  - Freight & Green Economy
  - Active Transportation & Complete Streets

Transit Funding

- Urbanized Area Transit (5307)
- Fixed-guideway Transit (5309)
- Enhanced Mobility (5310)

Local Funding

- Match to federal funding
- Locally funded projects
  - Regionally significant
  - Informational purposes only

Discussion – Framing for JPACT

1. Coordination between STIP and MTIP processes & JPACT input to STIP/ACT project selection

2. Continue existing RFFA policy framework with some adjustments?

Discussion – JPACT Framing continued

3. Are there regional needs that are not currently addressed in the 2015-18 MTIP proposals?

4. How to allocate additional RFFA funding

Oregon
John A. Kitzhaber, MD, Governor

Department of Transportation
Transportation Region 1
123 NW Flanders St
Portland, OR 97209-4012
(503) 731-8200
Fax: (503) 731-8259

August 16, 2012 File Code:

Andy Duyck, Chair
Washington County Commission
155 N. First Avenue, #300
Hillsboro, OR 97124

Dear Chair Duyck,

The Oregon Transportation Commission (OTC) decided on July 18th to advance a new process for identifying and funding transportation projects across the state. The newly adopted Statewide Transportation Improvement Program (STIP) process relies heavily on our state's network of Area Commissions on Transportation (ACT) to review and select projects for funding. Given that we do not have an ACT in Region 1, ODOT staff and OTC Chairman Pat Egan reached out to numerous individuals and organizations over the past two months seeking input as to how the process might be expanded to include a broader range of stakeholders in the project selection process. At its August meeting the OTC directed the Department to establish a region-wide committee to review and select projects in Region 1 for the 2015-2018 STIP.

This region-wide project selection committee will be composed of representatives nominated from Clackamas County (4), Hood River County (4), Multnomah County (4) and Washington County (4), the City of Portland, a Metro Councilor, TriMet, the Port of Portland, and the ODOT Region 1 Manager. To ensure that a wide range of interested stakeholders, with views from around the Region, are represented, we are asking your Board to designate the four representatives from Washington County to serve on the committee. One out of four appointments must go to an elected city official from within your boundaries and one seat may be retained for a member of the county board. Appointees to the remaining two seats per county should be made consistent with Chair Egan's guidance memo to ACT Chairs on April 24th. This guidance states the desire to include both public and private-sector members with expertise on active transportation, freight mobility and public transportation. Ideal nominees will come to the table with a transportation system perspective and have considerable transportation experience. I further recommend the counties work together and seek input from a variety of sources in considering their nominees. The OTC may name one or more at-large members, increase the number of appointments allowed per county or establish a subsequent process by which the committee itself would nominate additional members when it convenes in the fall, if needed.

The Region 1 transportation network plays a uniquely important role in our state's economy. It is within Region 1 where we see the intersection of our state's most travelled highways, transit lines, multimodal paths, busiest port and largest city. To the east, our partners in East Multnomah, Rural Clackamas and Hood River Counties rely on ports, trails, highways and interstates for the movement of agricultural goods, freight mobility and access to some of the most visited natural wonders in the state. When proposing members of the committee I urge you to seek out representatives that can look beyond jurisdictional boundaries and bring a system point-of-view.

We will hold the first Region 1 STIP Selection Committee meeting at the end of September, and therefore need to receive your nominations for membership by 5:00 PM on **September 7, 2012**. The OTC will formally appoint the committee at its September meeting in Pendleton. I will be in touch with you soon to schedule a meeting to discuss the nomination process further. Should you have any questions or concerns prior to this meeting please call Rian Windsheimer at 503-731-8456.

Thank you for your assistance and leadership.

Sincerely,

Jason Tell
Region 1 Manager

Cc: Roy Rogers, Commissioner
Pat Egan, OTC Chair
Matt Garrett, ODOT Director
Paul Mather
Jerri Bohard
Betsy Imholt
Travis Brouwer

CONTEXTUAL INFLUENCES ON TRIP GENERATION

Final Report

OTREC 2011-407

by

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OTREC
OREGON TRANSPORTATION RESEARCH
AND EDUCATION CONSORTIUM

August 2012

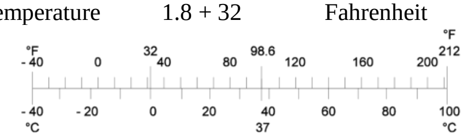
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



***** SI is the symbol for the International System of Measurement

(4-7-94 jbp)

ACKNOWLEDGEMENTS

This project was sponsored by a grant from the Oregon Transportation Research and Education Consortium (OTREC) with assistance from:

- Metro
- Talia Jacobson, ODOT
- Don Odermott, City of Hillsboro
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- Jason Rice, City of Milwaukie
- Judith Gray, City of Tigard

CONTEXTUAL INFLUENCES ON TRIP GENERATION

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EXECUTIVE SUMMARY

This study examines the ways in which urban context affects vehicle trip generation rates across a variety of land uses. An establishment intercept travel survey was administered at 78 establishments in the Portland, Oregon region during the summer of 2011. Data were collected from high-turnover (sit-down) restaurants (Mexican and pizza), 24-hour convenience markets, and drinking places. Combined with person trip counts, vehicle trip counts, and built environment data, a method to adjust ITE vehicle trip rates to reflect a local community's context has been developed.

Results from this study reveal a trend: for all land uses tested here, vehicle trip rates decrease as neighborhood types become more urban. Comparisons between ITE Trip Generation vehicle trip rates and vehicle trip rates from this study indicate a need for a local adjustment for both convenience markets (open 24-hours) and drinking places. High-turnover (sit-down) restaurants are consistently predicted by the ITE methodology, but based on our findings we recommend a vehicle trip rate adjustment to better match locally observed travel patterns.

A model to adjust ITE's trip generation rate for urban contexts was developed in this study. The key measure representing urban context is the average Urban Living Infrastructure (ULI) score from the Metro Context Tool within a ½ mile buffer around establishments. ULI is a measure representing the density of retail and service establishments serving daily needs and is highly correlated with other built environment measures such as lot coverage, density, and accessibility to transit. The model developed here has a good statistical fit and ease of use in an evaluation of new development. The approach is also useful in guiding plans as we have related the ULI measure to other planning relevant built environment measures.

The study findings are limited in a number of ways. The three land uses examined and the relatively small sample size limit the number of factors that could be accounted for in our statistical analysis. In addition, data collection was limited to the weekday evening peak hour of the facility for each of the three land uses. The findings are localized and may not have broad applicability beyond the Portland region. Work planned for the immediate future includes: validation of the method using data collected from additional sites in Portland and elsewhere and analysis of site level attributes including parking, building orientation, pedestrian and bicycle infrastructure and other design features.

1.0 INTRODUCTION

There is national interest in building data that expand upon the existing Institute of Transportation Engineers (ITE) trip generation rates to include sites located in a multi-modal context. Often criticized for their shortcomings, *ITE Trip Generation Handbook* rates were developed beginning in the 1960s and focused on single-use, vehicle-oriented in suburban sites in the United States. *ITE Trip Generation Handbook* rates were meant to provide engineers with off-the-shelf estimates for basic land uses and simple contexts to bypass expensive data collection costs (Institute of Transportation Engineers 2008, Gard 2007, Steiner 1998). Despite this intention, the *ITE Trip Generation Handbook* is commonly applied erroneously to more urban contexts. For these applications, ITE recommends that local rates be established via data collection for any non-suburban, paid-parking area with limited transit service or pedestrian access: "If the site is located in a downtown setting, served by significant public transportation... the site is not consistent with the ITE data" (Institute of Transportation Engineers 2004).

Measuring local trip rates and calculating the impact of urban form on vehicle trip rates are expensive and intensive processes. Many local jurisdictions ignore warnings on the limited applications in the *ITE Trip Generation Handbook* and apply generic rates to inappropriate contexts, like high density areas with more multimodal trips (Nelson\Nygaard Consulting Associates 2005, Lerner-Lam, et al. 1992, Badoe 2000, Fleet and Sosslau 1976).

Interestingly, the *ITE Trip Generation Handbook* Data Form has a box for "Location within Area" where one can check a box for the urban context of the study site location (Institute of Transportation Engineers 2004). Options are "CBD," "Urban (non-CBD)," "Suburban CBD," "Suburban (non-CBD)," "Rural," and "Freeway Interchange Area – Rural," which suggests that ITE would consider context type when developing or applying vehicle trip generation methods. But, this information is not available from ITE nor is it mentioned in *Trip Generation Handbook* methodology.

ITE acknowledges the limitations of the *Trip Generation Handbook* dataset as they relate to availability of transit, non-motorized transportation facilities, mixed land uses, and density. While the impacts of transit are discussed in the appendix of the *ITE Trip Generation Handbook*, the section begins with a disclaimer stating any information provided "is strictly for informational purposes... [and] provides no recommended practices, procedures, or guidelines." The *ITE Trip Generation Handbook* also recognizes the impact of pedestrian and bicycle infrastructure on reducing estimated vehicle trips, but does not provide site-trip generation data upon which reduction factors are based (Institute of Transportation Engineers 2004). Efforts are underway by ITE to address those issues, but methodology and extensive data will not likely be available soon. In the meantime, local governments burdened with short and long-range planning obligations are struggling with ITE rate applications in urban contexts with infill, mixed use, and transit-oriented developments (TODs) (Rizavi and Yeung 2010, Nelson\Nygaard Consulting Associates 2005).

Despite evidence that a more compact urban form, access to transit and a greater mix of uses generates fewer and shorter vehicle trips, local governments are often compelled to use current *ITE Trip Generation Handbook* rates to evaluate transportation impacts and calculate transportation system development charges (TSDCs). This is due to: a) the expense of collecting local data, b) lack of alternative sources of information, c) the strong industry bias toward using ITE published rates, and d) the absence of a consistent, empirically tested methodology for adjusting those rates for development occurring in different land use and transportation contexts.

When analysts ignore the impacts of transit, pedestrian infrastructure, bicycle facilities, and urban settings on vehicle trip generation, vehicle trips are overestimated. High vehicle trip estimates increase the amount of vehicle-oriented development. The creation of environments where there is more vehicle use, greater road capacity, abundant parking supply, and fewer automobile alternatives can be related to the overestimation of vehicle trip rates in sites and corridors and the subsequent accommodation of those estimates. Further, new development can be deterred by the impact fees associated with overestimating vehicle trips.

Compounding these challenges, cities in Oregon, like other communities with state-wide concurrency laws, are required to demonstrate that planning and zoning changes will not degrade the performance of state-owned transportation facilities based upon the levels of service documented in the Regional Transportation Plan under the Oregon Transportation Planning Rule, section -0060, and Oregon Highway Plan, Policy 1.F.6. These concurrency requirements can conflict with the Portland region's 2040 Growth Concept, which calls for development of mixed-use centers and corridors, TODs and robust neighborhood and main street commercial districts. Thus, there are gaps in the understanding about how best to evaluate, mitigate and plan for growth under these conditions.

This research project aims to address this issue by examining the relationship between trip generation and urban context. Here, we develop a method to adjust *ITE Trip Generation Handbook* rates to better reflect the relationship between land use, transportation and travel demand for specific land use types located in various urban settings. The project collected local data (using counts and establishment surveys) on a few specific land uses (restaurants, 24-hour convenience markets, and drinking places) from a variety of land use and transportation contexts. These observed local trip rates were compared to *ITE Trip Generation Handbook* rates for the same land use category and establishment size and a methodology for adjusting the ITE rates was developed.

The remainder of this report is organized as follows. A literature review summarizes the current state of the knowledge with respect to the role of context on trip generation. Then, the data used in this study and the methods used to collect them are described. Next, we document the methodology developed to adjust ITE *Trip Generation Handbook* rates for urban context and discuss the application of the approach in a planning context. Finally, the report concludes with a discussion of the implications of our study findings for planning and policy, the study limitations, and suggestions for future work. Supporting documentation is provided in the Appendices.

2.0 LITERATURE REVIEW

This literature review has three purposes. First, this review summarizes the academic and professional studies examining the predictive ability of ITE trip generation rates for different urban contexts. Second, we identify approaches to deal with the deficiencies in ITEs trip rates for different contexts. The last section relates the literature on the relationship between travel behavior and the built environment to this study: we aim to better inform which aspects of the built environment should represent context.

2.1 EVALUATION OF ITE TRIP GENERATION RATES

There have been many studies which evaluate the error in estimation of ITE Trip Generation rates compared to observed study values. These ranges of error, shown in Table 2-1, identify the large error range of results found from the variety of studies. To compare the error in ITE trip generation estimation, Equation 2-1is used. A negative rate indicates estimated vehicle trip counts being larger than those observed in the study.

Equation 2-1. ITE Trip Rate Error Equation

$$Estimated\ Error = \frac{Observed\ Vehicle\ Trip\ Rate - ITE\ Estimated\ Vehicle\ Trip\ Rate}{ITE\ Estimated\ Vehicle\ Trip\ Rate}$$

As shown in Table 2-1, the greatest range of error in ITE estimation of vehicle trips occurs in Central Business District/Urban Core/Downtown areas. One retail shop studied in Oakland, California had an observed AM peak trip count of 133 vehicle trips and an ITE estimated trip count of 11 vehicle trips. When this establishment is treated as an outlier, Mixed-Use Developments then show the greatest range of variation in error in estimation. Retail and residential developments tend to be both over and under estimated when using ITE Trip Generation rates. Standard deviations provided by ITE Trip Generation rates were not used in this assessment.

Prediction of vehicle trip generation rates is most complex when a variety of land uses are accessible within a single dense development site. For these sites, ITE provides a methodology to handle the interaction of land uses. But, this method has not been shown to be as effective as other alternatives (see the next section) developed to estimate vehicle trip generation rates at mixed-use sites (Lee, et al. 2011).

Table 2-1. Summary of ITE Trip Rate Error Findings Collected from the Literature Review[1]

	AM Peak			PM Peak			Automobile Mode Share		
Central Business District/Urban Core/Downtown	**-93%**	to	**1109%**	**-99%**	to	**11 %**	**8**	to	**100 %**
Eating / Restaurant	-93%	to	-57%	-99%	to	-70 %	17	to	57 %
Office	-80%	to	-22%	-62%	to	-21 %	56	to	95 %
Residential	-83%	to	15%	-80%	to	11 %	14	to	85 %
Restaurant		-35%			-26%		34	to	60 %
Retail	-17%	to	1109%*	-22%	to	8 %	8	to	100 %
Services		-14%			-66%				
Shopping		30%			3%				
Mixed-Use Development	**-109%**	to	**181%**	**-170**	to	**61 %**			
Mixed	-109%	to	38%	-80	to	61 %			
Town Center	-108%	to	181%	-170	to	-35 %			
Transit-Oriented Development	**-90%**	to	**20%**	**-92**	to	**35 %**	**50**	to	**96 %**
Office							50	to	96 %
Residential	-90%	to	20%	-92	to	35 %	53	to	93 %
Development near transit	**-58%**	to	**72%**	**-36**	to	**51 %**	**28**	to	**90 %**
Office							28	to	90 %
Residential	-58%	to	72%	-36	to	51 %	33	to	82 %
Suburban Activity Centers and Corridors	**-37%**	to	**-5%**				**54**	to	**98 %**
Office	-37%	to	-20%						
Residential		-5%							
Shopping							54	to	98 %

* This retail shop located in Oakland, California had an observed AM peak trip count of 133 vehicle trips and an ITE estimated trip count of 11 vehicle trips.

The automobile mode share is provided in Table 2-1 for studies that counted person trips and calculated persons taking a vehicle. The Central Business District/Urban Core/Downtown area shows the largest range of automobile mode share. But, sites in Suburban Activity Centers and Corridors contain a substantial range: automobile mode shares were observed to be as small as 54%.

2.2 ADJUSTMENTS & ALTERNATIVES TO ITE METHODOLOGY

The ITE Trip Generation Report and Handbook are the most commonly referenced and utilized practical guidelines for predicting vehicle trip rates during the development process. However, sites studied by ITE are often limited to vehicle-oriented, suburban locations with little to no

[1] Sources include (Samdahl 2010, Hooper 1989, Fehr & Peers 2008, Schneider 2011, Lee, et al. 2011, Kimley-Horn and Associates, Inc. 2009 June 15, Cervero and Arrington 2008a, Cervero, Ridership Impacts of Transit-Focused Development in California (UCTC No. 76) 1993, Dill 2008, Lapham 2001, Colorado/Wyoming ITE Section Technical Committee - Trip Generation 1987, Jeihani and Camilo 2009, Sperry 2010).

public transportation or bicycle and pedestrian facilities. Jurisdictions that require traffic impact studies often provide guidelines on how to approach local vehicle trip rate adjustments for sites with mixed-uses, presence of transit, bicycle/pedestrian amenities, or transportation demand management practices in place. This section reviews a selection of jurisdictional guidelines in North America and then reviews existing models that predict vehicle trip generation rates based on factors that encompass context and mixed land uses.

2.2.1 Jurisdictional Guidelines on Adjustment to ITE Trip Generation

This section details a review of 23 jurisdictional guidelines for local adjustment from around the United States and Canada. These guidelines originate from mega cities like New York City, New York to smaller, lower-density places like Bend, Oregon. These compiled guidelines identify trends in estimation of trip generation rates and traffic impact studies currently in practice. Table 2-2 shows how the guidelines approach ITE vehicle trip rates and adjust vehicle trip rates based on public transit, bicycle and pedestrian facilities, and mixed-use sites. More generally, the guidelines are summarized as follows:

- 22 jurisdictions reference ITE Trip Generation rates and methods as being appropriate in their local contexts, barring the presence of local rates or studies are not available.[2]

- Six jurisdictions have methods that allow for bicycle, pedestrian or transit adjustments to be applied from mode share information. One of these jurisdictions requires documentation of vehicle occupancy data in order to apply these adjustments (City of Frisco 2005).

- Six jurisdictions provide local vehicle trip generation rates of some sort. These areas tend to be more urban or have large authority areas (Montgomery Planning 2010, Southern New Hampshire Planning Commission 2010, San Francisco Planning Department 2002, San Diego Municipal Code 2003 May, City of Mississauga 2008, New York City 2010).

- 11 jurisdictions provide conditions or thresholds that require a traffic impact study at a particular development site. Conditions are based on vehicle traffic thresholds, land use plan requirements, or stipulations associated with development near roadway facilities with congestion and/or access problems. Of these jurisdictions, ten jurisdictions use vehicle trip thresholds. Table 2-3 shows the wide range of vehicle trip thresholds for a traffic impact study used by these ten jurisdictions. Decisions on the depth required of the impact analysis typically occur on a case-by-case basis.

[2] The 23rd study did not specifically reference the *ITE Trip Generation Handbook* as being appropriate or not appropriate. It appears that ITE methodologies may be acceptable, provided no better-fitting methods are available.

Table 2-2. Summary of Traffic Impact Study Guidelines for 23 Jurisdictions[3]

Trip Generation Methodologies

- 15of 23: Allow use of ITE Trip Generation rates as a primary method.
- 7 of 23: Allow use of ITE Trip Generation rates as an alternative method (typically after the use of locally provided rates or comparable data collection).
- 4 of 23: Provide some maximum reduction applicable to trip generation methodologies.
- 3 of 23: Recommend using previously collected and stored trip generation rates. WSDOT
- 6 of 23: Provide local trip generation rates to be used as a primary source for estimation. Three of these include some combination between local rates and ITE rates using travel surveys to inform the transition between vehicle trips and person trips (mode share and vehicle occupancy).
- 6 of 23: Recommend comparable data collection to development type and location. This is also recommended with in ITE Trip Generation methodologies.
- 1 of 23: Allow for alternative methods to be used, upon approval.

Transit Adjustments

- 14 of 23: Allow some adjustment for transit use.
- 7 of the 14: Provide fixed trip credit or percent adjustment for transit accessibility.
- 6 of 14: Allow for application of mode share rates. One of these mentioned the need for documentation of vehicle occupancy.
- 2 of 14: Provide maximum transit reductions limitations.
- 2 of 14: Provide reductions based on location within Transit-Oriented Development (TOD) or Area (TOA).

Bike/Walk Adjustments

- 13 of 23: Allow some adjustment walking or bike travel.
- 6 of 13: Allow for application of mode share rates. One of these mentioned the need for documentation of vehicle occupancy.
- 3 of 13: Provide fixed trip credit or percent adjustment for walk/bike amenities.
- 1 of 14: Provide maximum reductions (combined with transit reductions) limitations.

Mixed-Use or Internal Capture Adjustments

- 14 of 23: Allow some internal capture or mixed-use adjustments.
- 5 of 14: Accept ITE Trip Generation Internal Capture methods or data as being acceptable.
- 2 of 14: Provide maximum internal capture rate adjustments.
- 2 of 14: Provide fixed internal capture adjustments or guideline based on local context.

Miscellaneous Comments

- 7 of 23: Allow for reductions for transportation demand management (TDM) methods.
- 4 of 23: Provide some adjustment or special local rate by area-type or district.
- 11 of 23: Provide some guidance on a threshold of requirements before a Traffic Impact Study (TIS).

[3] Sources include (Bedford County Department of Planning 2004, Baltimore City Department of Transportation 2007, Montgomery Planning 2010, Harris County, Texas 1991, City of Vancouver 2010, City of Sedro-Woolley 2004, City of Henderson, Department of Public Works 2009 February, Charlotte Department of Transportation 2006, City of Pasadena 2005 August 24, Georgia Regional Tranpsortation Authority 2002 January 14, Southern New Hampshire Planning Commission 2010, San Francisco Planning Department 2002, City of Bend 2009, San Diego Municipal Code 2003 May, City of San Diego 1998, Virginia Department of Transportaiton 2010 April, City of Rockville 2011, City of Los Angeles Department of Transportation 2010, City of Mississauga 2008, New York City 2010, San Francisco Planning Department 2002, State of Flordia Department of Community Affairs 2006, City of Salem 1995, City of Bellingham 2012, City of Bellingham 2012).

Table 2-3. Trip Generation Thresholds Requiring Traffic Impact Study (TIS)

Jurisdiction	Daily Threshold (vehicle trips)	PM Peak Hour Threshold (vehicle trips)	Peak Hour Threshold (vehicle trips)
Bedford County, VA	500	-	-
Montgomery County, MD	-	-	30
Pasadena, CA	70	-	11
Sedro-Woolley, CA	500	-	50
Henderson, NV	-	-	100
Charlotte, WV	2,500	-	-
San Francisco, CA	-	50	-
San Diego, CA	500-1000	-	50-100
Mississauga, Canada	-	-	75
New York City, NY*	-	-	50

For sources, see page 7, footnote 3.

*Also provides thresholds for transit trips and pedestrian/bike trips generated as basis of required transit and pedestrian/bicycle impact studies.

2.2.2 Alternative Models and Approaches

ITE also recommends using an approach developed by JHK & Associates, et al. (1996) published in the ITE Handbook (Institute of Transportation Engineers 2004) with considers reductions in vehicle trip generation for locations in closer proximity to transit with supportive land uses (e.g. greater density, higher floor-to-area ratios, available pedestrian and bike facilities). This report was published as a draft, and is only presented in the handbook as a guild in procedure, does not necessarily pressent reductions based on context. ITE has also supported other methodologies for determining reductions including Gard's approach for transit-oriented developments (2007) using multimodal information to provide development wide reductions (assuming vehicle-occupant trip to non-vehicle trip substitution).

Internationally, there are two systems which have considered context in developing trip generation methods. Both the Trip Rate Information Computer System (TRICS) of the UK and Ireland and the New Zealand Trips and Parking Database Bureau (NZTPDB) provide an online data sets which include information on the area-type the data site was collected in, allowing the user to determine if the trip rates provided meet the environment of the site being estimated. Although the NZTPDB is relatively new, the established TRICS data set provides multimodal information for each site collected, and only retains sites less than 10 years old (New Zealand Trips and Parking Database Bureau (NZTPDB) 2012, Trip Rate Information Computer System (TRICS) 2012).

The Austrailian-based system "New South Wales Roads and Traffic Authority" provides a dataset comparible to the ITE Handbook, and like ITE, does not consider urban context in vehicle trip generation estimates. All data is aggregated into trip rate statistics and no site-level information is provided. When land use trip rates are not available for Austrailia, the ITE Handbook is a recommended option (New South Wales Roads and Traffic Authority 2002). There has been little literature providing comparisons and justifications for sharing intercountry trip generation data (I. Clark 2007).

There are also a few models available for application to the site-level development to determine potential adjustments to trip generaiton. URBEMIS is a pivot-model developed by Nelson/Nygaard Consulting Associates et al (2005) which applies relationships developed from previous literature between a variety of build environment characteristics with vehicle trip generation rates. The adjustment in estimated vehicle trips is then applied to the ITE trip generation estimates. A “default” or “standard” understanding of contexts for ITE Trip Genreation data is assumed. A portion of the model was also developed fo rthe California air pollution control disticts to help developers understand and mitigate emmissions problems at the development-level. For an area such as Kent, Washington, the URBEMIS model estimated reductions in ITE Trip Generation rates for the Central Business District to be rougly 15-20% (Samdahl, Travel Demand Research for Downtown Kent 2010).

Another post-processor is the INDEX tool used to assess the environmental impact at site-level developments baesd on changes to the built environment. This GIS-based post-procesor utilizes regional 4-step model output to determine changes in the built environment which may effect certain aspects of travel. While this tool to not explicitly estimate changes to estimates of vehicle trips generated, it remains a potential source for evaluating changes in site-level development (Hagler Bailly Services, Inc. and Criterion Planners/Engineers 1999).
Although out of the scope for this study, a few models and projects have been focusing on multi-use developments which tend to have increased levels of internal-capture due to the close proximity and design of such developments.

Recent research has been working to improving the estimates of internal trip capture at mixed-use developments. NCHRP Report 684, “Enhancing Internal Trip Capture Estimation for Mixed-Use Developments”, identifies of mixed-use development characteristics that affect the level of internal capture trips. The report also investigates data collection frameworks and protocols to develop reduction rates based on internal capture levels. For mixed-use sites, this method has been shown improve accuracy reducing error from observed rates from 35-59% using ITE methods to 13% using the provided method (Bochner, et al. 2011). As with the research discussed earlier, this research only applies to multi-use development sites, not locations within areas of high mixed-use.

There are also two models, MXD model (Fehr & Peers) and the 4D model (Environmental Protection Agency - EPA) which account for elasticities and impacts of contextual factors like density and diversity when predicting vehicle demand. Both models can be applied universally and do not require local data collection. Research suggests that the use of the MXD model may result in a 26% error compared with actual surveyed counts, compared with a roughly 40% error using *ITE Trip Generation Handbook* rates and a 32% error using *ITE Trip Generation Handbook* rates and reductions (Walters, Statewide Improvements of Tools for Regional & local Smart-Growth Planning 2009). The San Diego Association of Governments have utilized the MXD model to determine “smart growth” vehicle trip generation rates that are better suited for the local region, including some application on multi-use and internal capture at sites such as transit-oriented developments. One study suggests that use of the MXD model and application of local households travel survey data provides reductions in error from 29% to 9%, compared to locally derived vehicle trip rates (San Diego Association of Governments (SANDAG) 2010).

Additionally, in progress is the NCHRP 8-66 Project, *Trip-Generation Rates for Transportation Impact Analyses of Infill Developments*, which aims to:

> "develop an easily applied methodology to prepare and review site-specific transportation impact analyses of infill development projects located within existing higher-density urban and suburban areas. For the purposes of this study, "methodology" refers to trip-generation, modal split, and parking generation. The methodology will address both daily and peak-hour demand for all travel modes."

There are alternative methodologies to adjust *ITE Trip Generation Handbook* rates, but as of yet, none have shown to deliver consistent results (Lee, et al. 2011). Additionally, no research has been done in the Portland area alone to address the local adjustment of vehicle trip generation rates.

2.3 TRAVEL BEHAVIOR IN URBAN CONTEXTS

This section reviews the literature on travel behavior and the built environment as it pertains to urban context. Recognizing that this is a vast literature, we focus on a few meta-studies and emphasize vehicle trips and mode choices, rather than vehicle miles traveled. We seek to identify the built environment characteristics that relate to contextual definitions and are associated with reduced automobile traffic and greater non-automobile travel.

2.3.1 Built Environment

This section introduces built environment attributes that are shown in the literature to have a significant impact on automobile trips. These elements of the built environment are often grouped into categories reflecting the "D's of development": Density, Diversity, Design, and Distance to Transit (Cervero and Kockelman 1997, Ewing and Cervero 2001). This section is categorized as such.

Density

Employment and residential density both influence mode choice. One study suggests that the main benefit to greater densities is destinations become closer to origins (Lund, Cervero and Willson 2004). Another study found relevance in employment and residential density: by doubling residential density, household vehicle miles traveled may be reduced by 5%, and in some locations as much as 25% when additional factors like proximity to transit and mixed land use are also improved (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption 2009). High-density residential and employment areas also allow for easy provision of high-quality transit (those with lower service headways) because origin-destination pairs become concentrated.

Overall, the literature suggests increased density is correlated with reductions in the number of vehicle trips taken. In a synthesis of influences on the built environment, the aggregate (linear) elasticity of density and vehicle trips is -0.05, suggesting that as density increases by 10%, the number of vehicle trips decreases by 5% (Ewing and Cervero 2001).

Diversity (Land Use Mix)

Diversity, or land use mix, is measured in many ways. Simple measures include the percentage of commercial land use to total land and the percentage of single-family detached dwellings to total dwellings. More complex are measures of entropy, gravity or dissimilarity (D'sousa, et al. 2012). The results of one study suggest that although density is often used to justify the development of transit, it is the land use mix which tends to support transit use (Seskin, Cervero and Zupan 1996). In vehicle trip generation studies, areas with mixed uses tend to have greater reductions in vehicle trip generation. For example, Fehr & Peers conducted a trip generation study in Sacramento and the San Francisco Bay Area within the following mixed-use developments: (1) a medium-sized, dense suburban area; (2) a medium-sized, medium/high density downtown area with high employment; and (3) a large, low density, suburban residential area. They found that the downtown area (2) had roughly 12% fewer vehicle trips compared with ITE estimates. The areas in the suburbs (1) and (3), tended to have 45% fewer trips than ITE estimates. This same study calculated the internalization of trips and found that for all three mixed-use types, roughly 30%, 25%, and 7% reductions in internalization of trips compared with *ITE Trip Generation Handbook* was possible even at low densities when mixed land uses are present (Samdahl 2010).

Another study found that the greater density of discretionary businesses located within an area promotes non-motorized trips, and land use mix measured within a quarter mile of a traveler's residence tends to be correlated with additional observed reductions in motorized discretionary travel (Guo, Bhat and Copperman 2007). In a 2001 synthesis, the aggregate (linear) elasticity of diversity or mix and vehicle trips was found to be -0.03: as diversity increases by 10%, the number of vehicle trips decreases by 3% (Ewing and Cervero 2001).

Design

Design here reflects the street network within a particular area: typical measures include average block size, proportion of four-way intersections, number of intersections per area, sidewalk coverage, average building setbacks, average street widths, presence or number of pedestrian crossings, presence of street trees, street lights, street furniture, or other pedestrian-oriented amenities. The macro-scale measures here—average block size, proportion of four-way intersections, intersections per area—are characteristics that reflect street network connectivity. Micro-scale measures of street trees, street lights, street furniture, and pedestrian amenities reflect the walkability of neighborhoods.

The macro-scale design measures that describe the broader street network are typically significant in determining many travel behavior measures. Higher connectivity enables travelers to walk shorter distances to get from point A to point B. A grid street network (the pattern with the highest connectivity) allows multiple routes that are rather direct between two points, whereas a layout with cul-de-sacs and arterial roads restricts the number of possible routes and usually increases travel distance on the network. Research shows that high street connectivity (Lund, Cervero and Willson 2004) and smaller block sizes (Seskin, Cervero and Zupan 1996) are associated with transit use. Network connectivity near the residence also significantly affects the number of non-motorized trips taken by travelers (Guo, Bhat and Copperman 2007). In a synthesis of influences on the built environment, the aggregate (linear) elasticity of street network density (a design measure) and vehicle trips is -0.05, suggesting that as street network density increases by 10%, the number of vehicle trips decreases by 5% (Ewing and Cervero 2001).

Micro-scale design measures—presence of street trees, street lights, and street furniture—have positive impacts on neighborhood walkability (Lund, Cervero and Willson 2004). But, these effects are modest when compared to measures representing the other D's of development and data for these site-level measures are more difficult to gather than larger and broader built environment measures.

The design measures of sidewalk coverage and barriers to walking have been studied as they relate to transit use. Transit ridership and the amount of streets with sidewalks are positively correlated (Seskin, Cervero and Zupan 1996). The number of "conflict points" on a pedestrian route surrounding a transit station is negatively correlated to accessing transit by foot (Seskin, Cervero and Zupan 1996).

Distance to Transit

The *ITE Trip Generation Handbook* provides some guidance on typical transit accessibility reductions based on other built environment characteristics such as density and presence of pedestrian facilities. As the distance from transit increases, the ridership or demand of transit decreases. The handbook also suggests that distance to rail generates different demand than distance to bus. *ITE Trip Generation Handbook* suggests rate reductions between 5% and 20% for locations within a quarter mile of light rail or near transit centers. The *ITE Trip Generation Handbook* suggested rate reductions are 2.5% to 10% for locations within a quarter mile of bus transit corridors. The ranges of *ITE Trip Generation Handbook* reductions are due to accounting floor area ratios and mixed land uses. As floor area ratios and mixing of land uses increase, higher levels of reductions occur (Institute of Transportation Engineers 2004).

Reducing vehicle trip generation rates near transit is supported in the literature. A San Francisco Bay Area study surveyed more than 1,000 large employment sites to examine connections between commuters' use of rail and locations near stations. This study found that commuting by transit was higher at sites within one quarter mile of transit stations than it was at sites between one quarter and one half mile from stations (Dill 2003). Another study found that proximity to transit was more significant than street connectivity and other built environment measures, suggesting that proximity to transit is very important in reducing automobile mode shares (Lund, Cervero and Willson 2004). This same study also examined other factors involved with transit ridership and found that one quarter to one third of a mile is the most significant area around a transit station where mode shares are affected. These authors also found that bus headways under 15 minutes or rail headways under 50 minutes significantly affect mode shares within transit station areas (Lund, Cervero and Willson 2004). A meta-study conducted by Ewing and Cervero (2010) suggests that proximity to transit is associated with slightly fewer vehicle trips and is positively associated with walking and transit usage. These authors also found positive correlations between destination accessibility (jobs within one mile) and both automobile travel and walking. There is a slightly negative correlation between job accessibility and transit (within 30 minutes).

2.3.2 Area Types

The previous review of built environment measures relating to travel behavior has focused on individual measures independently. It is important to acknowledge that these measures do not stand alone in our physical environments. Rather, they interact with one another and characterize different places and neighborhoods. These interactions and resulting types of places are what planners and practitioners seek to encompass when categorizing the built environment into different area types, or urban contexts. Area types are typically qualitatively defined neighborhood typologies. This section explores travel behavior research as it relates to them.

Central Business District, Urban Core and Downtown Areas

The Central Business District (CBD) and Urban Core (UC) areas, defined as the core of the commercial district within the city, contain many of the built environment characteristics that are significantly correlated with reduced vehicle trips generated at establishments. Dense employment and residential populations, high accessibility to transit, pedestrian amenities, dense intersection networks (high street connectivity), and limited/paid parking work together to significantly reduce the amount of vehicle trips within these areas (Seskin, Cervero and Zupan 1996).

CBD, UC, and downtown areas are highly associated with lower vehicle mode shares. A study in San Francisco found vehicle mode shares to 3 pharmacies in UC areas between 8% and 13%, while 17 similar establishments in San Francisco suburbs had vehicle mode shares between 54% and 98%. UC locations had significantly higher land use mixes, on-street/paid parking, smaller site development setbacks, and pedestrian access (Schneider 2011). A separate study on commuting modes in the San Francisco Bay Area found that downtown stations in Oakland, Berkeley and San Jose had the highest use of commuter rail (Dill 2003).

Walking tends to have a greater mode share in CBDs. For commuting trips, research in Chicago and San Francisco found that almost all residents in CBD areas walk to their destinations instead of driving or taking transit (Seskin, Cervero and Zupan 1996).

Transit-Oriented Development

Travel behavior in and near Transit-Oriented Developments (TODs) or Transit-Oriented Areas (TOAs) has been researched extensively to assess the effectiveness of implementing smart growth TOD policies. By definition, TODs include a transit center or station with high density and mix of residential and employment land uses within a quarter to a half mile of the station. These areas are developed in an effort to reduce automobile travel. The research on TOD design is inconclusive in finding the best combination of the built environment measures, such as land use mix, density and pedestrian amenities, to minimize vehicle trip generation. The TOD literature identifies residential and employment densities, pedestrian amenities and connectivity, accessibility to transit, high-quality transit, and trip purpose as having influence on vehicle mode shares.

Traffic impact studies have shown that ITE vehicle trip generation rates at rail TODs are overestimated by up to 50% (Cervero and Arrington 2008b). The same research shows that implementing TOD can decrease residential vehicle trips to an average of 44% below *ITE Trip Generation Handbook* estimates.

But, not all developments near transit have the same effects on travel. Transit-Adjacent Developments (TAD) are places near transit that are not necessarily designed to capitalize on that proximity. They typically lack pedestrian connectivity to transit and tend to have vehicle-oriented design characteristics. TADs show significantly smaller reduction in vehicle mode shares compared with TOD locations (Renne 2005).

Some research has investigated whether transitioning suburban areas into TODs is effective at reducing vehicle travel. A Toronto, Canada study found that increasing transit accessibility and residential density over 25 years lowered the automobile-driver share of A.M. peak period trips 6% increased transit use 4%, and increased non-motorized mode share 2% (Crowley, Shalaby and Zarei 2009).

The built environment factors identified in the literature as significant in reduced vehicle travel at TODs are the following: residential density (Renne 2005, Crowley, Shalaby and Zarei 2009), proximity to employment (Lund, Cervero and Willson 2004), pedestrian access (Dill 2008, Crowley, Shalaby and Zarei 2009), land use mixing (Lund, Cervero and Willson 2004), parking costs at the site (Cervero and Arrington 2008a), transit service frequency (Cervero and Arrington 2008a), and trip purpose (Dill 2008). Excluding the latter three, all of these factors are encompassed in the D's of development identified in the built environment and travel behavior literature. Clearly, there is agreement in the TOD literature and the built environment literature on the measures associated with reduced vehicle travel.

Mixed-Use Developments

Mixed-Use Developments (MXD) are defined in the *ITE Trip Generation Handbook* as having more than two land uses, typically planned as a single real-estate project between 100,000-2,000,000 square feet in size with some trips between on-site land uses, and not located on major streets (Institute of Transportation Engineers 2004). No part of this definition includes access to transit for mixed-use developments. One of the main phenomena observed in MXD areas include internal capture, the ability to perform multiple activities at a single development due to the close proximity to a variety of land uses and potentially greater pedestrian amenities. Internal capture is a critical issue to the *ITE Trip Generation Handbook* methodology because vehicle trip rates are typically estimated for each individual establishment and not the entire site; if people instead make one trip to the site and then walk to multiple establishments within the site then *ITE Trip Generation Handbook* estimates will over-predict vehicle trips.

Research has attempted to address this issue, but at this point in time is not comprehensive. Internal capture rates at mixed-use developments along the MAX corridor in Portland, Oregon were found to be between 2% and 20% of all trips to or from retail establishments during the PM peak hour and between 4% and 28% of all daily trips to or from retail (Lapham 2001). Another project—NCHRP 8-51, "Enhancing Internal Trip Capture Estimation for Mixed-Use Developments"—provides a method to estimate internal capture rates based on site characteristics and urban context. This research found that the highest levels of internal capture were at sites with diverse and balanced land use mixing, compact (or dense) development, and high connectivity between establishments, providing further agreement with the built environment measures identified in section 2.3.1.

Suburban City Centers and Corridors

ITE Trip Generation rates are typically collected at suburban-type locations (Institute of Transportation Engineers 2004), but evidence suggests that even these locations are difficult to estimate with accuracy. Table 2-1 shows the actual vehicle trips seen in developed suburban city centers range from 5 to 37% below ITE estimates. Medium-density suburban locations near transit corridors with small parcels and low single-family housing percentages tend to promote walking and biking of shorter trips (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption 2009). Only the most suburban and vehicle-oriented sites are estimated accurately with ITE methods.

2.4 SUMMARY

From the evaluation of *ITE Trip Generation Handbook* methods and excluding the most suburban and automobile-oriented sites, we see that there does not appear to be any area type in which vehicle trip generation rates are well estimated. Vehicle trip rates are consistently over-predicted by ITE, necessitating further investigation in area types other than highly suburban sites.

Alternatives to the *ITE Trip Generation Handbook* methodology exist. Many jurisdictions provide recommendations to their regions to develop local rates as alternative to ITE, but their requirements across jurisdictions are not consistent. Other methods and models are being developed and refined to address ITE's shortcomings, but as stated by the authors of a recent evaluation the available smart growth trip generation methodologies, "no clear 'winner' emerges among currently available methods" (Lee, et al. 2011). These methods and models are typically focused on either mixed-use development, air quality, or infill development.

A vast body of research informs us that the built environment is significantly related to travel behavior. The D's of development—measures of density, diversity, design, and distance to transit—are most related to reduced automobile travel. Area types, or urban contexts, encompass many individual built environment together to categorize places, and they are also significantly related to levels of automobile travel. The literature shows that places in central business district, urban core, and downtown areas tend to have the lowest levels of automobile mode shares and the greatest differences to ITE rate estimates. Urban contexts also encompass development patterns like mixed-use, TOD, and infill, and provide a means to analyze these patterns and individual built environment measures together.

In this study, we present a method to adjust *ITE Trip Generation Handbook* rates based on urban context. The model presented is based on an extensive data collection effort at 78 establishments in the Portland, Oregon region. An adjustment model to *ITE Trip Generation Handbook* rates based on context is useful in many ways. A model of this type provides an off-the-shelf alternative to *ITE Trip Generation Handbook* rates that accompanies and improves upon other alternatives introduced earlier in this literature review. It also contributes an evaluation of *ITE Trip Generation Handbook* rates to existing establishments in the Portland region. By focusing on context, built environment measures, both individual measures and combinations of them, can be assessed for impacts on travel behavior to provide a contribution to that body of knowledge. The model effectively develops a local rate to the Portland region for the land uses studied. This method also provides a basis for other regions to develop adjustments to ITE based on local urban contexts. The study design underlying the method is presented in the next chapter, followed by a comparison to ITE rates and an analysis that introduces the model.

3.0 DATA & METHODS

This chapter presents the study design, data collection processes, and sample used to develop an adjustment method to ITE vehicle trip rates based on area type. Data were collected in 2011 from June through early October. Because of the relatively small sample size, we controlled for weather by only collecting data on days with favorable conditions. Data collection events occurred from 5:00PM to 7:00PM on Mondays, Tuesdays, Wednesdays, and Thursdays, as they are considered “typical” travel days. The 5:00PM to 7:00PM time window was chosen to overlap with ITE’s Trip Generation weekday, peak hour (4:00PM to 6:00PM) as well as the peak hour of generators for some land uses. According to many store managers, most restaurants do not experience much visitor traffic during the 4:00PM to 5:00PM hour.

Information collected at each location included: (1) visitor intercept surveys, including socio-demographic status and travel information; (2) counts of persons entering and leaving the establishments and of automobiles leaving (where possible); (3) establishment information, including site-specific attributes such as gross square footage, number of employees, parking capacity, and other site design characteristics; and (4) archived information about the built environment.

The chapter is organized as follows:

1. Survey site selection, establishment types, and definitions of area types
2. Survey instrument design and sample description
3. Count data collection methods and sample description
4. Built environment data

Data collected from this study are then compared to ITE Trip Generation Manual information to form the basis of a method to adjust ITE rates locally.

3.1 SITE SELECTION & ESTABLISHMENT TYPES

To analyze trip generation at different types of urban environments, establishments were included in the study based on characteristics of their surrounding built environment. Environmental variables were included in the sampling analysis[4] to ensure that selected sites represented the entire spectrum of the urban landscape found in the Portland metropolitan region. Five unique classifications of area type resulted:

- Central Business District neighborhoods (near downtown Portland)
- Urban Core neighborhoods (e.g. inner Northeast and Southeast Portland neighborhoods)
- Neighborhood and Regional Centers (similar to Regional Centers defined by Metro)
- Suburban Town Centers and Corridors (typically areas farther from the Central Business District but more densely developed than suburban residential areas)

[4] K-means clustering analysis was performed with the statistical package of R on built environment measures to classify area type. Variables in the cluster analysis include intersection density, block size, percent of dwellings that are single-family detached, percent of employment that is retail and percent of parcel lot coverage by buildings.

- Suburban Areas (the least densely developed areas)

Individual establishments from each of the five different area types were recruited to participate in the study. Oversampling of establishments was done in more urban area types (Central Business District, Urban Core, Neighborhood/Regional Centers) as we hypothesize that these are likely to have greater non-motorized and transit trips. We anticipate that establishments in more automobile-oriented area types (Suburban Town Centers, Suburban Areas) have higher automobile mode shares and trip rates similar to those found in the ITE manual. Agreement with ITE rates requires fewer observations (a smaller sample size) to support statistical analyses.

Given the resource limitations for this study, only a few ITE land use types are examined. Land uses chosen for the study include a) Land Use 932: High-Turnover (Sit-Down) Restaurants (pizza and Mexican restaurants were used in this study), b) Land Use 851: Convenience Markets (Open 24-Hours) without gas stations and c) Land Use 925: Drinking Places. These land use types were chosen because they are found throughout the region in all area types and are common in areas where vehicle trip overestimation is most problematic: urban infill, mixed-use, and TODs.

Most establishments in the study are regionally owned and operated franchises. Local establishments are overrepresented in the sample because they were more willing to participate than national corporate franchises. This potentially creates limitations in the study: establishments were generally smaller (most under 3,000 sq. ft. gross floor area) and may cater to a different market segment than those patrons of national chains. Table 3-1 summarizes the number of establishments that participated in the study. Figure 3-1 shows the spatial distribution of the 78 survey establishments throughout the Portland region and illustrates how area types change from more urban to more suburban as distance from the Central Business District increases.

Table 3-1. Establishments Surveyed by Area and Land Use Type

Area Type	# Restaurant Locations	# Convenience Locations	# Bar Locations	Total
Central Business District	12	4	3	19
Urban Core Neighborhoods	10	5	6	21
Neighborhood and Regional Centers	6	6	4	16
Suburban Town Centers	5	7	0	12
Suburban Areas	6	4	0	10
Total	39	26	13	78

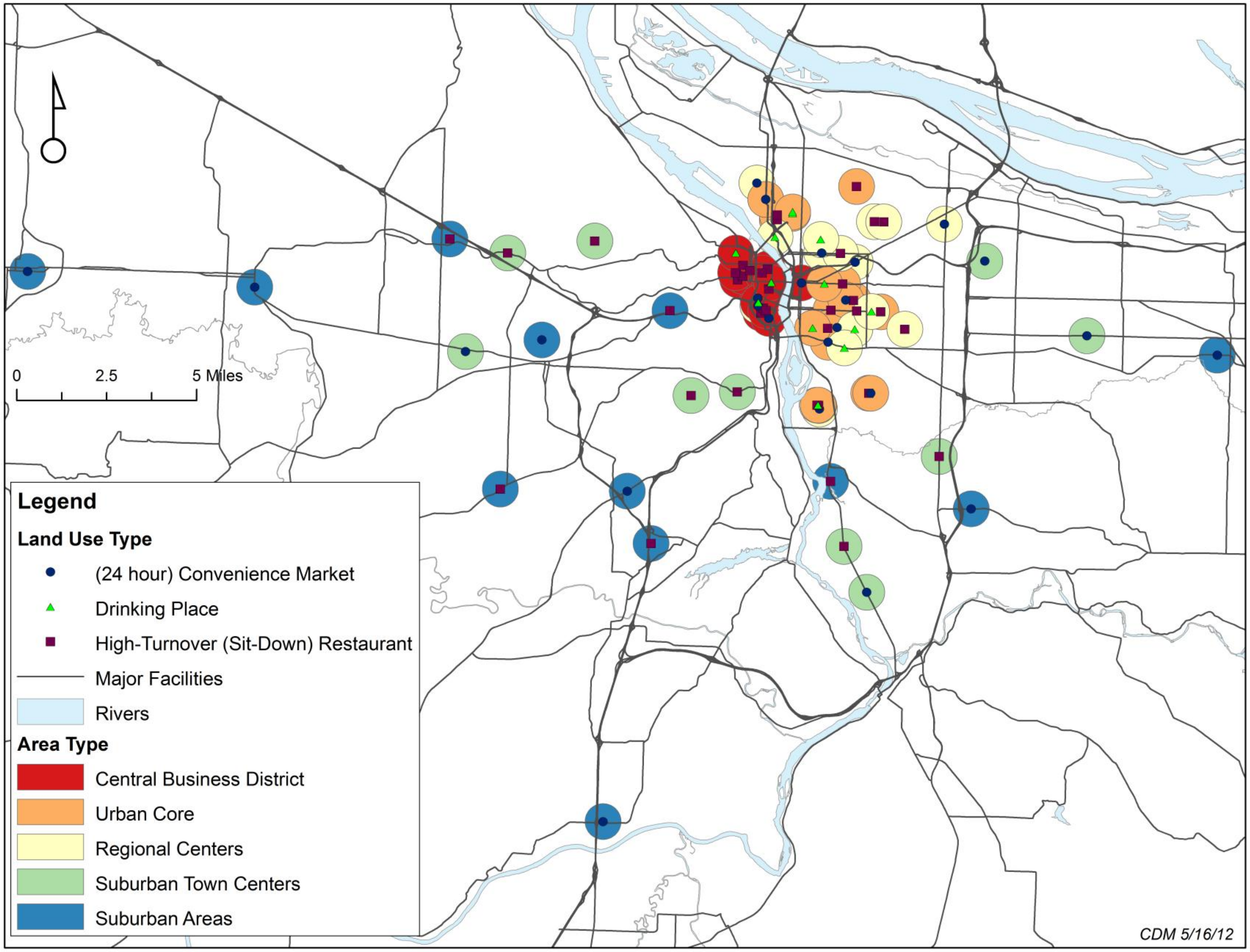

Figure 3-1. Locations of Survey Establishments

3.2 SURVEY DATA

This section details the methods used for survey data collection and provides a description of the survey sample. The surveys were administered by intercepting visitors as they leave the establishment. Two survey options were offered to visitors: (1) a five-minute survey administered via handheld computer tablets, and (2) a shortened version of just four questions. The five-minute survey collected information on demographics, travel mode(s), consumer spending behavior, attitudes towards transportation modes, the trip to and from the establishment, and map locations of home and work. Appendix A contains a paper version of the five-minute survey instrument.

The short survey was offered as an alternative to visitors refusing the five minute survey. It does not collect as much detailed information, but it does help obtain a larger sample. This survey collected four pieces of information: mode of travel, amount spent on that trip, frequency of visits to the establishment, and the respondent's home location. Gender was recorded by the survey administrator. See Appendix B for the short survey instrument.

3.2.1 Sample Description

An average of 24.2 surveys was collected at each establishment, for a total of 1884 surveys (697 long surveys and 1187 short). The overall response rate was 52% for all surveys. More detail on sample size is provided in Table 3-2.

Table 3-2. Survey Sample Size

Land Use	Establishments (N)	Long Surveys (N)	Short Surveys (N)	Response Rates		Total
				Long Survey	Short and Long Survey	
Drinking places	13	107	108	30%	50%	215
Convenience	26	281	710	14%	61%	991
Restaurants	39	309	369	24%	52%	678
Total	78	697	1187	19%	52%	1884

Table 3-3 shows the demographic information of long survey respondents. In addition, the sample demographic characteristics are compared to Census and 2010 3–year American Community Survey (ACS) data for the Portland metropolitan statistical area. Household income, vehicle ownership, and household size are closely aligned with Census information. Men and younger people were slightly overrepresented in our sample.

Table 3-3. Survey Demographics Compared to U.S. Census Data

Variable	Survey observed*	2010 Census/ACS Portland (MSA)
Median household income per year	$50,000 - $99,000	$55,618
Average household income per year	$50,000 - $99,000	$72,200
Median Age	25-34	36
Male respondents	57%	49%
Average # vehicles per household	1.6	1.7
Average # bicycles per household	1.7	NA
Average # transit passes per household	0.5	NA
Average # adults per household	2.2	NA
Percentage of households with children	29%	33%
Average household Size	2.5	2.5

*Note: demographic data from long survey only. N = 697

Mode share

Table 3-4 shows automobile mode share is consistently higher in suburban areas than in more urban settings. Automobile mode share decreases as locations become more urban. Note that no drinking places were surveyed in suburban locations.

Table 3-4. Automobile Mode Share

Area Type	Drinking Place	24-hour Convenience Store	High Turnover (Sit-Down) Restaurant
Central Business District	26%	34%	35%
Urban Core	46%	51%	64%
Regional Centers	52%	60%	70%
Suburban Town Centers	N/A	70%	85%
Suburban Areas	N/A	72%	86%

Table 3-5 shows mode shares in more detail. Higher proportions of walking and bicycling occur at establishments in the Central Business District, Urban Core, and Regional Center area types than in suburban area types. Transit mode shares are highest in the Central Business District, but there is not as consistent a trend in transit mode shares between urban to suburban area types as there are trends with other travel modes. Non-automobile mode shares appear highest in the areas of the region that offer the most variety of convenient travel choices.

Table 3-5. Percent Mode Shares by Area Type and Land Use

Area Type & Land Use	Automobile Mode Share	Walk Mode Share	Bicycle Mode Share	Transit Mode Share
Convenience	58%	27%	7%	6%
Central Business District	34%	49%	10%	10%
Urban Core	52%	31%	9%	6%
Regional Centers	60%	26%	7%	5%
Suburban Town Centers	70%	18%	3%	7%
Suburban Areas	72%	14%	8%	3%
High-turnover Restaurant	63%	22%	8%	6%
Central Business District	35%	42%	7%	16%
Urban Core	65%	20%	13%	2%
Regional Centers	70%	24%	6%	1%
Suburban Town Centers	85%	6%	1%	6%
Suburban Areas	86%	5%	0%	8%
Drinking Place	43%	27%	22%	7%
Central Business District	26%	40%	19%	15%
Urban Core	46%	20%	25%	8%
Regional Centers	52%	30%	18%	1%
Suburban Town Centers*	N/A	N/A	N/A	N/A
Suburban Areas*	N/A	N/A	N/A	N/A
Overall	58%	25%	9%	7%
Central Business District	34%	43%	9%	14%
Urban Core	57%	23%	15%	5%
Regional Centers	61%	26%	10%	3%
Suburban Town Centers	79%	11%	2%	7%
Suburban Areas	78%	10%	5%	5%

*Drinking places were not surveyed in suburban area types

Figure 3-2 shows the resulting automobile mode share for all establishments surveyed in a spatial context. As shown, automobile mode shares are generally lower in establishments closer to the city center. There is variation in automobile mode share in the inner east side of Portland where area type varies between Urban Center and Neighborhood/Regional Center. For a more detailed map of mode shares of survey establishments, see Appendix D.

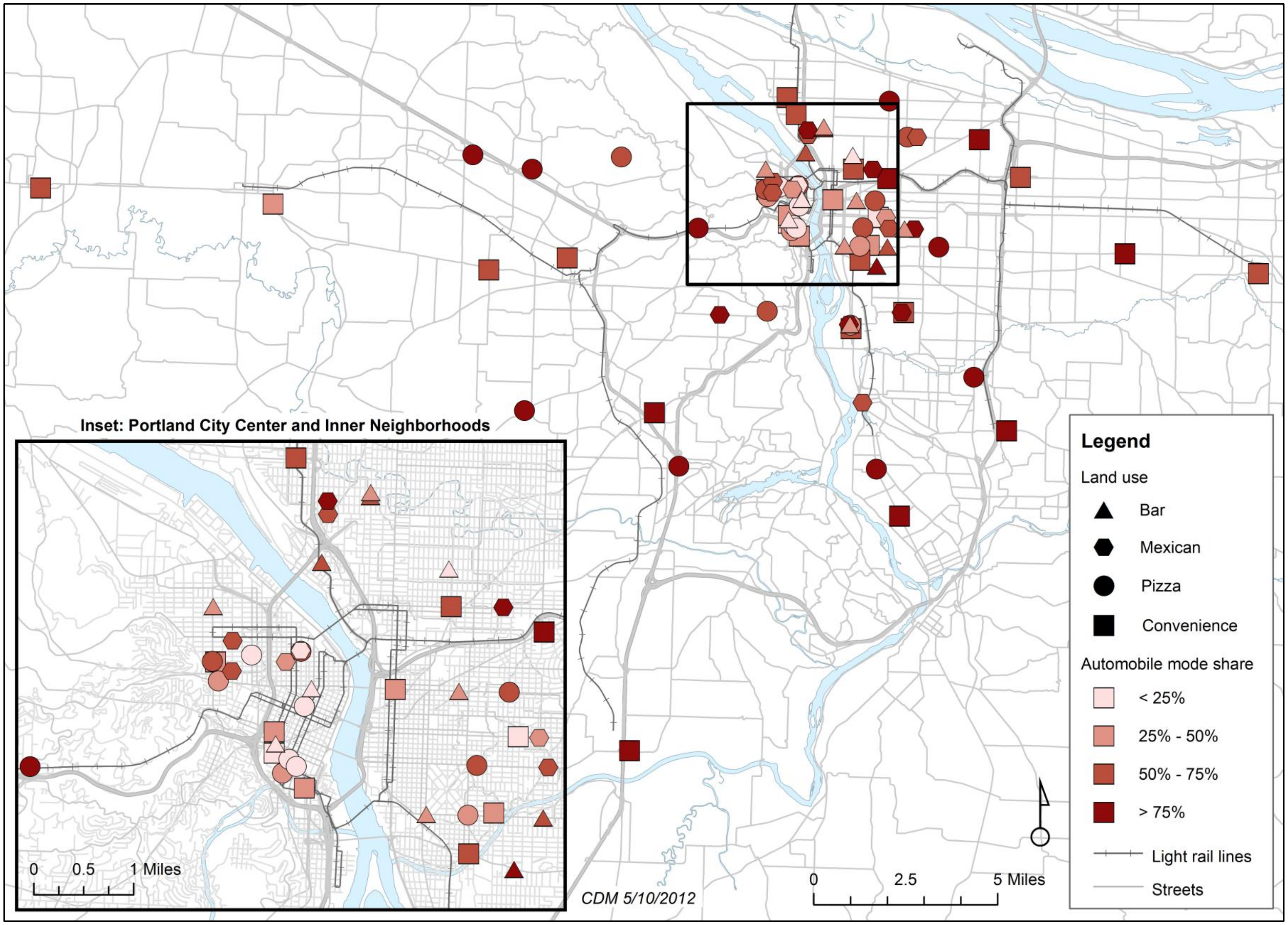

Figure 3-2. Automobile Mode Share of Survey Establishments

Vehicle occupancy

Table 3-6 shows the average observed vehicle occupancy from long survey responses tabulated by land use and area type. Convenience stores had the lowest vehicle occupancy and high-turnover restaurants had the highest. There appears to be little variation in vehicle occupancy across area types.

Table 3-6. Average Vehicle Occupancy from Long Survey

Area Type	Drinking Place	24-hour Convenience Store	High Turnover (Sit-Down) Restaurant
Central Business District	1.5	1.0	1.8
Urban Core	1.5	1.1	1.8
Regional Centers	1.8	1.3	1.8
Suburban Town Centers	N/A	1.2	1.5
Suburban Areas	N/A	1.1	1.8

Sample Comparison to Regional Data

Vehicle occupancy and automobile mode share data collected from the survey are compared to data from another regional survey of travel behavior, the Oregon Household Activity Survey (OHAS). Table 3-7 and Table 3-8 show that automobile mode shares and vehicle occupancies observed in this study are lower than those observed in OHAS data.

Adjustment for potential survey bias was not applied to the survey sample. OHAS data are collected at the households of participants, unlike data from this study that are collected at establishments.

Table 3-7. OHAS Comparison: Automobile Mode Share

Land Use	TGS Data	Oregon Household Travel Survey Data (OHAS, 2011)[5]
Convenience Market (Open 24-Hours)	58.5%	84.8%
High-Turnover (Sit-down) Restaurant	62.9%	79.0%
Drinking Place	43.3%	79.0%

Table 3-8. OHAS Comparison: Vehicle Occupancy

Land Use	TGS Data	Oregon Household Travel Survey Data (OHAS, 2011)[5]
Convenience Market (Open 24-Hours)	1.2	1.6
High-Turnover (Sit-down) Restaurant	1.8	2.0
Drinking Place	1.6	2.0

[5] OHAS Trip purpose comparing Convenience Market (Open 24-hours) includes "Routine Shopping (Groceries, Clothing, Convenience Store, Household Maintenance)". OHAS trip purpose comparing High-Turnover (Sit-down) Restaurants and Drinking Places is aggregated by "Eat Meal Outside of Home" trip purposes.

3.3 COUNT DATA

This section details the methods used to collect person trip counts and vehicle trip counts from establishments. It also describes the resulting trip count data.

3.3.1 Method

Surveyors counted persons entering and exiting the establishment at every entrance to the store. The number and gender of people refusing to participate in the survey was recorded in order to later calculate response rate and bias in the survey data. Counts of vehicles and bicycles exiting the site were recorded when feasible (typically when the site had parking adjacent to the store entrance). Vehicles and bicycles were only counted when exiting because many establishments were in shopping centers and mixed-use developments. Counting vehicles entering a mixed-use development site could potentially introduce error from counting vehicles that went to non-survey establishments. By counting vehicles and bicycles exiting, we ensure that these trips came to the site before leaving.

3.3.2 Sample description

Observed person trips exiting establishments varied across establishment types. In Figure 3-3 we see that convenience stores had the highest person trip rates of any particular land use type. We can also see that visitor traffic appears to be greater during the 6-7 PM hour than visitor traffic during the 5-6 PM hour for all land uses except convenience stores.

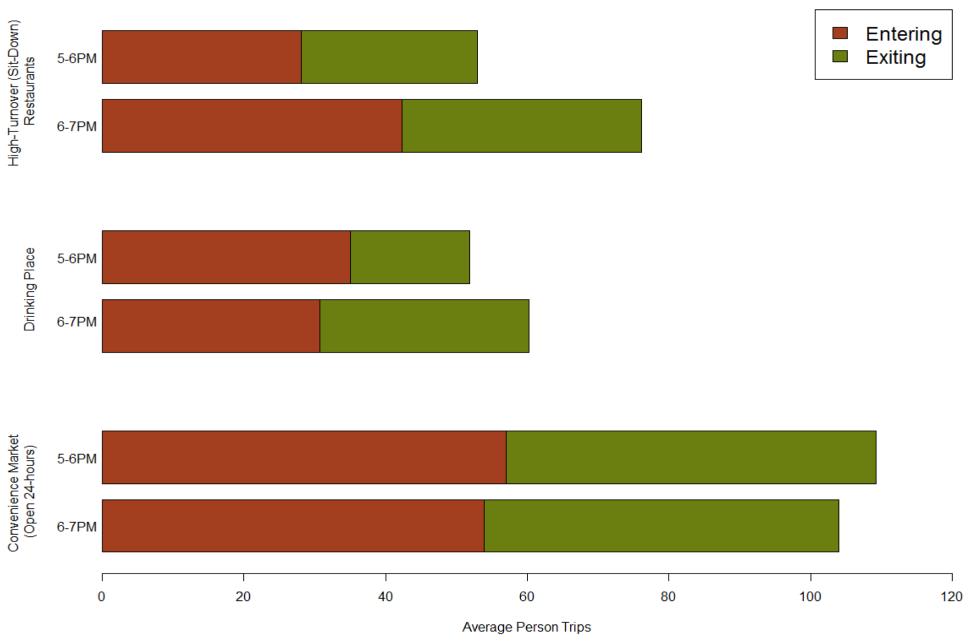

Figure 3-3. Observed Person Trips by Establishment Type

Figure 3-4 shows the mean observed vehicle trips exiting different establishment types. Vehicle trips do not appear to vary substantially between the 5-6 PM and 6-7 PM hours. We see that convenience stores have the most observed vehicle trips on average. Exiting vehicle trip counts were obtained for just 44 of the 78 establishments studied. Many study sites, especially those in urbanized neighborhoods, contained on-street and complex parking situations and did not allow vehicle counts to be obtained during data collection.

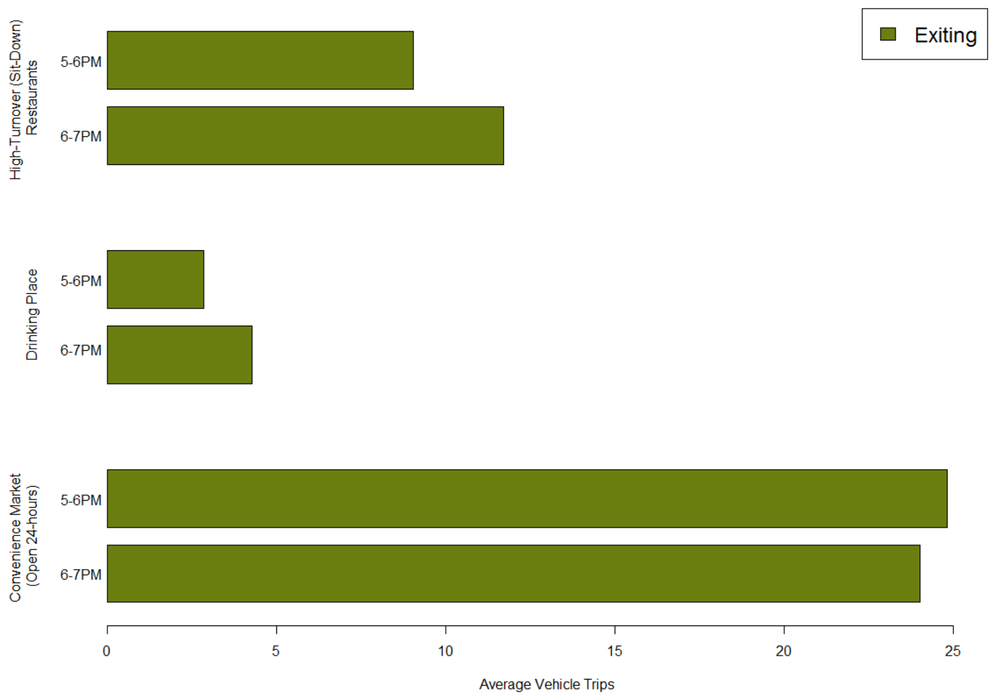

Figure 3-4. Observed Vehicle Counts by Establishment Type

Table 3-9 shows a summary of person and vehicle trips aggregated to land use. The survey locations were on average not very big (most between 1800 and 3200 square feet in area). Convenience stores had the most visitor traffic during the 5:00 – 7:00 PM hour.

Table 3-9. Observed Person and Vehicle Trip Counts by Land Use Type

ITE Land Use		Convenience Market (Open-24 Hours)		Drinking Place		High-Turnover (Sit-Down) Restaurant	
ITE Land Use Code		851		925		932	
Sample Size (N)		26		13		39	
		Mean	*Std. Dev.*	Mean	*Std. Dev.*	Mean	*Std. Dev.*
Average Gross Floor Area of Establishment (Sq. Ft.)		2529	*278*	3197	*2881*	1747	*871*
Person Trips	Enter	57.0	*29.6*	35.0	*15.3*	28.1	*18.2*
	Exit	52.3	*29.2*	16.8	*5.6*	24.9	*12.0*
Vehicle Trips	Exit	48.8	*21.4*	7.1	*9.4*	20.8	*18.9*

3.4 BUILT ENVIRONMENT DATA

Built environment information was gathered directly from the establishment sites and from archived data sources in order to support our analysis of context. The archived information was collected within a ½ mile radius (Euclidean distance) from each establishment point, hereby referred to as the establishment buffer. The measures that were included in this study are described below in more detail.

3.4.1 Establishment information

Site-level characteristics were collected during field data collection events. These characteristics include vehicle parking spaces, parking configuration, and site amenities for pedestrians and cyclists. Building square footage was collected from business managers at the establishments and through Google Earth.

3.4.2 Metro Context Tool

The Context Tool, developed by Metro, is a set of GIS raster indices[6] of built environment dimensions including: bicycle access, people per acre (population and employment density), transit access, urban living infrastructure (ULI), sidewalk density, and block size. Each individual raster index, or indicator, is a component of the larger Context Tool. Only the Context Tool ULI Indicator is used in the analysis presented here. Other built environment measures used in this study are described in the next section.

ULI serves as a measure of the density and diversity of retail and service destinations. Figure 3-5 illustrates the Context Tool ULI Indicator across the Metro region. The measure is based on the different retail and service land uses that accommodate everyday non-work living needs[7]. The ULI Indicator increases as the number of these business types nearby increases. The highest ULI values are in places like downtown Portland, where many different retail and service establishments exist in close proximity.

The Context Tool ULI Indicator is developed by calculating the densities of retail and service businesses within a ¼-mile of each raster cell and then classifying them into a one through five index. Classification is performed using Jenks' natural breaks algorithm, a method typically used to display data on chloropleth maps. The method finds actual breaks in the data instead of using an arbitrary classification scheme like equal intervals. The range of observations comprising each index value varies as a result.

[6] Rasters are calculated using Kernel Density Tool (1/4 mile distance) in Spatial Analyst Toolbox in ArcGIS 10.

[7] Business types in the ULI Context Tool (and corresponding NAICS 2007 codes) are the following: retail bakeries (311811), breweries (312120), nursery/garden/farm supply stores (444220), supermarkets and other grocery (except convenience) stores (445110), other specialty food stores (445299), beer/wine/liquor stores (445310), men's clothing stores—men's, women's, children and infants, family (448110, 448120, 448130, 448140), sporting goods stores (45110), bookstores (451211), department stores (except discount department stores) –but only including large supermarket-type department stores (452111), gift/novelty/souvenir stores (453220), motion picture theaters (except drive-ins) (512131), child day care services (624410), fitness/recreational sports centers (713940), drinking places (722410), full-service restaurants (722110), limited-service restaurants (722211), cafeterias/grill buffets/buffets (722212), snack and nonalcoholic beverage bars (722213), and dry cleaning and laundry services (except coin-operated) (812320).

Figure 3-6 provides an example. Business densities around establishments, the underlying calculation of ULI, are plotted against vehicle trip rates at establishments. The ULI of survey establishments is shown in the shaded background of the plot. This chart illustrates an increased range in business density as the ULI score increases. Only two establishments have a ULI of 5 and are located in the central business district of Portland. Many locations have ULI values of 2, 3, and 4. Figure 3-5 also provides an example: very few areas in the Metro region besides downtown Portland have ULI values of 5 and the majority of the region has a ULI of 1. Most areas with ULI values 2, 3, and 4 are located along major corridors and town centers.

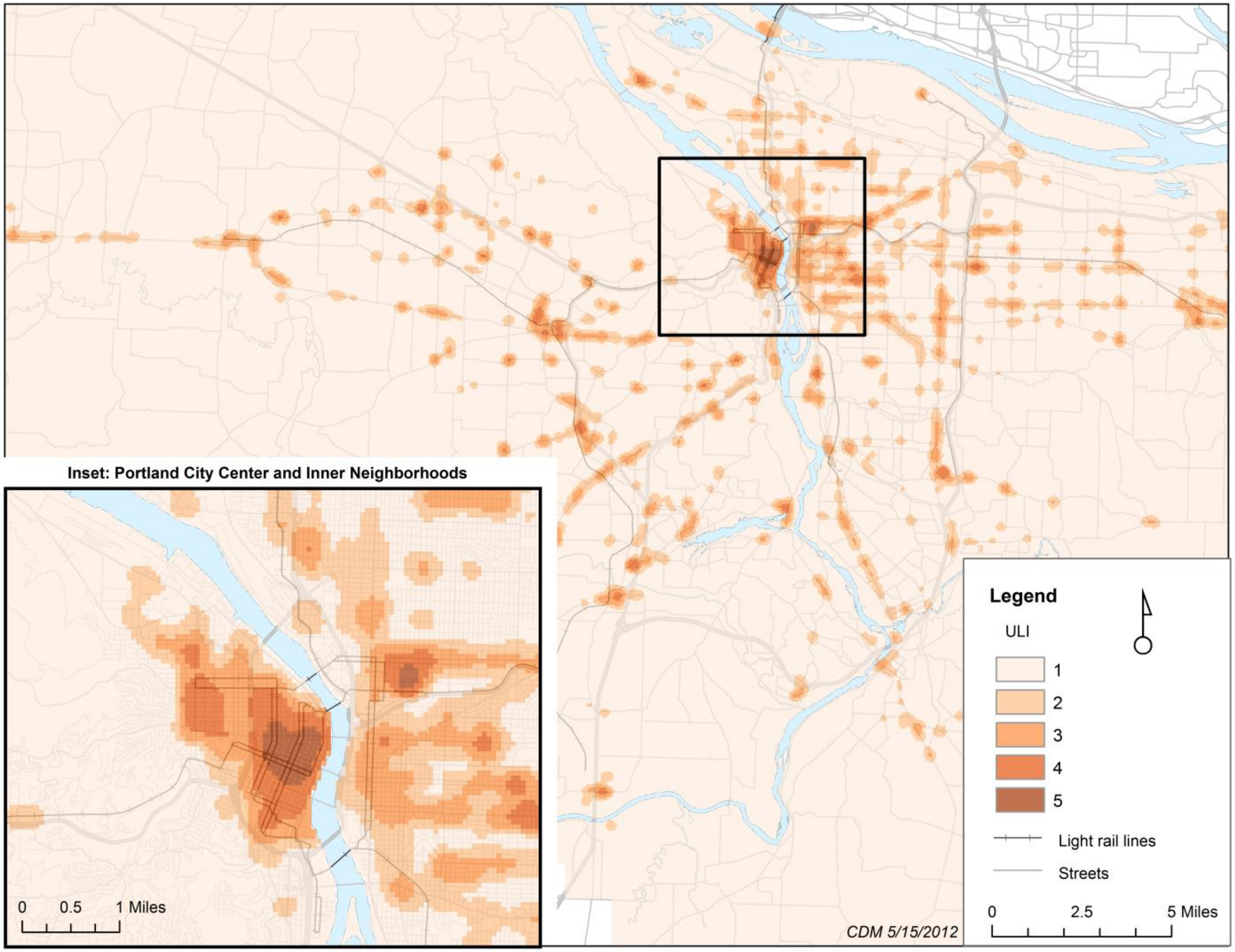

Figure 3-5. Urban Living Infrastructure Context Tool

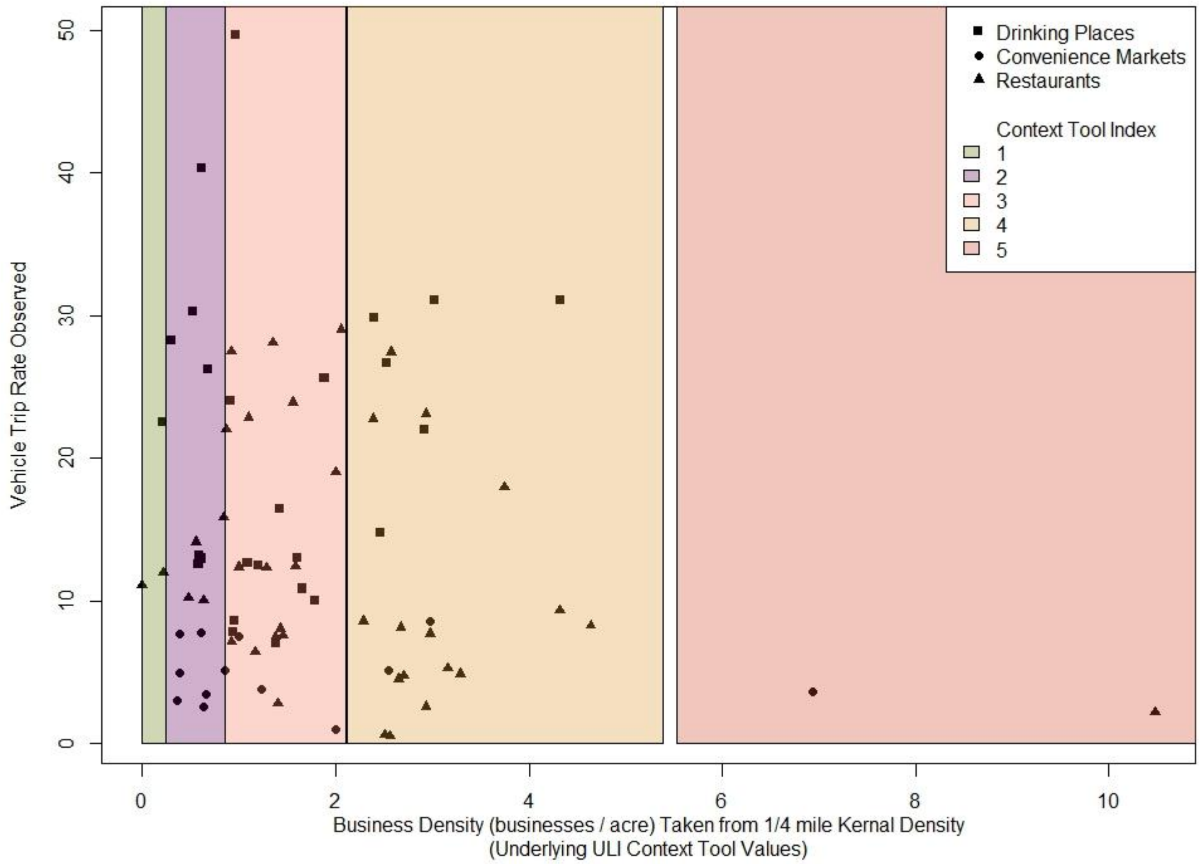

Figure 3-6. Context Tool Index Ranges and Observed Vehicle Trip Rates: ULI Business Density

We use ULI in our analysis by calculating the average ULI score within a half mile radius of the establishment. This average provides a representation of area surrounding the establishment. An example is illustrated in Figure 3-7. The ULI score found at this establishment point is 3, while the average ULI score within the establishment buffer is 2.19.

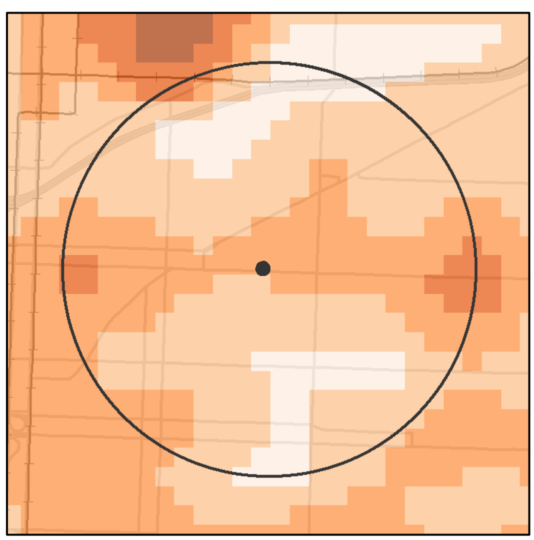

Figure 3-7. Example Establishment with ½-mile Buffer and ULI Context Tool

ULI is also highly correlated with other built environment attributes that are associated with higher rates of non-automobile travel, such as measures of density, street configuration, block size, bicycle and pedestrian networks and transit service. As such, ULI is an indicator of the character of a particular neighborhood: a place with a high ULI score is very likely to also have a more gridded street network with small blocks, higher densities of housing and employment, higher-quality transit access, and amenities that make walking and cycling more convenient. Figure 3-8 shows the observed mode shares within average ULI ranges of survey establishments. Clearly, ULI is strongly associated with non-automobile travel. Establishments with the highest ULI scores have the highest proportion of people who walked. Additionally, transit appears to have a greater mode share for those locations with a ULI of 3, areas often located along corridors and neighborhood centers.

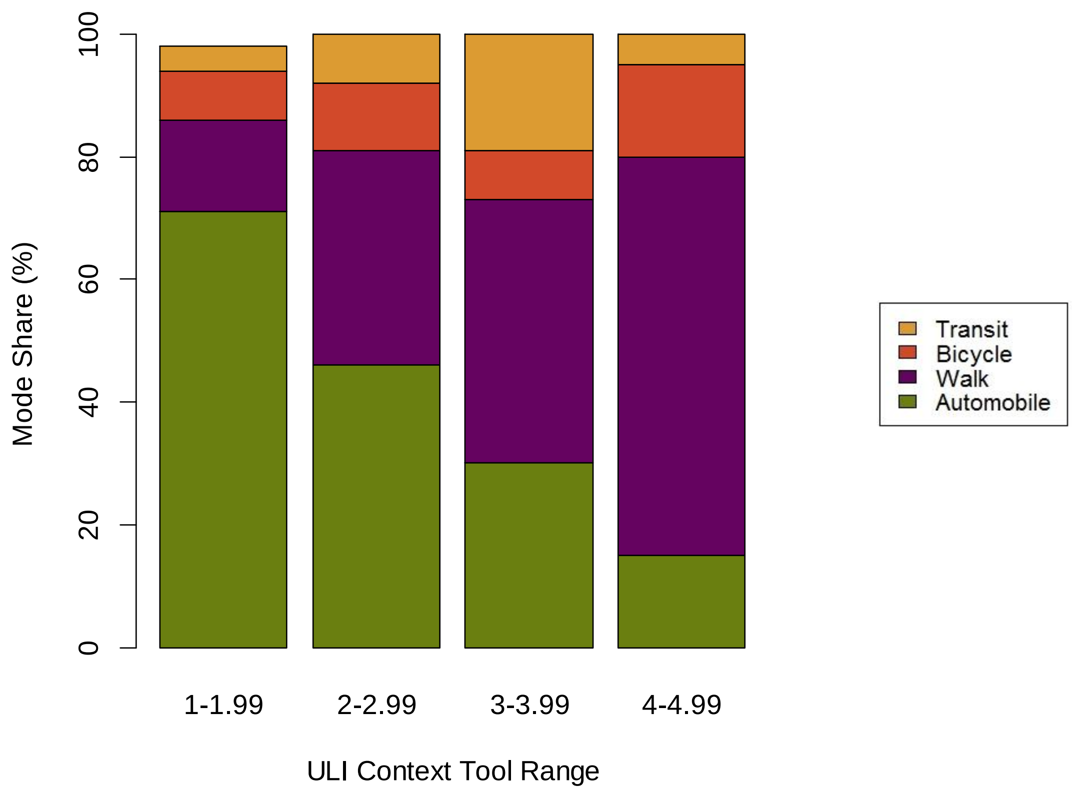

Figure 3-8. Average Mode Share by ULI Range (Metro Context Tool)

3.4.3 Other built environment data

In addition to the ULI measure discussed previously, several additional built environment features that are influential in travel choices were considered in our analysis. These built environment features were also measured at a ½ mile buffer around each establishment.[8] These measures are listed in Table 3-10 and are described below.

[8] Water features were excluded from all calculations when water fell within the ½ mile buffer

Table 3-10. Built Environment Measures List and Data Source

Measure	Units	Data Source*	Average	Range		
Number of Transit Corridors	Number of transit bus/rail lines within ½-mile	Light-rail and Bus Stop layer (RLIS, 2010)	24	0	to	112
People Density	Residents and employees per acre	ESRI Business Analyst (2010) and Multifamily/Household layers (RLIS, 2010)	34	7	to	164
Number of High-Frequency Transit Stops	Number of stops within ½-mile with headways under 15 Minutes	Bus Stop layer (RLIS, 2010) and TriMet schedules (2011)	47	0	to	244
Employment Density	Employees per acre	ESRI Business Analyst (2010)	21	0.4	to	141
Lot Coverage	Percent	Tax lot and Building Layers (RLIS, 2010)	28%	9%	to	67%
Length of Bike Facilities	Miles	Bike Route layer (RLIS, 2010)	6.7	0.2	to	13.8
Access to Rail	Presence of rail station within ½-mile	Light-rail Stop layer (RLIS, 2010)	45%	No	to	Yes
Intersection Density	Intersections per acre	Lines file (TIGER 2009)	0.22	0.01	to	0.56
Urban Living Infrastructure	Density index based on the number of retail & service establishments within ½ mile	Metro Context Tool, Portland Metro	2.1	1.0	to	4.2

* RLIS: Regional Land Information System, Portland Metro. TriMet: Regional transit provider.

Number of Transit Corridors: A count of the transit routes accessible within the establishment buffer.

People Density: The total residential and employment population within the establishment buffer divided by its buffer area in acres.

Number of High-Frequency Transit Stops: The number of high-frequency bus stops within the establishment buffer. High-frequency stops have service headways of 15 minutes or less (including at least four stops) between 4:30 and 5:30PM. Data for 5:00-6:00PM are not available.

Employment Density: The number of employees within the establishment buffer divided by its area in acres.

Lot Coverage: The percent of tax lot parcel area covered by building footprints. This measure is a proxy for parcel setbacks and is calculated for all parcels within the establishment buffer.

Length of Bike Facilities: Miles of bicycle facility links within the establishment buffer.

Access to Rail: A binary variable indicating access to a light-rail station within the establishment buffer. A value of one indicates the presence of at least one rail station within the buffer, and a value of zero indicates no station.

Intersection Density: The number of intersections per 1,000,000 square feet within the establishment buffer.

Median Block Perimeter: The median perimeter distance (miles) of census blocks within the establishment buffer.[9]

[9] The median is selected as a more robust measure than the mean of the typical block size; the median is less influenced by outliers and uneven distributions than the mean.

4.0 ANALYSIS

Based on the descriptive analysis discussed in the previous chapter, we detail here the methods and assumptions employed to compare study findings with ITE. We aim to develop a consistent method for adjusting ITE trip generation estimates to control for urban context. This is based upon relationships between built environment characteristics and mode shares found from analysis of data collected from specific establishments across the Portland region.[10]

This chapter is organized as follows:

1. Testing key assumptions in our analysis
2. Comparison of ITE trip rates to data collected in this study
3. ITE adjustment method
4. Implications for planning the built environment

4.1 PERSON TRIP RATE ASSUMPTION

A critical assumption in this study is that person trip rates for a specific establishment type (land use category) and size (gross floor square footage or similar measure) do not vary across urban contexts. Rather, the distribution of those person trip rates across various modes of transportation varies by the urban built environment. See Figure 4-1 for an illustrated example. If this hypothesis is true, it suggests that automobile and non-automobile trips may be substitutable across contexts (person trip rates are constant) rather than complements (non-automobile trips may be additional trips). If non-automobile trips are complementary (vary across contexts), the ability to compare ITE vehicle trip rates with collected data proves difficult. In that case, the error between observed and estimated vehicle trip rates cannot be distinguished from non-automobile trip rates.

The average person trip rate (trips per square foot gross floor area) from the PM peak hour (5:00 – 6:00 PM) across land use types was tested for significant variance across contexts. Tests were performed for: (1) all land uses combined across contexts (pooled data) and (2) specific land use types across contexts (data segmented by establishment type). The null hypothesis (H_0) stated that average person trip rates are equal across contexts, and the alternate hypothesis (H_1) stated that average person trip rates are not equal across contexts. Hypothesis testing was performed via one-way analysis of variance statistical means testing at 95% confidence. In every case, we failed to reject the null hypothesis (all p-values > 0.189); average person trip rates per building area were not significantly different across urban contexts. This result suggests that person trips do not vary significantly for establishments of a specific size and type, but rather the distribution of trip rates by different travel modes.

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[10] Statistical analyses were performed with SPSS, Version 19.0 (IBM Company, 2010) and R, version 2.6 (The R Foundation for Statistical Computing, 2008). Spatial analysis was conducted in ArcGIS 10.0 (ESRI, 2011).

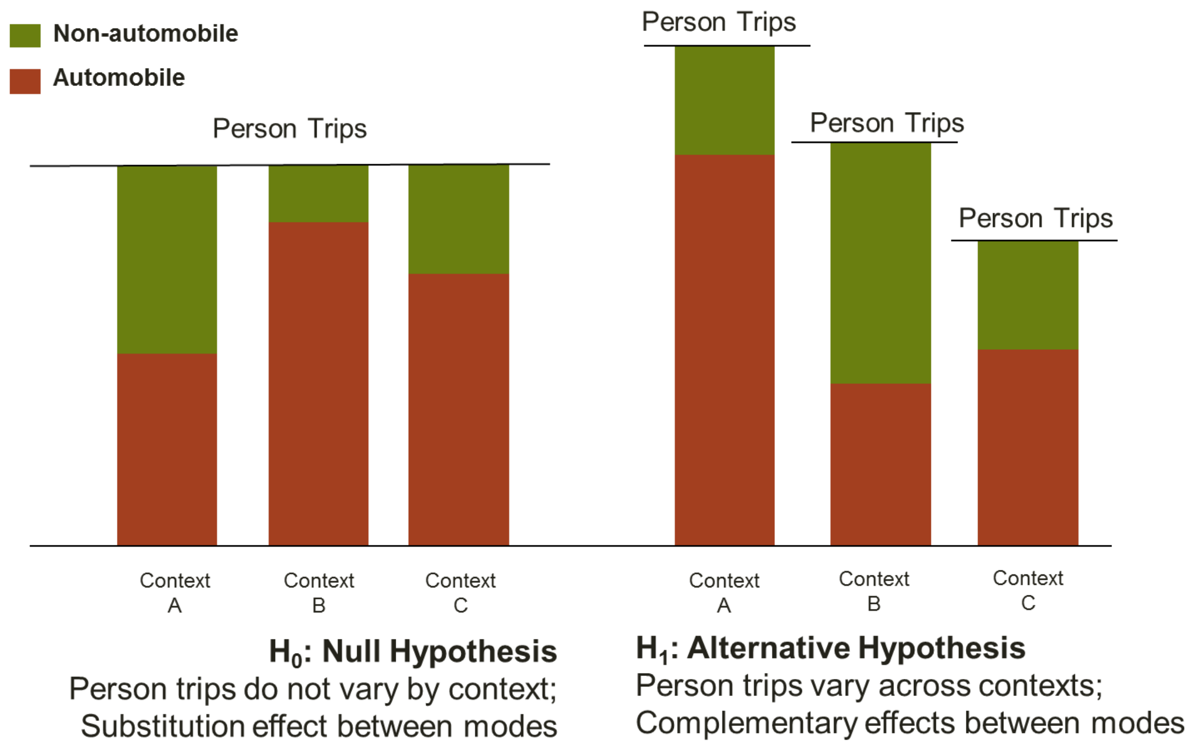


Figure 4-1. Do Person Trip Rates Vary Across Contexts?

4.2 COMPARISON OF OBSERVATIONS WITH ITE DATA

This section details a comparison between the Trip Generation Study (TGS) observations and the ITE Trip Generation vehicle trip rates (Institute of Transportation Engineers 2008) using the *ITE Trip Generation Handbook* methodology (Institute of Transportation Engineers 2004). To compare TGS observed person trips to ITE vehicle trips for each establishment, we need estimates of the number of vehicles entering and exiting sites. In Equation 4-1, we estimate vehicle trip rates from survey data.[11]

Equation 4-1. TGS Vehicle Trip Rate

$$VEH\ TRIP\ RATE_{TGS} = \frac{(P_{IN} + P_{OUT})_{TGS}(\%AUTO)_{TGS}}{VEH\ OCC_{TGS}} \times \frac{1}{1000\ Sq.Ft.Area}$$

Where: P_{IN} = Person count entering the establishment,
P_{OUT} = Person count exiting the establishment,
$\%AUTO_{TGS}$ = automobile mode share from the survey, and
$VEH\ OCC_{TGS}$ = Average vehicle occupancy for the survey

Comparison of TGS vehicle trips to ITE vehicle trip rates for the weekday peak hour of the facility (5– 6PM) can be seen in Figure 4-2, Figure 4-3, and Figure 4-4.[12,13] TGS vehicle trips are

[11] For an explanation on the development of Equation 1, see Appendix F.
[12] No sites were evaluated during the peak hour of the generator, and limited data were available to determine the number of seats provided by restaurant-type establishments for comparison.

consistently below ITE rates and ITE data points for convenience stores and drinking establishments. Figure 4-4 shows that for high-turnover, (sit-down) restaurants, the TGS vehicle trips and ITE trip rate are in agreement. Table 4-1 shows a comparison of ITE and TGS vehicle trip rates for all three land uses. Convenience markets are the least correlated with ITE. Although high-turnover (sit-down) restaurants agree the most with ITE trip rates, a local refinement on application in various contexts may assist in explaining the variation observed at establishments with greater gross floor areas.

ITE lists the criteria recommended to adopt the ITE Trip Generation methodology for local use and TGS results (see Table 4-2). All criteria must be met to consider application of ITE Trip Generation data in local context. Otherwise, it is recommended that a local rate or equation be developed (Institute of Transportation Engineers 2004, 21). From Table 4-1 and Table 4-2, we recommend a local adjustment to ITE rates for convenience stores and drinking establishments. We do not have sufficient evidence to recommend adjusting ITE rates for high-turnover (sit-down) restaurants in the Portland region.

We hypothesize that the differences between ITE and TGS are largely due to differences in the travel modes visitors use to access/egress these sites. As discussed in section 4.1, this is supported by the fact that person trip rates are similar across area types. This points to the need to adjust ITE rates for urban context, as differences in vehicle trips across context are largely due in part to the built environment attributes that support transit and non-motorized modes. The next section introduces the model used for adjusting ITE vehicle trip rates.

[13] No models are provided by ITE for any of these land uses due to weak correlation between establishment size and vehicle trips produced for adjacent street traffic during PM peak hours.

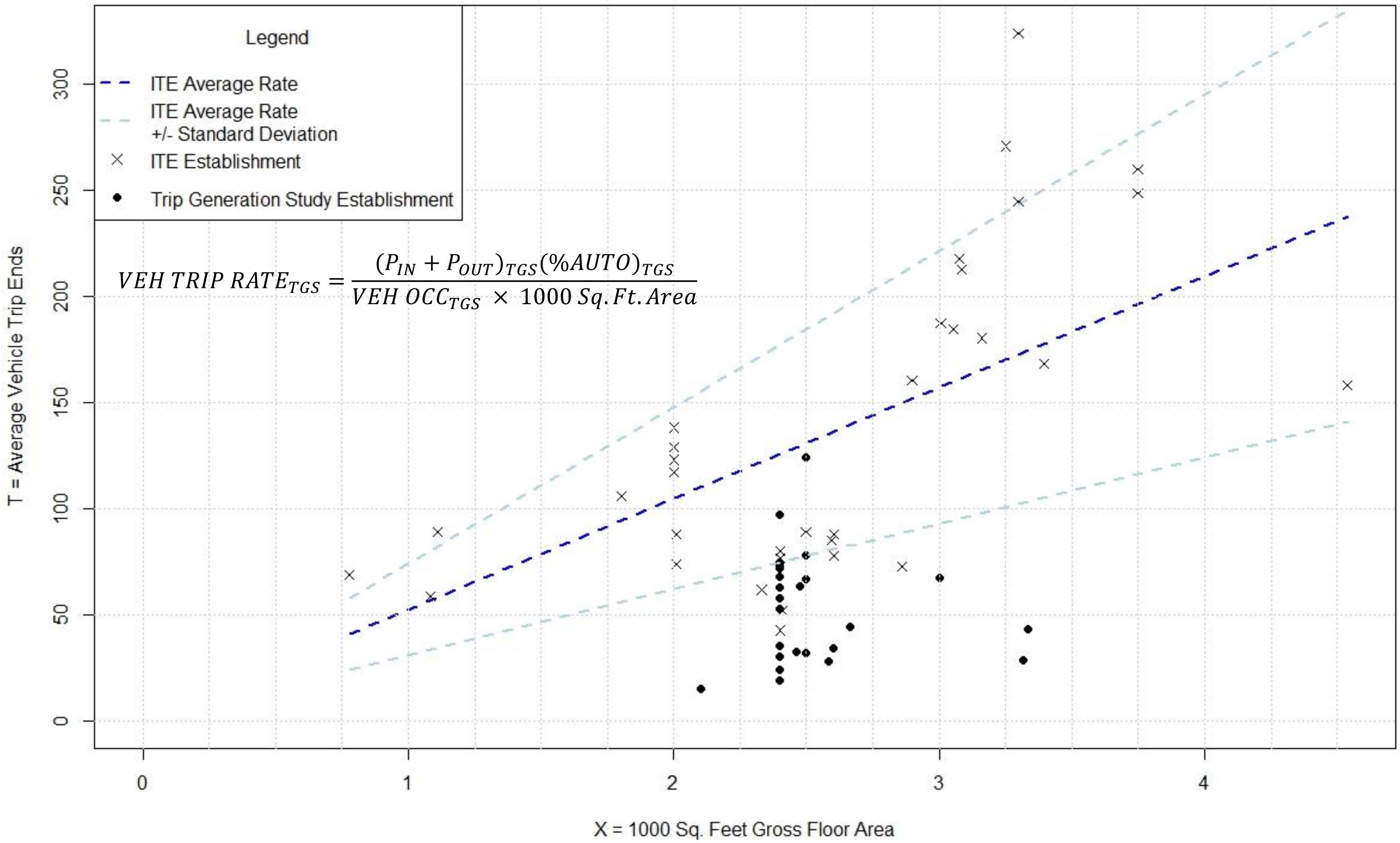


Figure 4-2. Convenience Market (Open 24-hours) (LU 851): Weekday, Peak Hour of Adjacent Street Traffic, 4-6PM - TGS Vehicle Trips and ITE Vehicle Trip Rates Data

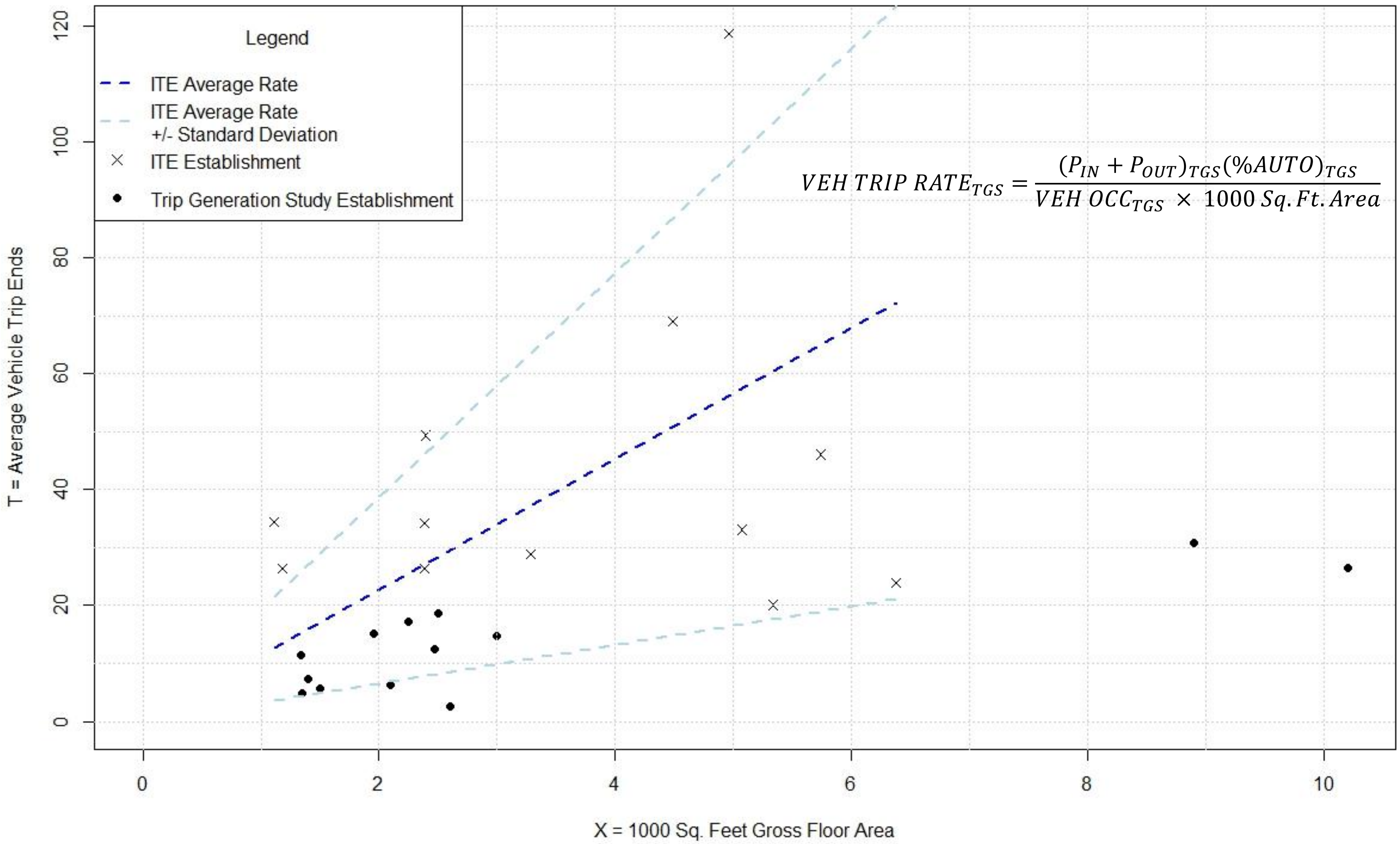


Figure 4-3. Drinking Places (LU 925): Weekday, Peak Hour of Adjacent Street Traffic, 4-6PM - TGS Vehicle Trips and ITE Vehicle Trip Rates Data

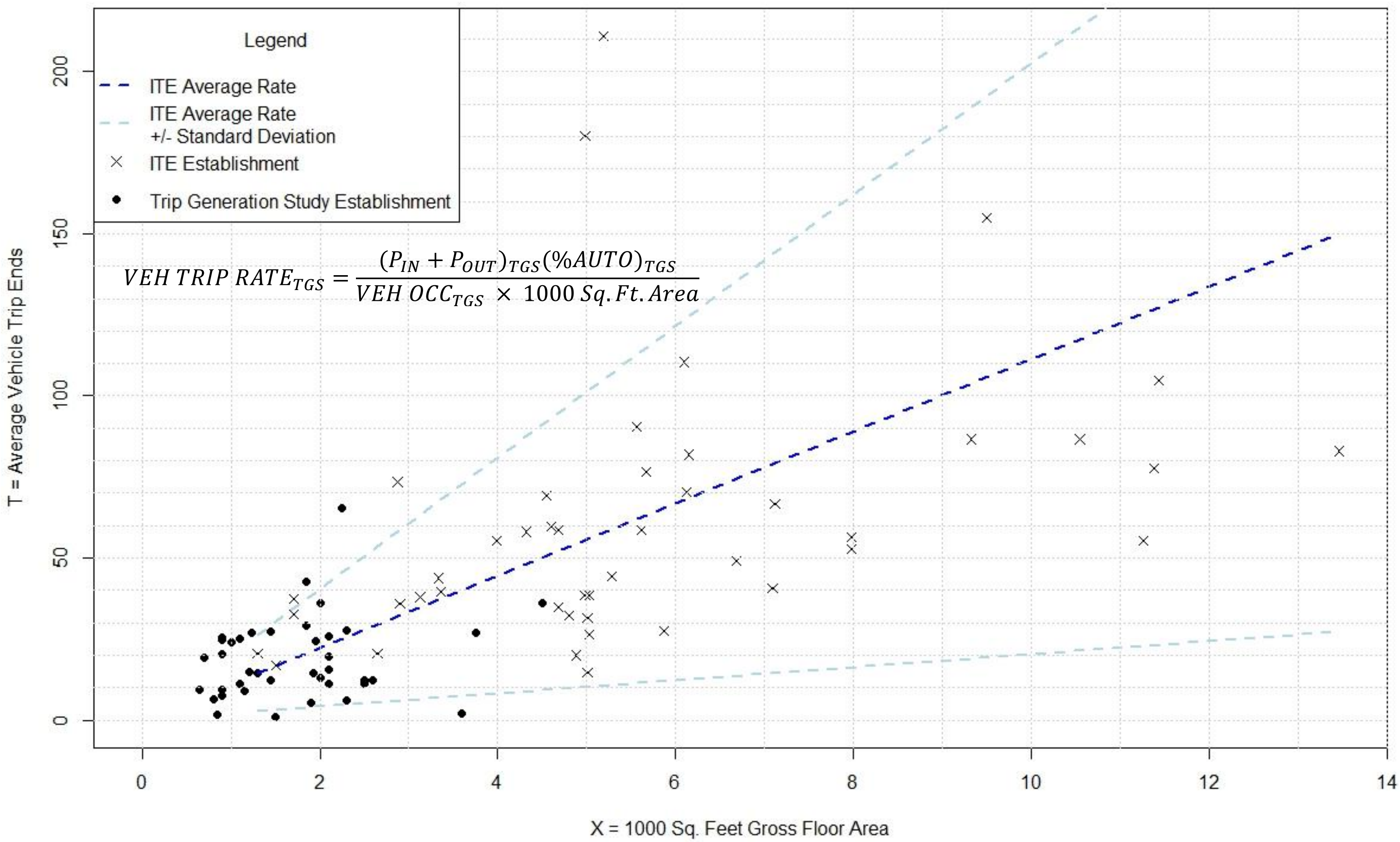


Figure 4-4. High-Turnover (Sit-Down) Restaurants (LU 932): Weekday, Peak Hour of Adjacent Street Traffic, 4-6PM - TGS Vehicle Trips and ITE Vehicle Trip Rates Data

Table 4-1. Comparison of Vehicle Trip Rates - ITE versus TGS rates

ITE Land Use	Convenience Market (Open-24 Hours)		Drinking Place		High-Turnover (Sit-Down) Restaurant	
ITE Land Use Code	851		925		932	
Sample Size (N)	26		13		39	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
TGS vehicle trip rate (vehicles per 1000 Sq. Ft. area)	20.8	*10.8*	4.9	*2.3*	12.3	*8.3*
ITE Vehicle trip rate (vehicles per 1000 Sq. Ft. area)	52.4	*21.4*	11.3	*9.1*	11.2	*8.0*
Vehicle trip rate difference (TGS - ITE)	-31.6	*10.8*	-6.4	*2.3*	1.2	*8.3*

Table 4-2. ITE Criteria for Local Rate Development

ITE Criteria	LU 851: Convenience Market (Open 24-Hours) (N=26)	LU 925: Drinking Place (N=13)	LU 932: High-Turnover (Sit-Down) Restaurant (N=39)
1.) A trip generation study (with at least three locations) provides a vehicle trip rate that falls within one standard deviation of the mean provided by ITE.	TGS_{RATE} (20.8) does not fall within one standard deviation ITE_{RATE} (31.0 - 73.8)	**TGS_{RATE} (4.9) falls within one standard deviation ITE_{RATE} (3.3 - 19.4)**	**TGS_{RATE} (12.3) falls within one standard deviation ITE_{RATE} (2.0 - 20.3)**
2.A.) At least one study site has a rate that falls above the ITE weighted average or equation, and one that falls below; <u>OR</u>	0 locations fall above, 26 location fall below	0 locations fall above, 13 locations fall below	**17 locations fall above, 22 locations fall below**
2.B.) All study locations fall within 15% of the ITE average rate or equation. ((TGS_{RATE} - ITE_{RATE}) / ITE_{RATE}) < ±15%	1 of 26 location falls within 15%	0 of 13 locations fall within 15%	7 of 39 locations fall within 15%
3.) Locally collected studies fall within the scatter of rates provided by ITE	Appear slightly below	Appear below	**Appear within scatter**
4.) "Common sense" indicates appropriate use of ITE rates for location application.	Vague	Vague	Vague
Conclusion	Local rate or adjustment is recommended.	Local rate or adjustment is recommended.	Use of ITE methods may be appropriate.

Note: bold indicates that the criterion is met in this study.

4.3 URBAN CONTEXT ADJUSTMENT (UCA) MODEL

In this section, we introduce a method to estimate an Urban Context Adjustment (UCA) to ITE vehicle rates for the land uses: high-turnover (sit-down) restaurants (LU 932), convenience markets (LU 851), and drinking places (LU 925). Using ordinary least squares regression, we have estimated several models of the adjustments to ITE rates (for the weekday, PM peak hour of the facility) using a variety of model specifications with a number of built environment measures and controlling for land use type. The model with the best performance is shown in Equation 4-2 below and makes use of the Context Tool Urban Living Infrastructure (ULI) Indicator as a proxy for context (see Section 3.4 for a complete discussion of ULI).

ULI is a measure of local access to a number of retail and service establishments that accommodate a variety of non-work activities. This measure is highly correlated with other built environment attributes also known to be associated with higher rates of non-automobile travel, such as measures of density, street configuration, block size, bicycle and pedestrian networks and transit service. However, many of these measures are correlated with one another and cannot be used together in a single model. Thus, in this preferred model, ULI serves as a proxy for these other built environment characteristics, yet provides a simple and straightforward method for adjusting ITE trip rates for different urban contexts. See the following section (4.4) for a detailed discussion of these other built environment measures and their relative contributions to vehicle trip rates, as they are also important to consider for planning and policy.

The difference in the ITE vehicle trip rate for convenience markets is nearly five times larger than those for high-turnover restaurants and drinking places. Additionally, the average UCA vehicle trip rate for drinking places is significantly lower than the ITE vehicle trip rate and the average UCA trip rate for restaurants is higher than the provided ITE vehicle trip rate (see Table 4-1 for more details). However, the sample size for each land use is too small to develop a segmented model, and so we estimate a pooled model that uses binary variables to indicate the land use type.

The UCA model below predicts the difference between ITE vehicle trip rates and UCA vehicle trip rates, or the local adjustment *to* ITE trip rates for the weekday PM peak hour of the facility.[14] The model fit as indicated by Adjusted R^2 is 0.763. Note that drinking places are the base case for the model; if calculating the adjustment to a drinking establishment, set values for restaurant and convenience variables to zero.

From the model coefficients, the land use indicators contribute more to the adjustment than the ULI variable representing context. However, once land use is controlled for, significant differences in trip generation can be attributed to context.

Using this model, we can see the range of possible adjustments for different contexts. For example, in locations with an average ULI of 1.0 (the lower bound of ULI), the ITE trip rate for restaurants should not be increased more than 4.7[15], resulting in a new vehicle trip rate of 15.2

[14] Drinking establishments are the base case for this model, so the "Restaurant" and "Convenience" terms equal zero if calculating an adjustment to a drinking place. Significance level for Restaurant is at 99%, Convenience at 99.9%, ULI at 98%.

[15] Computed from Equation 4-2, 0.643 – 3.29 * (1.0) + 7.41 * (1) – 26.04 * (0) = 4.7

vehicle trips (per PM peak hour, per 1,000 square feet of gross floor area). The UCA adjustment to convenience markets in the same area (with average ULI of 1.0) would be a reduction of 28.7 to the ITE trip rate[16]; when applied to the ITE trip rate this results in 23.7 vehicle trips per hour per 1,000 sq. ft. (a 45% reduction from the ITE vehicle trip rate). The UCA adjustment to drinking places in the same area (average ULI = 1.0) is a reduction of 2.6 to the ITE trip rate[17]; the resulting trip rate is 8.7 vehicle trips per hour per 1,000 sq. ft. (a 77% reduction from ITE).

Equation 4-2. Urban Context Adjustment Model

$$\boldsymbol{ADJ} = 0.643 - 3.29 * \boldsymbol{ULI} + 7.41 * \boldsymbol{Restaurant} - 26.04 * \boldsymbol{Convenience}$$

$$\boldsymbol{ADJ} = VEH\ TRIPS_{UCA,LU} - VEH\ TRIPS_{ITE,\ LU} \equiv \text{Difference in vehicle trip rates}$$

$$\boldsymbol{ULI} \equiv \text{Average of ULI values within establishment buffer}$$

$$\boldsymbol{Restaurant} = \begin{cases} 1, \text{ if ITE Land Use} = 932\text{: High-Turnover (Sit-Down)Restaurant} \\ 0, \text{ if ITE Land Use} \neq 932\text{: High-Turnover (Sit-Down)Restaurant} \end{cases}$$

$$\boldsymbol{Convenience} = \begin{cases} 1, \text{ if ITE Land Use} = 851\text{:Convenience Market (Open 24-hours)} \\ 0, \text{ if ITE Land Use} \neq 851\text{:Convenience Market (Open 24-hours)} \end{cases}$$

$$\boldsymbol{Adjusted\ R^2} = 0.763$$

Note: Drinking places are the base case for the model. To calculate adjustments to drinking places, set the values for ***Restaurant*** and ***Convenience*** to zero.

Table 4-3 and Figure 4-5 provide some additional guidance on the range of observed values for which this equation is valid. Table 4-3 shows the ranges observed in this study. Figure 4-5 illustrates the results of Equation 4-2 plotted for each of the three land uses (see Appendix F for more detail).

Table 4-3. Range of Observed Values in Data Used for Model Estimation

ITE Land Use and Code		Average ULI Score	Establishment Size (sq. ft.)	Estimated Vehicle Trip Rate (trips per 1000 sq. ft. per hour)
851	Convenience Market (Open 24-hours)	1.10 – 3.29	2,100 – 3,334	7.1 – 49.7
925	Drinking Place	1.25 – 3.27	1,340 – 10,200	1.0 – 8.5
932	High Turnover (Sit-Down) Restaurant	1.02 – 4.20	650 – 4,500	0.5 – 29.0

[16] Computed from Equation 4-2, 0.643 – 3.29 * (1.0) + 7.41 * (0) – 26.04 * (1) = -28.7
[17] Computed from Equation 4-2, 0.643 – 3.29 * (1.0) + 7.41 * (0) – 26.04 * (0) = -2.6

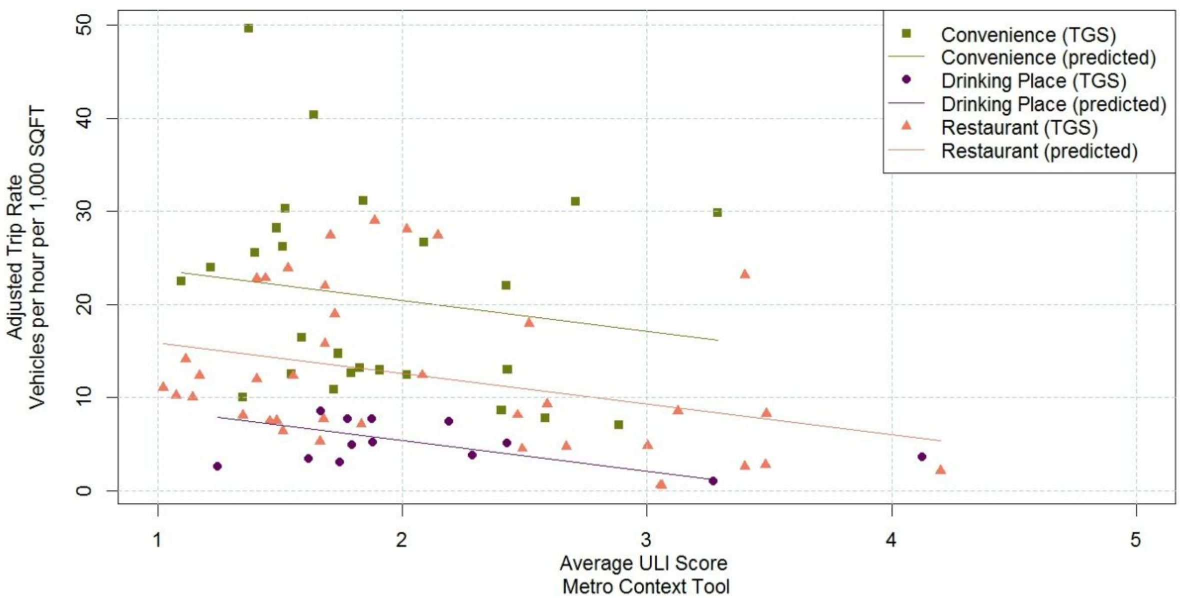


Figure 4-5. Urban Context Adjustment to ITE Vehicle Trip Rate for the PM Peak Hour of the Facility by Average ULI Score[18]

4.4 IMPLICATIONS IN PLANNING & POLICY

The model shown in Equation 4-2 is based on the ULI variable from the Metro Context Tool. It is important to note that ULI is highly correlated with many other built environment measures and may not be directly sensitive to policy. In this section, we relate ULI to several additional built environment variables. Understanding these relationships is useful since ULI may not always be the most sensitive built environment measure for policy decisions. If planners seek to make long-term changes to neighborhoods, this section will help identify important characteristics associated with lower automobile mode shares, based upon our findings.

Table 4-4 shows a list of the built environment measures highly correlated with ULI and their respective model performance in an ordinary least squares regression model predicting an adjustment to the ITE vehicle trip rates. Each row in this table represented a separate regression considered; the first row is the identical model presented in Equation 4-2. Each model considered contains the same two land use measures to identify whether the establishment is a restaurant or convenience market and one built environment measure representing context. Drinking places are the base case for each model.

[18] Vehicle trip rate is measured in vehicle trip ends (entering and exiting) per PM peak hour per 1,000 square feet of gross floor area

Table 4-4. ITE Rate Adjustment Models Using Built Environment Measures

Built Environment Measure (units)	Correlation with ULI	Adjusted R^2	Model Variable Coefficient	Convenience Market Coefficient	Restaurant Coefficient	Intercept Coefficient
Average ULI (unitless)		0.763	-3.29**	-26.04***	7.41***	0.64
Number of Transit Corridors (count)	0.78	0.767	-0.09***	-25.48***	7.62***	-4.31*
People Density (residents and employees per acre)	0.89	0.766	-0.07***	-26.19***	7.24***	-3.41
Number of High-Frequency Bus Routes (count)	0.84	0.766	-0.05***	-26.07***	7.19***	-3.62
Employment Density (employees per acre)	0.84	0.764	-0.08**	-26.13***	7.16***	-4.24*
Lot Coverage (%)	0.92	0.760	-0.17**	-26.60***	6.97**	-0.86
Length of Bike Facilities (mi.)	0.86	0.760	-0.79**	-26.24***	7.55***	-0.75
Rail Access (binary)	0.47	0.756	-3.99**	-24.31***	8.09***	-5.19**
Intersection Density (number per acre)	0.77	0.756	-14.35**	-26.85***	6.47**	-2.20

***p-value ≤ 0.01
** p-value ≤ 0.05
*p-value ≤ 0.10

The land use measures are highly significant in all models, indicating that identifying land use type in this pooled model structure is very important when determining an adjustment to ITE vehicle trip rates. However, predicting an ITE vehicle trip rate adjustment based on land use type indicators alone is not very sensitive to planning or evaluations of policy. Therefore, the additional independent variables are investigated individually to identify potential influences of the built environment on travel behavior.

All of the models shown in the table have good statistical fit (adjusted $R^2 > 0.75$). Four models perform better than the ULI model (Number of transit corridors, people density, number of high-frequency bus routes, and employment density), but ULI was selected because it is a more robust measure of the overall built environment than any of the other independent contextual variables and has more explanatory power while remaining significant. For example, the Number of Transit Corridors model has an adjusted R^2 of 0.767, higher than that of the ULI model at 0.763. But in application, adding one transit corridor within the half-mile establishment buffer equates to a trip rate adjustment of -0.1 vehicle trips per 1000 sq. ft. per hour for a drinking place. An increase of average ULI from 1.0 to 2.0 provides an adjustment of -3.3 vehicle trips per 1,000 sq. ft. per hour for a drinking place. Therefore, we choose ULI as the more useful model. Increasing the number of transit corridors in an area has less of an effect on ITE rates (per unit increase) than increasing the average ULI does.

Examining the underlying data comprising the Metro Context Tool ULI Indicator shows that as the ULI scores increase, densities of retail and service establishments also increase (see Table 4-5). Additionally, Table 4-5 shows that the ranges of densities increase along with ULI. This means that the ability to increase a ULI score by *one unit* is easier to achieve in suburban areas with ULI scores of 1 or 2 than in more urban areas of ULI 4 or 5.

Table 4-5. Retail and Service Establishment Densities Associated with ULI Index

ULI Index	Density of Establishments associated with ULI			Range
1	0.0	-	0.2	0.2
2	0.2	-	0.9	0.7
3	0.9	-	2.1	1.2
4	2.1	-	5.4	3.3
5	5.5	-	12.6	7.1

Comparing the ULI index with other built environment measures is useful in order to relate these findings to planning and policy decisions. Table 4-6 summarizes measures of the built environment that are associated with ULI. All measures in the table are correlated with ULI (Pearson's correlation of greater than 0.4; bold measures have a correlation of greater than 0.6). The built environment measures shown here were calculated for all locations observed within the Metro Context Tool ULI Indicator – a grid of more than 383,000 locations covering the Metro area. This table shows the associated mean values of these other built environment attributes found in the same buffer.

For areas outside of the Portland area, where a measure of ULI may not be available, Table 4-6 is provided to assist in classifying the level of urbanization of an area. For example, if a planner desires a non-automobile mode share of approximately 66%, they may be looking at mode shares similar to an average ULI value range between 3 and 3.99 (see Figure 3-8). By using Table 4-6, the planner can assess the necessary built environment components to lay the ground work to achieve these high non-automotive mode shares, e.g. approximately 25 ± 10 transit corridors, 35 ± 6% lot coverage, or 103 ± 33 residents and employees per acre. Planners can then use these metrics to determine how they may be able to change the built environment to achieve the goals they set for the region.

Additionally, provided an absence of detailed local data on local business establishments to derive a regional ULI index in regions outside of Portland, Table 4-6 may also serve as a means for classifying the region into ULI categories for application of the UCA methodology.

Table 4-6. Built Environment Measures Correlated with Observed Average ULI Score

Built Environment Measure	Average ULI Score									
	1 - 1.99		2 - 2.99		3 - 3.99		4 - 4.99		ALL	
	N = 379832		N = 2907		N = 387		N = 95		N = 383221	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Number of Transit Corridors (count)	1	2	9	6	25	10	34	4	1	2
People Density (residents and employees per acre)	4	5	31	16	103	33	161	13	4	7
Number of High-Frequency Transit Routes (count)	2	7	46	29	132	49	196	34	3	10
Employment Density (employees per acre)	1	2	19	16	81	35	141	14	1	5
Lot Coverage (%)	1.8	3.6	18.8	9.3	35.1	6.5	42.4	5.2	2.0	4.1
Length of Bike Facilities (mi.)	2.0	1.7	7.3	2.4	11.7	0.9	13.2	0.5	2.1	1.8
Access to Rail Station (binary)	4%	20%	66%	47%	100%	0%	100%	0%	5%	21%
Intersection Density (number per acre)	0.07	0.17	1.01	0.56	1.72	0.21	2.11	0.11	0.08	0.20

Note: **Bold** measures are highly correlated with ULI (Pearson's correlation > 0.6).

5.0 VERIFICATION OF METHODOLOGY

The purpose of this chapter is to test the methodology developed within this report and to verify the applicability of the TGS methodology. Additional data were collected at 47 establishment locations solely for verification. These sites were selected and studied subsequently to the UCA 78 establishments in the report.

5.1 DATA COLLECTION

The data collection for the verification effort included vehicle entering and exiting counts for the peak hour between 5-6PM for 47 additional establishment locations. For those locations with shared parking lots or for locations with on-street parking, persons leaving/returning to their vehicle were tracked to verify that their trip was tied to the establishment being surveyed. All 47 establishments include the three land uses considered in the TGS methodology: Land Use Code (LU851): Convenience Markets (Open-24 hours); (LU925) Drinking Places, (LU932) High-Turnover (Sit-Down) Restaurants. The verification data collection took place between April and May of 2012. Gross floor area in square feet was estimated using Google Earth.

Approximate temperature and rain were recorded. There were no vehicle counts taken on days of heavy rain or abnormally cool temperatures. Two sites had small construction occurring outside of the establishment, but neither limited the access to the location. Construction activity was not occurring during the PM peak hour studied. Sites with one or no vehicle trips observed during the peak hour were examined further for abnormalities at the establishment or location. Four sites were removed from the verification data set due to oddities in the location or of the establishment itself (e.g. newly established restaurant, misleading parking situation, etc.).

5.2 VERIFICATION

Of the total 47 establishments in the verification study, 34 fall within the bounds of the TGS methodology for establishment size and average ULI. Verification of the TGS methodology includes analysis on these 34 locations. The additional 12 locations were collected to examine the applicability of the TGS methodology beyond the bounds established by the UCA data collection. Table 5-1 Table 5-1shows the distribution of establishments across average ULI values for the UCA establishments in the study and the additional verification sites.

Table 5-2 and Table 5-3 compare estimated vehicle trips using the UCA to the observations from the 34 verification sites. Based on these results, convenience markets are the land use that benefits most from the UCA. For 6 of the 10 convenience markets included in the verification process, UCA overestimated vehicle trips by an average of 31%. While this is still an overestimation, it represents a significant improvement over ITE, which overestimates by 169% (see Table 5-3).

For 9 of the 12 drinking places, the UCA provides better estimates of vehicle trips than *ITE Trip Generation Handbook*. Although more drinking places are underestimated using UCA, the average rate of underestimation tends to be similar to that of the ITE methodology. We also observed an overall improvement in the mean squared error of vehicle trip rates between UCA estimates and observed verification data points compared with ITE.

Based upon this verification, the UCA provides a consistent, yet conservative, estimate of vehicle trips for all three land uses studied in this research. The UCA shows significant improvement to the *ITE Trip Generation Handbook methodology*, particularly for convenience markets (LU 850) and drinking places (LU 925). For restaurants, it appears that the UCA offers only marginal improvement over ITE.

Table 5-1. Establishment Counts for UCA and Verification Data Collection, by Land-Use Type and Average ULI Range

	Convenience Markets (Open 24-hours) (851)		**Drinking Places (925)**		**High-Turnover (Sit-Down) Restaurants (932)**		**Total**	
Average ULI Range	UCA	Verification	UCA	Verification	UCA	Verification	UCA	Verification
1-1.99	17	7	8	8	22	8	47	23
2-2.99	8	3	3	4	8	4	19	11
3-3.99	1	0	1	0	8	0	10	0
4-4.99	0	0	1	0	1	0	2	0
Total	**26**	**10**	**13**	**12**	**39**	**12**	**78**	**34**

Table 5-2. Comparison of Vehicle Trip Rates – ITE and Urban Context Adjustment (UCA) rates to Observed Verification Data Collected[19,20]

		Convenience Market (Open 24-hours) LU (851)		Drinking Place LU (925)		High-Turnover (Sit-Down) Restaurants LU (932)	
Sample Size		10		12		12	
		Mean	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
Trip Rate	Observed	19.4	6.1	6.9	3.3	12.0	5.9
	UCA	21.4	1.5	5.7	1.4	13.4	1.8
	ITE	52.4	21.4	11.3	8.0	11.2	9.1
Difference to Observed	UCA	2.0	6.2	-1.1	3.0	1.4	5.4
	ITE	33.0	6.1	4.5	3.3	-0.9	5.9
Absolute Difference to Observed	UCA	5.2	3.5	2.0	2.5	4.1	3.2
	ITE	33.0	6.1	4.9	2.7	4.4	3.2
Mean Squared Error	UCA	38		10		29	
	ITE	1120		30		33	
Average Percent Error	UCA	32%		31%		68%	
	ITE	195%		119%		63%	

Table 5-3. Comparison of Vehicle Trip Rates – ITE and UCA rates to Verification Data Collection – Differences in Rates for Establishments Underestimated and Overestimated

		Convenience Market (Open 24-hours) LU (851)		Drinking Place LU (925)		High-Turnover (Sit-Down) Restaurants LU (932)	
Sample Size		10		12		12	
Number of times UCA is closer than ITE		10 (100%)		9 (75%)		7 (58%)	
		Average Difference in Trip Rates	**Percent of Observed Trip Rate**	**Average Difference in Trip Rates**	**Percent of Observed Trip Rate**	**Average Difference in Trip Rates**	**Percent of Observed Trip Rate**
Underestimated	UCA	-4.0	-21%	-2.7	-40%	-4.5	-38%
	ITE	---	---	-2.3	-33%	-4.8	-40%
Overestimated	UCA	5.9	31%	1.1	16%	4.4	37%
	ITE	33.0	169%	5.1	74%	4.7	39%

Additionally, some of the establishments studied in the verification data collection and classified as drinking places may also qualify for classification as a restaurant. These locations are often referred to as "brew pubs". The composition of trip purposes for these types of establishments ranged from those observed at both drinking places and restaurants. By excluding the brew pub-

[19] The mean squared error is calculated by averaging the squared difference between all estimated and observed data values.
[20] The average percent error is calculated by taking the absolute difference between estimated and observed data values, dividing by the observed value and averaging across each land use.

style drinking places from comparison, the deviation between the TGS estimate and the observed trip rates improves further.

Table 5-4. Comparison of Vehicle Trip Rates – ITE and TGS rates to Verification Data Collection – Differences between All Drinking Places and Non-Brew Pub Drinking Places

		Drinking Place		Drinking Place (without Brew Pub-style locations)	
Sample Size		12		7	
		Average Difference in Trip Rates	Percent of Observed Trip Rate	Average Difference in Trip Rates	Percent of Observed Trip Rate
Overall	UCA	-1.1	-17%	-0.4	-7%
	ITE	4.5	65%	4.8	70%
Underestimated	UCA	-2.7	-40%	-1.2	-18%
	ITE	-2.3	-33%	---	---
Overestimated	UCA	1.1	16%	0.6	8%
	ITE	5.1	74%	4.8	70%

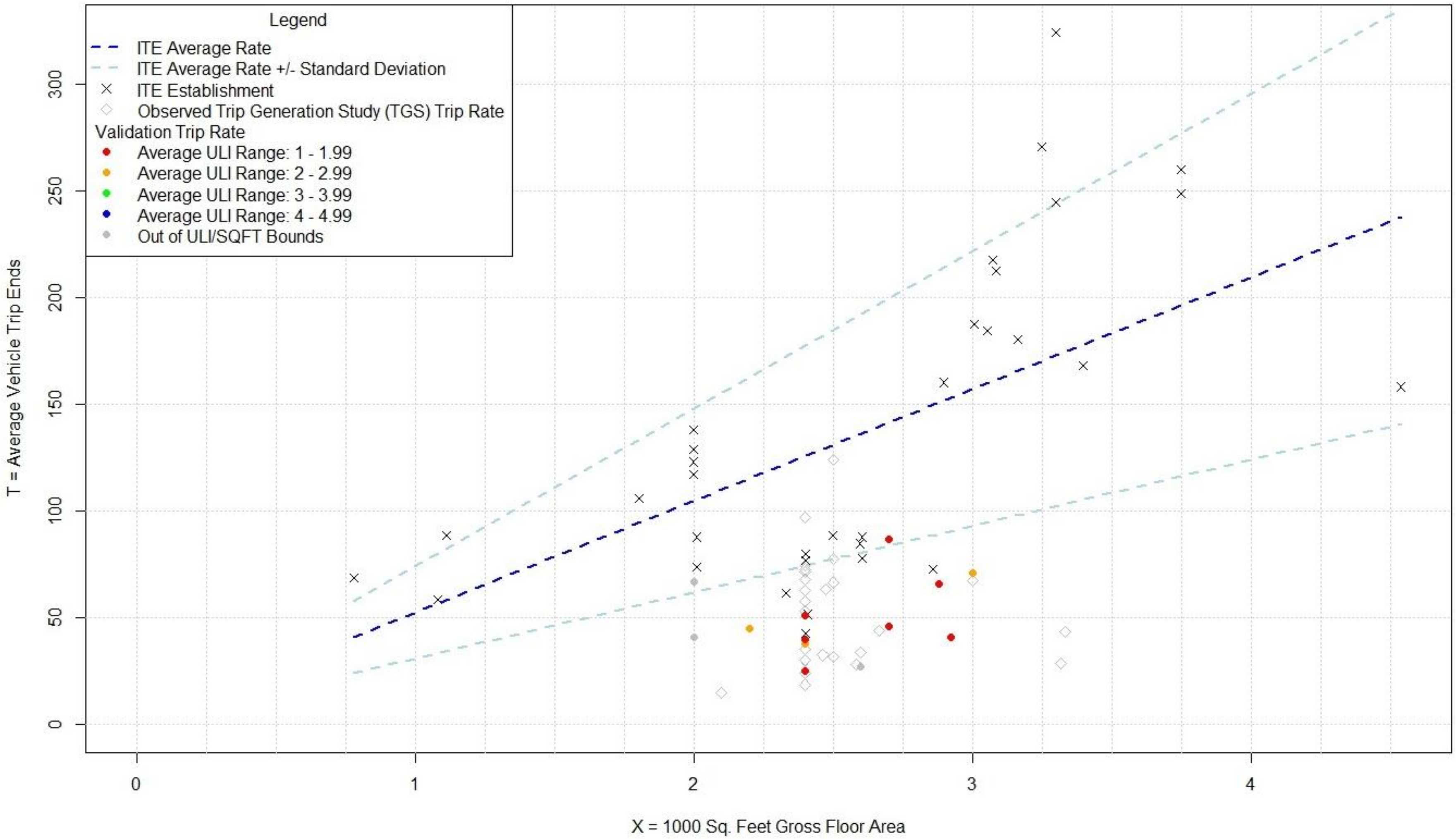


Figure 5-1. Convenience Market (Open 24-hours) (LU 851): Weekday, Peak Hour of Adjacent Street Traffic, 4-6PM – Trip Ends Data from UCA TGS methodology development, Validation Data Collection and ITE Vehicle Trip Rates Data

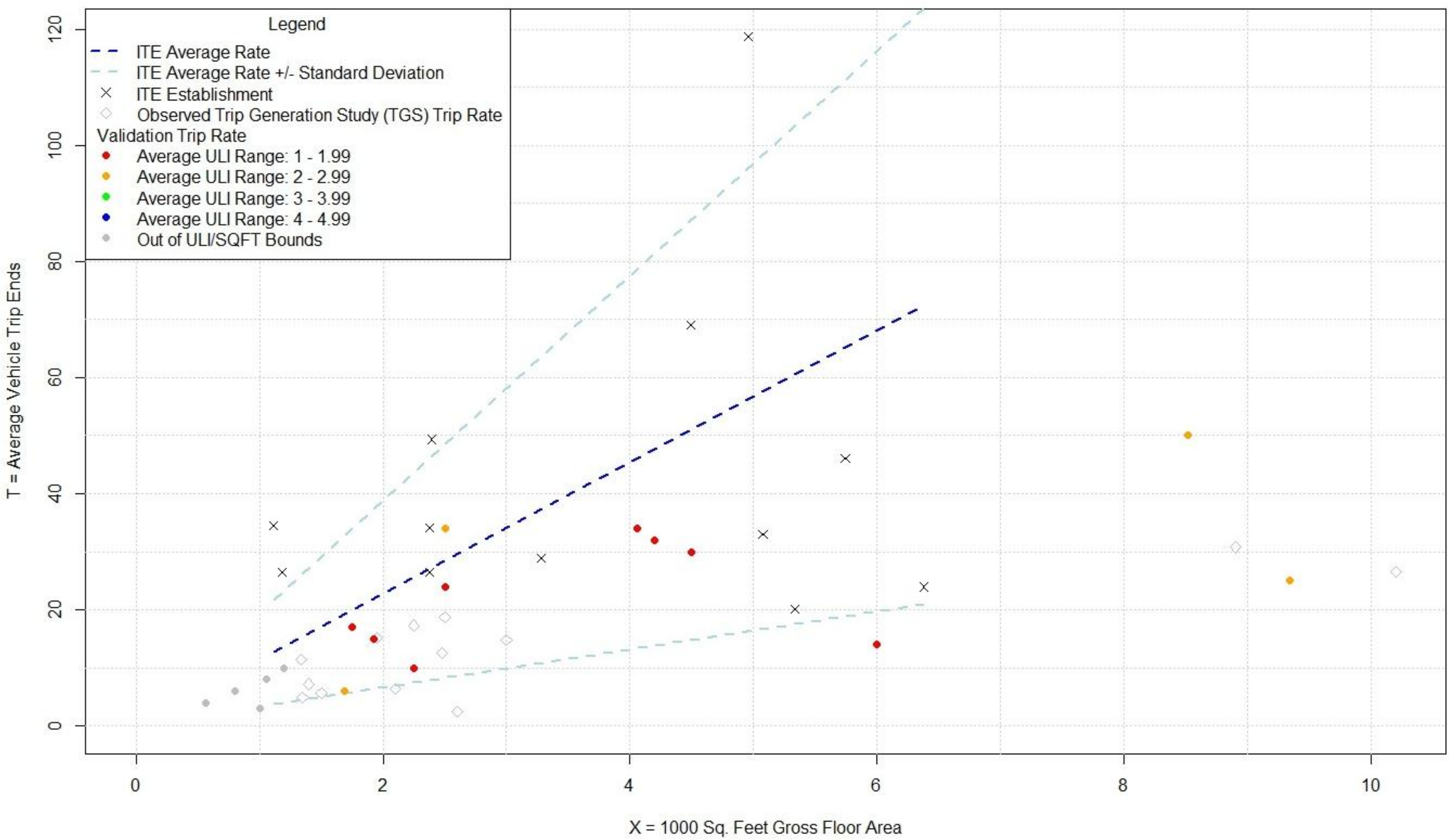


Figure 5-2. Drinking Place (LU 925): Weekday, Peak Hour of Adjacent Street Traffic, 4-6PM – Trip Ends Data from UCA TGS methodology development, Validation Data Collection and ITE Vehicle Trip Rates Data

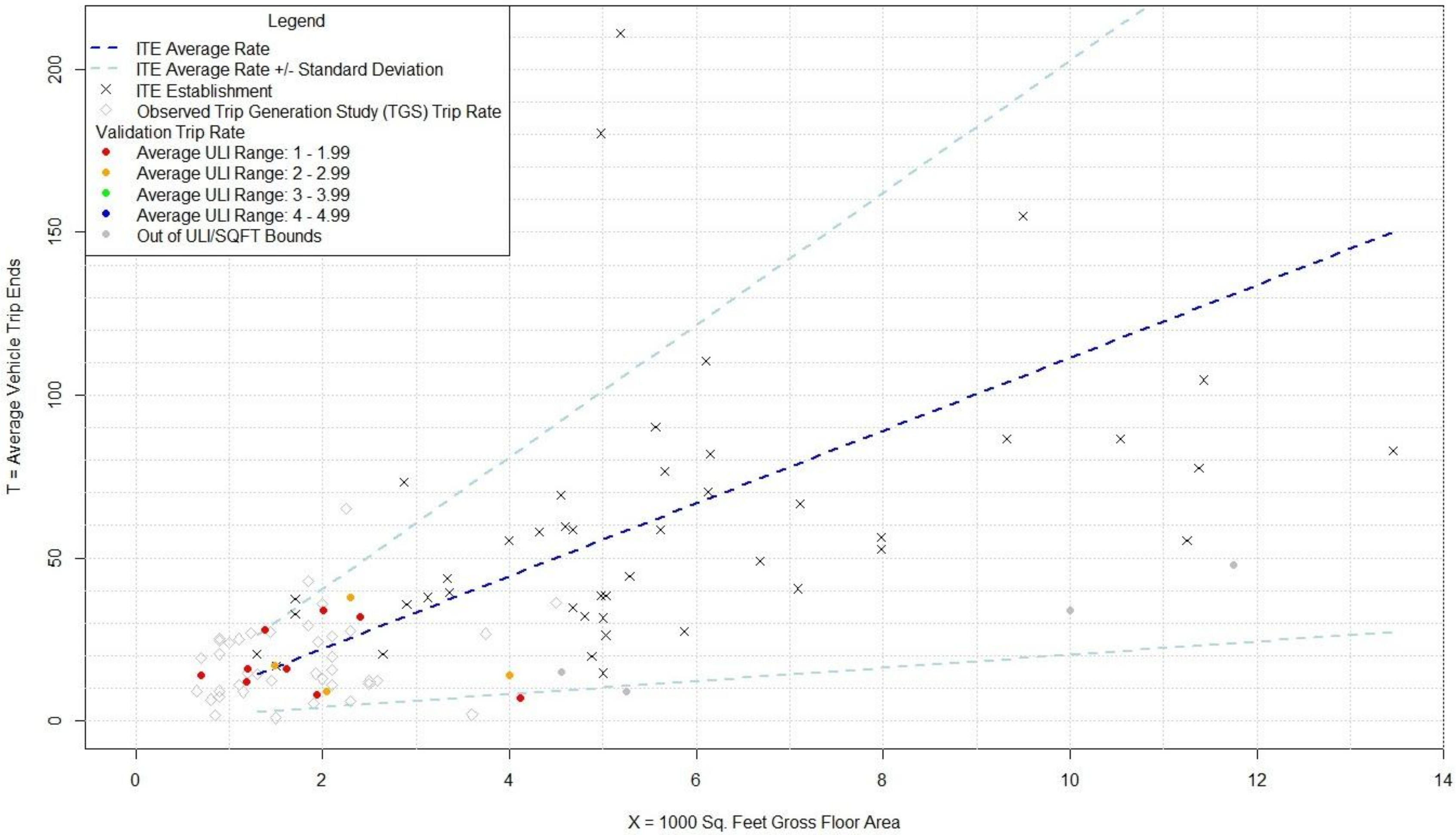


Figure 5-3. High-Turnover (Sit-Down) Restaurant (LU 932): Weekday, Peak Hour of Adjacent Street Traffic, 4-6PM – Trip Ends Data from UCA TGS methodology development, Validation Data Collection and ITE Vehicle Trip Rates Data

5.3 SUMMARY

This verification process demonstrates that TGS methodology provides reliable and accurate estimates all three land uses studied in this report. The TGS methodology shows significant improvement over ITE's rates, particularly for convenience markets (LU 850) and non-brew pub drinking places (LU 925). While the average error in estimation of high-turnover (sit-down) restaurants (LU 932) is similar between ITE and TGS methodology estimates, the number of underestimations occurring while using the TGS methodology is fewer than ITE.

For the locations that have an average ULI range of less than 3, the TGS methodology appears to be more accurate than ITE methodology for all land uses. For convenience markets, the ITE estimation consistently overestimates the vehicle trip rate significantly for Portland convenience markets. Application of the TGS methodology reduces the absolute difference in estimated vehicle trip rates from 33.0 to 5.2 vehicle trip ends per hour per 1,000 square foot gross floor area in the PM peak.

For drinking places, the TGS methodology tends to overestimate vehicle trips less often than the ITE methodology. Although the TGS methodology underestimated trip rates more frequently than the ITE methodology, the differences in trip rates tends to be closer to the observed rate 75% of the time. Additionally, the data suggest the need for future research identifying unique vehicle trip rates for brewpub-style drinking place establishments. Verification data collected at establishment sizes smaller than the TGS methodology bounds also suggest that drinking places with smaller square footages also tend to have vehicle trip rates below ITE trip rates.

High-turnover (sit-down) restaurants tend to be predicted similarly using ITE and TGS methodologies. However, the number of observed establishments underestimated by ITE is greater than TGS methodology estimates (54% versus 31%, N = 13). Moreover, establishments with large gross floor area suggest that larger restaurants may be over estimated by ITE in local context. Additional data for larger restaurants (gross floor area of greater than 4,500 square feet) are needed to confirm this observation.

The limitations of the verification analysis include the limited sample size and the range of contexts observed in the Metro area. Due to the nature of the verification data collection methodology, data from highly-urbanized locations with more difficult parking arrangements were not able to be collected by observation methods alone. They require person counts at the establishment and an intercept survey collecting trip modes and vehicle occupancy. Because of this limitation, we were not able to collect and verify the methodology in areas with average ULI values of greater than 3. These areas represent less than 0.1% of the total Metro area. From this verification process, we are not able to say to what degree the TGS methodology is conservative. However, these are the areas that pose the most difficulty in estimation of trip generation for infill developments.

6.0 CONCLUSIONS AND DISCUSSION

This study provides a means to adjust ITE's *Trip Generation Handbook* for urban context, a much needed gap in the state of the practice. The Urban Context Adjustment (UCA) method developed in this study is simple, straightforward, and consistent. It relies on one built environment measure as a proxy for urban context – the Urban Living Infrastructure (ULI) – representing the density and diversity of retail and service establishments that support daily activities. This measure is available for current conditions for all communities in the Portland region and can be computed for communities in other locations throughout the United States. The findings and methodology provided here can help communities assess the transportation impacts of new development and plan for desired long-term transportation outcomes for commercial centers, corridors, and transit oriented development.

The documentation of the findings and methodology provided here can aid local communities assess the transportation impacts of new development as well as planning for the desired transportation demand outcomes over the long term for commercial centers, corridors and transit oriented development. Results from this study reveal a trend: for all land uses tested here, vehicle trip rates decrease as neighborhood types become more urban. Specifically, findings strongly support the need for a local adjustment for both convenience markets and drinking places. High-turnover restaurants appear to be better aligned with the ITE rates, but a vehicle trip rate adjustment is recommended to better match locally observed travel patterns.

The method developed in this study to adjust ITE trip rates for convenience markets, restaurants and bars for weekday evening peak hour of the facility is simple and straightforward to apply in the Portland metropolitan area. It relies on one built environment measure – the Urban Living Infrastructure (ULI) – representing the density and diversity of retail and service establishments that support daily activities. This measure is available for current conditions for all communities in the region. The estimated model performs well with a good statistical fit. This finding is consistent with a study that showed increasing shares of non-motorized travel as the density of discretionary businesses increases (Guo, Bhat and Copperman 2007).

ULI can also be related to a variety of policy-relevant built environment characteristics, such as density and intensity of development, transportation system attributes, and urban design features. Thus, the study findings can be used not only for transportation impact assessments for new development but also to guide planning decisions to better achieve the desired travel patterns in an area over the long term.

6.1 LIMITATIONS

Despite these conclusions, the study has some limitations that impact its applicability. More research is needed in order to broaden the types of land uses considered and to strengthen the conclusions.

The greatest limitation of this study is the number of establishments and types of land uses studied. ITE requires only three or four points to develop a rate for a land use (Institute of Transportation Engineers 2004, 20-21), and in that respect, this study exceeds the standards of sample size set forth by ITE. In this analysis, however, the aim was to provide a robust method for contextual adjustments and establishment sample size for each type of land use did not allow for separate models to be developed. With a greater number of establishments, segmented models could be estimated for each land use type. In addition, larger numbers would allow for statistical testing of the impacts of more built environment variables on trip generation, including those site-level attributes such as parking, building orientation, bicycle parking and pedestrian circulation, and the location of transit stops.

Three land use types were included in the research design. ITE Trip Generation includes 162 land use classifications. Including more land uses is imperative to understanding how urban context influences vehicle generation as different land uses within the same urban context are likely to have varying mode shares. A large scale study of a magnitude rivaling ITE Trip Generation would be cost prohibitive. But including more land uses in future studies, particularly those commonly found in mixed use, infill, transit oriented developments, historic downtowns and other smart growth projects, would greatly address the practical needs of planning for appropriate travel demand.

While the ULI measure used here can be replicated, it is not a measure that is readily available outside of the Metro region. Although we have related the ULI to other built environment attributes that can be easily constructed for other communities, the model cannot be directly applied without the ULI measure. Thus, for the time being, our approach is limited in its applicability to the Portland metropolitan area.

There were a few issues that impacted our data collection. First, the urban nature of many sites restricted the ability to count vehicles entering and exiting the sites. On-site parking lots are less common in urban areas and it is difficult to determine the extent of on-street parking that serves a particular establishment. In shared parking lots, it is difficult to count vehicles and attribute them to specific establishments.

The characteristics of survey respondents were similar to the demographics of the region as a whole; however, there may be response bias in the survey based upon mode of travel. It is possible that people who drive or take transit were less willing to complete the survey. Similarly, visitors who have a larger group size (greater vehicle occupancy) may also be less likely to respond.

We controlled for the weather in this study by only collecting data on fair days without precipitation. The data collection period ranged from June to October, when conditions were most favorable for the use of alternative modes. Thus, the study observed non-automobile mode shares at their peak. These shares likely decline in other times of year when temperatures are low and rain is common. However, we have no basis for estimating the degree to which modes shift by season.

6.2 FUTURE WORK

There are several issues that merit consideration for future research and development. This section discusses plans for addressing additions to the project that would benefit our understanding of the contextual influences of trip generation.

6.2.1 Additional Land Uses

We recognize the limitations of just three land use types studied in this project. Incorporating additional land uses in developing is critical to implementing accurate vehicle trip rate adjustments to the region. The following list includes potential ITE land uses (LU) for future data collection and analysis that are likely to occur in infill and TOD locations:

- Supermarket (ITE LU 850)
- Coffee/Donut Shops with or without Drive-Through Windows (ITE LU 936 – 938)
- Bread/Donut/Bagel Shops with or without Drive Through Windows (ITE LU 939 – 940)
- Banks, Walk-in and Drive-in (ITE LU 911 – 912)
- Pharmacy/Drugstore with or without Drive-Through Window (ITE LU 880 – 881)
- Apartments and Townhouses (ITE LU 220 – 224)
- Retail uses, such as Specialty, Shopping Center, or Apparel (ITE LU 814, 820, or 876 respectively)

6.2.2 Micro-scale Analysis

The study relies heavily upon the Metro Context Tool ULI Indicator (retail density and diversity), but many other built environment factors interact to make places with high levels of non-automobile travel. Understanding the relationships between micro-scale or site-level characteristics and travel behavior is important. Site-level attributes include things such as vehicle and bicycle parking supply, sidewalk width, circulation patterns and building orientation. These micro-scale built environment characteristics were observed at the study locations of this project. Next steps are to qualitatively understand how they impact mode shares. Here matched pairs of establishments of similar land use, size and context but with different levels of vehicular trips will be compared to understand more about how these fine-grain site details contribute to our findings. This site-level analysis may provide a better understanding of travel characteristics and could potentially enhance vehicle trip rate adjustments and policy and investment choices to reduce trips and vehicle miles traveled.

Another built environment measure that is critical to understanding vehicle trip generation is parking supply. The ability to park at the destination end of a trip taken is often a key player in selecting a mode choice. Existing research shows a significant difference in transit ridership when the destination is located in an area with limited or paid parking compared with free parking (Cervero 2007), and free parking at work has been shown to reduce transit's share of commuters by 40% (Lund, Cervero and Willson 2004). To address this issue, at least in part, will require analysis of the parking data collected in this study. Here, we need to allocate parking supply in mixed use developments to the individual establishments therein. Parking will then be tested in both the statistical models and the qualitative site analysis to understand its role. The micro-scale analysis will also be incorporated into a supplementary chapter to this report.

6.2.3 Transferability

A universally applicable method to adjust ITE rates would facilitate effective planning for current and future smart growth. We hope to evaluate the transferability of our findings to communities in locations beyond the Portland, Oregon region. The issues identified with ITE trip generation rates persist across the United States; however, it is not clear that our findings are valid for locations beyond our study area. Therefore, to broaden the range of influence of our approach, it is necessary to validate these methods with data from other locations and contexts.

6.3 CONCLUSIONS

Results from this effort reveal a consistent trend: for all land uses tested here, vehicle trip rates decrease as the urban context becomes more urban. Specifically, findings strongly support the need for an urban context adjustment to the vehicle trip rates given in ITE's *Trip Generation Handbook.* While this study tested a limited number of land uses in one metropolitan region, it confirms that amendments to the long-term industry standards provided in ITE's *Trip Generation Handbook* are long overdue. We need methodologies backed by empirical evidence that provide planning support for the automobile as well as non-motorized and transit modes in urban environments.

Specifically, the methods and data provided by ITE need to move away from a focus on vehicle-trips towards a paradigm of collecting person-trip information and multi-modal travel. Transportation impact analyses can be important and powerful planning tools, but only if they reflect the multi-modal nature of urban environments. The analysis should provide a basis for how these person-trips are distributed across the various modes, as a function of site and urban context characteristics. To do this, data collection protocols and analytic methods may need to also move beyond the focus of the peak hour of the adjacent roadway in order to accommodate all transportation system users.

This study represents a first step in moving this bar forward and advancing national standards. Data for more land uses and covering a wider range of urban contexts are needed to inform a nationally relevant methodology. But, many communities across the country already have a great deal of information from their own local trip generation studies to inform a larger scale study and validate available methodologies for regional and urban context variations. The opportunity exists to make these data more readily available to researchers to help improve practice and create new professional standards that better reflect the multi-modal nature of our cities.

APPENDIX A. LONG SURVEY

Question	Text To Read to Respondent	Answers
Q55. Age	*What best describes your AGE?*	[ ] under 18, [ ] 18-24, [ ] 25-34, [ ] 35-44, [ ] 45-54, [ ] 55-64, [ ] 65-74, [ ] 75 and over
Q52. HH	*Please provide the following information for your household:* *Number of Adults*	[ ] 0, [ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
	Number of Children	[ ] 0, [ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
	Number of Automobiles	[ ] 0, [ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
	Number of people with BICYCLES	[ ] 0, [ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
	Number of Transit Passes	[ ] 0, [ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
Q57. Decision	*When did you decide that you would visit [LOCATION]?*	[ ] passing by, [ ] after leaving home, [ ] today before leaving home, [ ] yesterday, [ ] before yesterday, [ ] do not know
Q2. Origin	*We would like to ask you some questions about your travel here today, Can you tell me the nearest intersection or address from where you came from?*	____ _____________ ____ _____________ ____ _____________
Q30. Beginning of Day	*Is this the place where you began your day?*	[ ] yes, [ ] no
Q3. Origin Type	*The best description of this location is one of the following:*	[ ] Home, [ ] Work, [ ] School, [ ]Restaurant, [ ] Coffee shop, [ ] Service errand, [ ] Other: ____________________
Q8. Origin Mode	*How did you travel to [establishment]?* **Explain that we want travel modes in the order used. Remind respondent for walk trips if >1 block.**	
	Segment 1: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	
	Segment 2: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	
	Segment 3: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	
	Segment 4: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	
	Segment 5: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	
	Segment 6: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	
Q9-Q14. Veh Occ	**IF VEHICLE CHOSEN:** *For trip segment [#], how many people were in the vehicle?*	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
Q58. Parking cost	**IF VEHICLE CHOSEN:** *How much did you pay for PARKING in traveling to [LOCATION]? (Enter zero if you have a parking pass)*	$_________

Question	Text To Read to Respondent	Answers
Q60. Transit Cost	**IF TRANSIT CHOSEN:** *How did you pay for your public transportation in travelling to [LOCATION] today?*	[ ] cash only, [ ] ticket at kiosk, [ ] transit pass, [ ] free zone
Q63. Mode Attitudes	*Now, we will ask you about your attitudes towards different transportation options in traveling to [LOCATION]. Please evaluate the following on a scale from 1 (strongly disagree) to 5 (strongly agree), even if you do not use these modes:*	
	Car parking here is easy and convenient	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5
	Bike parking here is easy and convenient	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5
	Biking here is safe and comfortable	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5
	Walking here is safe and comfortable	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5
	Taking transit here is convenient	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5
Q38. Shopping frequency	*In order to understand more about why you came here, we will ask a few questions about your consumer habits. Can you tell me how frequently you come here?*	[ ] rarely, [ ] once a month, [ ] a few times per month, [ ] once a week, [ ] a few times a week, [ ] daily
Q62. Time spent	*Could you tell me the approximate amount of TIME you spent here at [LOCATION]*	________ Minutes
Q39. Money spent	*Could you tell me the approximate amount of money you spent here at [LOCATION]?*	$_________
Q53. Group size	*How many people in your group did this purchase pay for?*	[ ] 1, [ ] 2, [ ] 3, [ ] 4, [ ] 5 or more
Q31. Destination location	*We are going to ask you a series of questions about where you will be going after [Location]. Can you tell me the nearest intersection or address you will be going NEXT?*	________________________ ________________________ __ ________________________ ________________________ __ ________________________ ________________________ __
Q32. Destination type	*The best description of this location is one of the following:*	[ ] Home, [ ] Work, [ ] School, [ ]Restaurant, [ ] Coffee shop, [ ] Service errand, [ ] Other: ___________________
Q8*. Destination mode	*How will you travel to the next location from here?* **Explain that we want travel modes in the order used. Remind respondent for walk trips if >1 block.**	
	Segment 1: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	
	Segment 2: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	
	Segment 3: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	

Question	Text To Read to Respondent	Answers
	Segment 4: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	
	Segment 5: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	
	Segment 6: [ ] Walk, [ ] Bicycle, [ ] MAX/WES, [ ] Bus, [ ] Streetcar, [ ] Vehicle-driver, [ ]Vehicle-passenger, [ ] Other:_______________	
Q36. Home location	**IF HOME NOT ALREADY GIVEN IN ORIGIN/DESTINATION QUESTIONS:** *Can you tell me the nearest intersection or address for your HOME?*	________________________ ________________________ __ ________________________ ________________________ __ ________________________ ________________________ __
Q37. Work location	**IF WORK NOT ALREADY GIVEN IN ORIGIN/DESTINATION QUESTIONS** *Can you tell me the nearest intersection or address for your WORK?*	________________________ ________________________ __ ________________________ ________________________ __ ________________________ ________________________ __
Q54. Limitations	*Do you have any medical limitations that prevent you from walking, bicycling or driving?*	[ ] yes, [ ] no
Q56. HH Income	*What best describes your total annual HOUSEHOLD INCOME?*	[ ] less than $25,000, [ ]$25K - $49,999, [ ] $50K - $99,999, [ ] $100K - $149,999, [ ] $150K - $199,999, [ ] $200K or more
Q40. Gender	*What gender do you most identify with?*	[ ] male, [ ] female
Q71. Follow up	*Finally, would you like to participate in follow-up research about travel & consumer choices?*	Name:__________________ ____________________ Phone/email: ________________________ _________
END	*We appreciate your time in completing this survey. Thank you, and have a great day!*	

APPENDIX B. SHORT SURVEY

Contextual Influences on Trip Generation Survey II
Location: ____________________
Date: ________________

Thank you for taking this 30 second survey about your travel choices and consumer behavior. The information you provide will inform Portland State University research about transportation, environment and behavior. Your participation in this study is voluntary, your information will be kept confidential and you can opt out at any time. (Circle M for male respondents and F for Female respondents.)

Questions:

1. How did you get here? (multiple modes allowed)

    (Walk; Bicycle; MAX/WES; Bus; Streetcar; Vehicle driver; Vehicle passenger; Other--write in)

2. Can you tell me the nearest intersection or address to/of your home?

3. Can you tell me how frequently you come to this plaid pantry?

    (Rarely; Once / month; A few times / month; Once / week; A few times / week; Daily)

4. Could you tell me the approximate amount of money you spent here during this visit?

APPENDIX C. DATA COLLECTION FORMS

Person Count Tally Sheet				
Date:				
Location:				
Name of Counter:				
	Male		**Female**	
	Entering	**Exiting**	**Entering**	**Exiting**
0:00 – 0:14				
0:15 – 0:29				
0:30 – 0:44				
0:45 – 0:59				
1:00 – 1:14				
1:15 – 1:29				
1:30 – 1:44				
1:45 – 1:59				
Data entered Date: **Data entry name:**				

Automobile/Bicycle Exit Tally Sheet		
Date:		
Location:		
Name of Counter:		
(For visitors observed exiting establishment.)	**Automobiles Exiting**	**Bikes Exiting**
Feasible to count at this location ? Please mark NO if no counts are taken.	**YES or NO**	**YES or NO**
If no, please explain:		
# of Parking Spaces		
0:00 – 0:14		
0:15 – 0:29		
0:30 – 0:44		
0:45 – 0:59		
1:00 – 1:14		
1:15 – 1:29		
1:30 – 1:44		
1:45 – 1:59		
Data entered Date: **Data entry name:**		

Site Data Collection Sheet		
Date*:		
Location*:		
Team*:		
Weather:		
Entrance Description	❒ Single Entrance ❒ Multiple Entrances (num____) ❒ Shared entrance ❒ Awning present	
Description of parking	Automobiles ❒ On Street unrestricted ❒ On street, restricted ❒ Lot ❒ Garage	Bikes ❒ Bike Corrals________ ❒ Bike Racks_________
Site Amenities	❒ Drive Through ❒ Awning ❒ Tree Canopy ❒ Benches ❒ Sidewalks Width ________	❒ Bio-swales ❒ Pedestrian Refuge ❒ Sidewalk Bump-out ❒ Bus line ❒ Bus Stop
Is there construction present?*		
Other observations about site & visitor behavior*		
Pictures Taken	❒ Entrance ❒ Example Auto Parking & Parking Lot ❒ Example Bike Parking ❒ Streetscape ❒ Surveyors in action (Smile!)	
Data entered Date: **Data entry name:**		

APPENDIX D. MODE SHARES

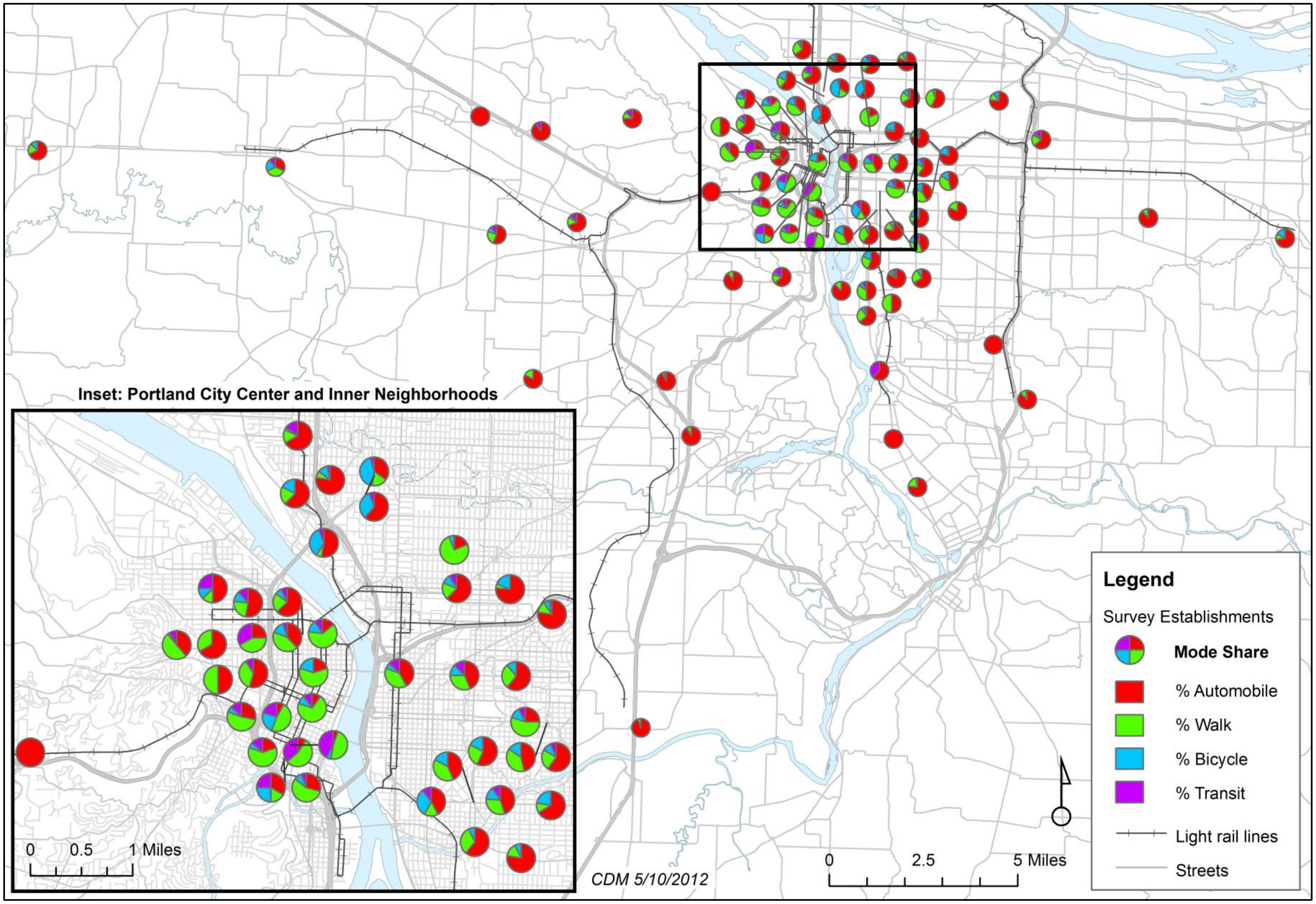


Figure 6-1. Survey Establishment Mode Shares

APPENDIX E. CONVERTING PERSON TRIPS TO VEHICLE TRIPS

Vehicle trip estimation method

To develop a method to adjust ITE vehicle trip rates, we used vehicle trips from our data collection effort. But vehicle trips exiting sites were obtained for just 44 of the 78 establishments studied. Many study sites, especially those in urbanized neighborhoods, contained on-street and complex parking situations and did not allow vehicle counts to be obtained during data collection. We describe the method used to develop vehicle-equivalent trips from person counts and vehicle occupancy.

At all study establishments, person counts entering and exiting the establishment were collected. Both the short-form and long-form survey collected mode choice, and the long-form survey gathered vehicle occupancy data from those who traveled by automobile. Vehicle occupancy was not collected in the short survey. Because vehicle occupancy data were only collected within the long-form survey, it has a smaller sample size. Therefore, for establishments with less than ten observations for vehicle occupancy, average vehicle occupancy observed for that particular land use was used in the vehicle-equivalent trip estimate type (see Table 3-7 and Table 3-8**).**

Vehicle trip estimation method to exiting trips

In Equation 6-1 we estimate vehicle trips exiting establishments.

Equation 6-1. Conversion to vehicle trip equivalents method for exiting trips.

$$VT_{CNTS,OUT} \approx VT_{EST,OUT} = \frac{(P_{OUT})(\%AUTO)}{V_{OCC}}$$

Where:
P_{OUT} = Person count existing the establishment,
$\%AUTO$ = Automobile mode share from the long- and short-form surveys,
V_{OCC} = Average vehicle occupancy from the long-form survey,
$VT_{CNTS,OUT}$ = Vehicle trips counted from patrons exiting establishment, and
$VT_{EST,OUT}$ = Vehicle trips estimated from patrons exiting establishment.

Verification of estimation method

Since only exiting vehicle counts were counted at establishments, we test our method by comparing estimated exiting vehicle trips with observed exiting vehicle trips. A plot of estimated exiting vehicle trips is plotted against observed exiting vehicle trips is shown in Figure 6-2. Estimated vehicle trips are close to observed vehicle trips. Ideally, the points would follow the 1:1 unit line plot. The graph shows that results are not very far from the unit line.

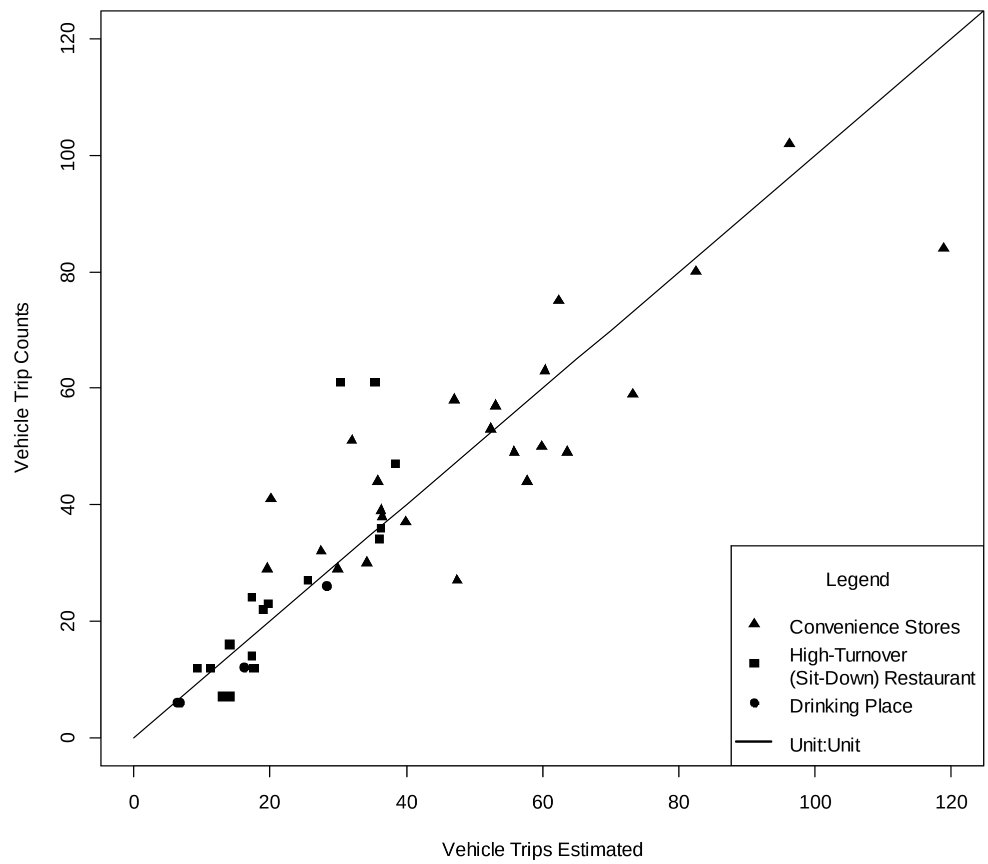


Figure 6-2. Comparison of vehicle trip counts to calculated

Table 6-1. Estimated vehicle trips compared to observed

Type	Mean Square Error	Weighted Average*	Sample Size
All Land Uses	128.3	1.02	44
Convenience Markets	155.9	0.98	24
High-Turnover (Sit-Down) Restaurants	117.4	1.17	16
Drinking Place	6.1	0.87	4

*Weighted averages less than one mean vehicle trips are overestimated (estimated vehicle trips > actual vehicle trips); values greater than one mean vehicle trips are underestimated.

Table 6-1 shows the comparison between estimated exiting vehicle trips and observed exiting vehicle trips. Weighted averages indicate the accuracy of the estimation method (Equation 6-1). Restaurants tend to have underestimated vehicle trips when compared with observed counts (weighted average > 1.0). Drinking places tend to have overestimated vehicle trips, but that may be due to smaller sample size. Overall, the weighted average between observed and estimated vehicle trips for all land uses is very close to 1.0, suggesting that converting person trips to vehicle trips using observed mode share and vehicle occupancy is a valid approach. This method could be applied elsewhere, since estimating vehicle trips in highly urbanized areas is difficult.

APPENDIX F. ADJUSTED VEHICLE TRIP RATE GRAPHICS

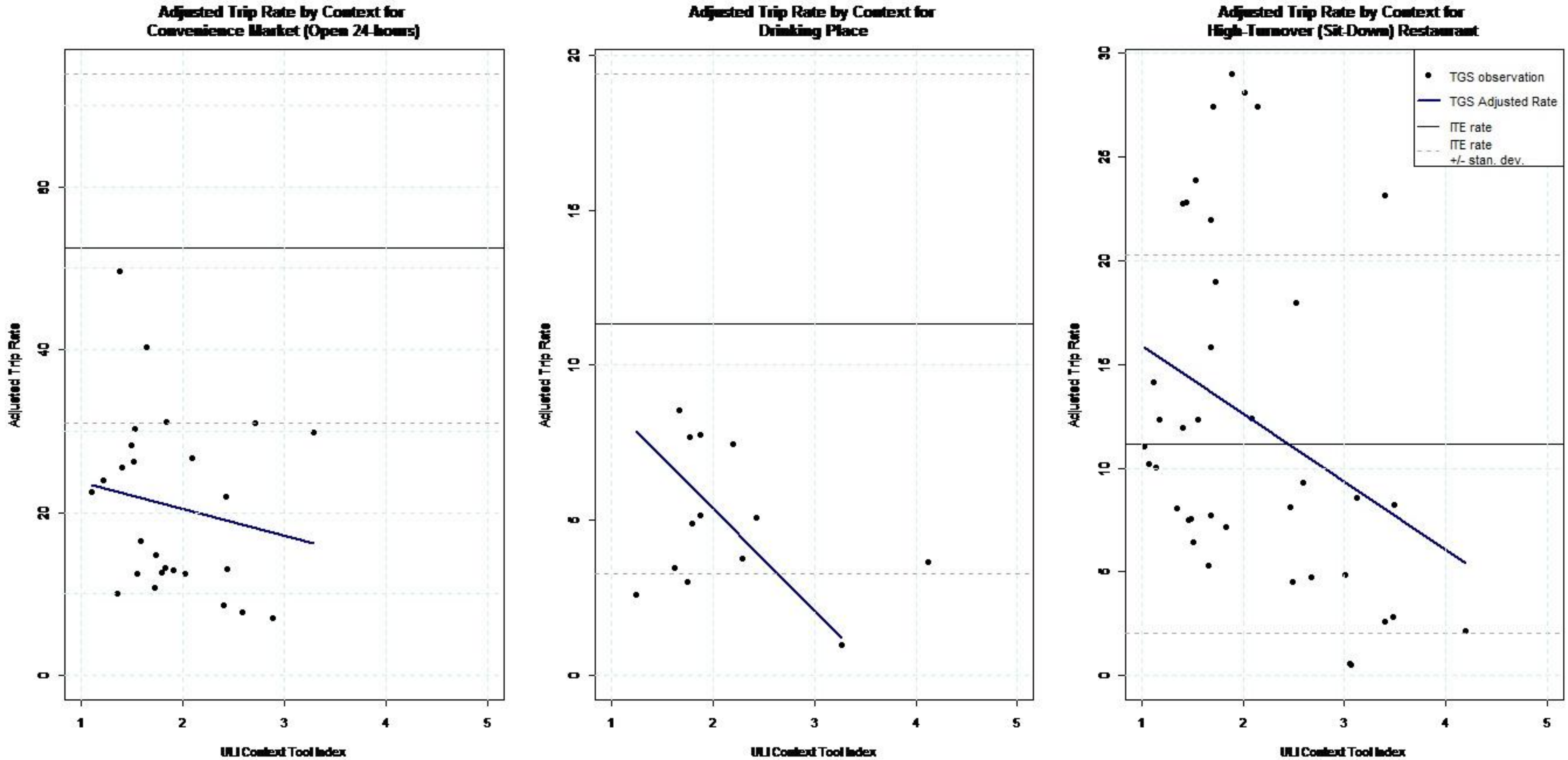


Figure 6-3. Adjusted Vehicle Trip Rate by Average ULI Score and Land Use

APPENDIX G. BIBLIOGRAPHY

Badoe, Daniel. "Transportation - Land-use Interaction: empirical findings in North America, and their implications for modeling." *Transportation Research. Part A: Policy and Practice* (National Academiy for the Sciences), 2000: 263.

Baltimore City Department of Transportation. "Procedures and Requirements for Conducting a Traffic Impact Study in Baltimore City." Baltimore City, Maryland, 2007.

Bedford County Department of Planning. "Bedford County Traffic Impact Study (TIS) Guidelines." Bedford, VA, 2004.

Bochner, Brian S., Kevin Hooper, Benjamin Sperry, and Robert Dunphy. *NCHRP Report 684: Enhancing Internal Trip Capture Estimation for Mixed-Use Developments.* Washington, D.C.: Transportation Research Board, 2011.

Cervero, Robert. *Ridership Impacts of Transit-Focused Development in California (UCTC No. 76).* Working Paper, Berkeley, CA: The University of California Transportation Center, 1993.

Cervero, Robert. "Transit-Oriented Development's Ridership Bonus: A Product of Self-Selection and Public Policies." *Environment and Planning A* 39 (2007): 68-85.

Cervero, Robert, and G. B. Arrington. *TCRP Report 128: Effects of TOD on Housing, Parking, and Travel.* Washington, D.C.: Transit Research Board, 2008a.

Cervero, Robert, and G. B. Arrington. "Vehicle Trip Reduction Impacts of Transit-Oriented Housing." *Journal of Public Transportation* 11, no. 3 (2008b): 1-17.

Cervero, Robert, and Kara Kockelman. "Travel Demand and the 3Ds: Density, Diversity, and Design." *Transportation Research: D* 2, no. 3 (1997): 199-219.

Charlotte Department of Transportation. "Land Development Rezoning and Traffic Impact Study Review Process." Charlotte, Carolina, 2006.

City of Bellingham. "Development Guidelines & Improvement Standards: Section 11-2.02 Traffic Studies: Project Trip Generation and Design-Hour Volumes." Bellingham, WA, 2012.

City of Bellingham. "Development Guidelines & Improvement Standards; Section 11-2.13 Traffic Studies: Technical Requirements of Final Report." Bellingham, Washington, 2012.

City of Bend. "Bend Code - Chapter 10-10 - Development Code." City of Bend, Oregon, 2009.

City of Frisco. "Article IV: Site Development Requirements; Seciton 10: Traffic Impact Analysis and Mitigation." City of Frisco, Texas, 2005.

City of Henderson, Department of Public Works. “Traffic Impact Analysis Guidelines.” City of Henderson, Nevada, 2009 February.

City of Los Angeles Department of Transportation. "Traffic Study Policies and Procedures (December 2010)." Los Angeles, California, 2010.

City of Mississauga. "Traffic Impact Study Guidelines." Mississauga, Canada, 2008.

City of Pasadena. “Transportaiton impact Review Current Practice and Guidelines.” City of Pasadena, California, 2005 August 24.

City of Rockville. "Comprehensive Transportation Review (21 March 2011)." Rockville, Maryland, 2011.

City of Salem. "Development Bulletin 19: Transportation Impact Analysis (20 January 1995)." Salem, OR, 1995.

City of San Diego. "Traffic Impact Study Manual (July 1998)." San Diego, CA, 1998.

City of Sedro-Woolley. "Traffic Impact Study Guidelines (14 July 2004)." 2004.

City of Vancouver. "City of Vancouver Traffic Study Requirements." City of Vancouver, WA, 2010.

Clark, Ian. "Trip Rate and Parking Databases in New." *National convergence: let's sort out our differences : conference papers : 2007 AITPM National Conference.* Canberra, Austrialia: Austrialian Institute of Traffic Planning and Management, 2007.

Colorado/Wyoming ITE Section Technical Committee - Trip Generation. "Trip Generation for Mixed-Use Developments." *Institute of Transportation Engineers Journal* 57, no. 2 (February 1987): 27-32.

Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption. *Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions.* Special Report 298, Board on Energy and Environmental Systems, Transportation Research Board, National Academy of Sciences, 2009.

Crowley, David, Amer Shalaby, and Hossein Zarei. "Access Walking Distance, Transit Use and Transit-Oriented Development in North York City Center, Toronto, Canada." *Transportation Research Record: Journal of Transportation Research Board* (Transportation Research Board) 2110 (2009): 96-105.

Dill, Jennifer. “Transit Use and Proximity to Rail: Results from Large Employment Sites in the San Francisco, California, Bay Area: Paper No. 03-4352.” *Transportation Research Record*, 2003: 19-24.

Dill, Jennifer. “Transit Use at Transit-Oriented Developments in Portland, Oregon, Area.” *Transportation Research Record: Journal of the Transportation Research Board* 2063 (December 2008): 159-167.

D'sousa, Ed, et al. *Neighborhood Environment for Active Transport--Geographic Information System--version 5.1.* Manual, University of Minnesota Center for Transport Studies, 2012.

Ewing, Reid, and Robert Cervero. "Travel and the Built Environment: A Meta-study." *Journal of the American* 76, no. 3 (2010): 265-294.

Ewing, Reid, and Robert Cervero. “Travel and the Built Environment: A Synthesis.” *Transportation Research Record: Journal of the Transportation Research Board* (Presented at the Transportation Reserach Record 1780) 1780 (2001): 87-114.

Fehr & Peers. "Summary of Research Demonstrating that Smart Growth Reduces Traffic." Internal - Referenced in Samdahl, Donald. Travel Demand Research for Downtown Kent. Kent, Washington: Fehr & Peers, 2010., 2008.

Fleet, Christopher, and Arthur Sosslau. "Trip Generation Procedures: An Improved Design for Today's Needs." *Institute of Transportation Engineering Journal* 46, no. 11 (November 1976).

Gard, John. “Innovative Intermodal Solutions for Urban Transportation Paper Award: Quantifying Transit-Oriented Develpment's Ability to Change Travel Behavior.” *Institute of Transportation Engineers Journal* 80, no. 11 (2007): 42-46.

Georgia Regional Tranpsortation Authority. “GRTA DRI Review Package Technical Guidelines.” 2002 January 14.

Guo, Jessica, Chandra Bhat, and Rachel Copperman. "Effect of Built Environment of Motorized and Nonmotorized Trip Making: Substitutive, Complementary or Synergistic?" *Transportation Research Repord: Journal of the Transportation Research Board*, January 2007: 1-11.

Hagler Bailly Services, Inc. and Criterion Planners/Engineers. *The Transportatoin and Environmental Impacts of Infill Versus Greenfield Development: A Comparative Case Study Analysis: EPA Pub. Number 231-R-99-005.* Environmental Protection Agency, 1999.

Harris County, Texas. "Chapter 5, Article II of the Land Development Code: Traffic Impact Analysis Guidelines." Harris County, TX, 1991.

Hooper, Kevin G. *NCHRP Report 323: Travel Characteristics at Large-Scale Suburban Activity Centers.* Research Report, Washington D.C.: Transportation Research Board, National Research Council, 1989.

Institute of Transportation Engineers. *Trip Generation Handbook: An ITE Recommended Practice, 2nd Ed.* Washington, D.C.: Institute of Transportation Engineers, 2004.

—. *Trip Generation: An Information Report , 8th Edition.* Washington, D.C.: Institute of Transportation Engineers, 2008.

Jeihani, Mansoureh, and Ricardo A Camilo. *Trip Generation Studies for Special Generators (MD-09-SP808B4J).* Research Report, Maryland: State Highway Administration, Maryland Department of Transportation, 2009.

JHK & Associates, Pacific Rim Resources, and SG Associates. *DRAFT Final Report: Accessibility Measure and Transportatoin Impact Factor Study.* Salem, Oregon: for the Oregon Department of Transportaton/Oregon Department of Land Conservtion and Development, Transportation and Growth Management Program, 1996.

Kimley-Horn and Associates, Inc. *Trip Generation Rates fo rurban Infill Land Uses in California; Phase 2: Data Collection.* California: Caltrans, 2009 June 15.

Lapham, Michael. *Transit-Oriented Development - Trip Generation & Mode Split in the Portlan dMetropolitan Region.* Portland, Oregon: Portland State University, 2001.

Lee, Richard, et al. *Evaluation of Operation and Accuracy of Five Available Smart Growth Trip Generation Methodologies (UCD-ITS-RR-11-12).* Research Report, Davis, CA.: Institute of Transportation Studies, University of California, Davis, 2011.

Lerner-Lam, Eva, Stephen P. Celniker, Gary W. Halbert, Chester Chellman, and Sherry Ryan. "Neo-Traditional Neighborhood Design and Its Implications for Traffic Engineering." *Institute of Transportation Engineers* 62, no. 1 (1992).

Lund, Hollie M., Robert Cervero, and Richard W Willson. *Travel Characteristics of Transit-Oriented Developmen in California.* California: Caltrans Transportation Grant "Statewide Planning Studies" FTA Section 5313(b), 2004.

Montgomery Planning. *Local Area Transportation Review.* Montgomery County, Maryland.: The Maryland National Capital Park and Planning Commission, 2010.

Nelson\Nygaard Consulting Associates. "Crediting Low-Traffic Developments: Adjusting Site-Level Vehicle Trip Generation Using URBEMIS." San Francsico, California, 2005.

New South Wales Roads and Traffic Authority. *Guide to Traffic Generation Developments, Version 2.2.* Sydney, Austrailia: Roads and Traffic Authority (RTA), 2002.

New York City. *City Environmental Quality Review (CEQR): Chapter 16.* New York City, NY: Mayor's Office of Environmental Coordination, 2010.

New Zealand Trips and Parking Database Bureau (NZTPDB). *New Zealand Trips and Parking Database Bureau.* 2012. www.tdbonline.org (accessed 07 11, 2012).

Renne, John Luciano. “Transit-Oriented Development: Measureing Benefits, Analyzing Trends, and Evaluating Policy.” *Urban Planning dissertation.* New Brunswick, New Jersey: Rutgers, The State University of New Jersey, 2005.

Rizavi, Amir, and Alfred Yeung. “Urban Commuting Trends - Comparing Trip Generation Practices.” *Institute of Transportation Engineers.* Vancourver: Institute of Transportation Engineers, 2010.

Samdahl, Donald. *Travel Demand Research for Downtown Kent.* Memorandum submitted to the City of Kent WA, June 28, 2010, Kent, Washington: Fehr & Peers, 2010.

Samdahl, Donald. *Travel Demand Research for Downtown Kent.* Memorandum submitted to the City of Kent WA, June 28, 2010, Kent, Washington: Fehr & Peers, 2010.

San Diego Association of Governments (SANDAG). “Trip Generation for Smart Growth: Planning tools for the San Diego Region.” San Diego, CA., 2010.

San Diego Municipal Code. “Land Development Code: Trip General Manual.” San Diego, California, 2003 May.

San Francisco Planning Department. *Transportatoin Impact Analysis Guildelines for Environmental Review.* San Francisco, California: City and County of San Francisco, 2002.

Schneider, Robert J. *Understanding Sustainable Transportation Choices: Shifting Routine Automobile Travel to Walking and Bicycling (UCTC-DISS-2011-01).* Dissertation, Berkeley, CA: University of California Transportation Center, 2011.

Seskin, S. N., Robert Cervero, and Jeffrey Zupan. *NCHRP Report No. 16: Transit and Urban Form.* Washington, D.C.: National Academy Press, 1996.

Southern New Hampshire Planning Commission. "Trip Generation Study." New Hampshire, 2010.

Sperry, Benjamin R. "Comparing Methodologies to Estimate Internal Trip Capture at Mixed-Use Developments." *Institute of Transportation Engineers, Annual Meeting.* Institute of Transportation Engineers, 2010.

State of Flordia Department of Community Affairs. "Transportation Concurrency Requirements and Best Practices: Guidelines for developing and maintaining an effective transportation concurrency management system (September 2006)." Tallahassee, FL, 2006.

Steiner, R. L. “Traditional Shopping centers.” *Access: Research at the University of California Transportation Center* 12 (1998): 8-13.

Trip Rate Information Computer System (TRICS). "Trip Rate Information Computer System Good Practice Guide." UK and Ireland, 2012.

Virginia Department of Transportaiton. “Traffic impact Analysis Regulations Small Area Plan Amendments: 24VAC30-155-60.D.1: Traffic Impact Statement.” Virginia, 2010 April.

Walters, Jerry. *Statewide Improvements of Tools for Regional & local Smart-Growth Planning.* Presentation to Caltrans, Caltrans: Fehr & Peers, 2009.

Contextual Influences on Trip Generation

Project Overview

TPAC Meeting
08/31/2012

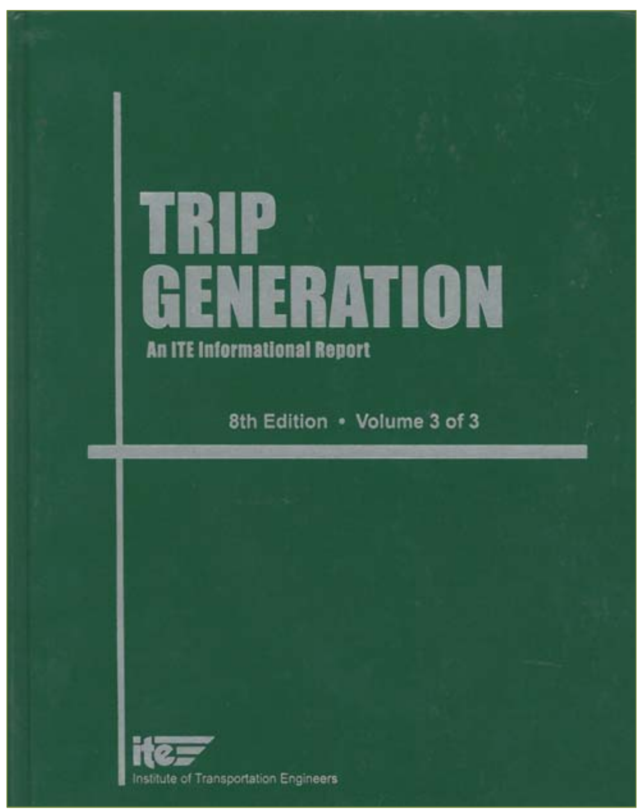
Outline

- Background and Project Goals
- Methodology
  - Site Selection
  - Data Collection
  - Analysis
  - Local Adjustment Model
  - Verification of Approach
- Implications for Planning and Policy
- Conclusions & Limitations

BACKGROUND & PROJECT GOALS

Background

- *Trip Generation* represents the state of the practice for estimating impacts of new development.
- Manual includes methodological approach & data from ~5,000 sites.
- Data/methods focus on vehicle trips only
- Heavily biased toward suburban, automobile-oriented locations
- No consideration of urban context of new development

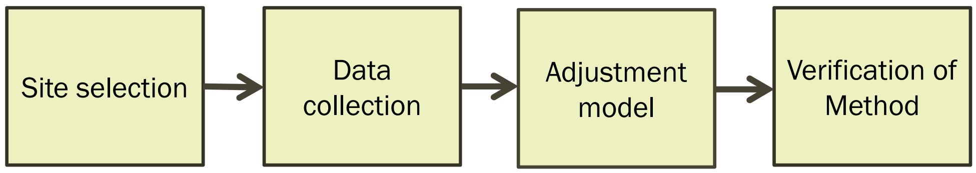


Project Goals

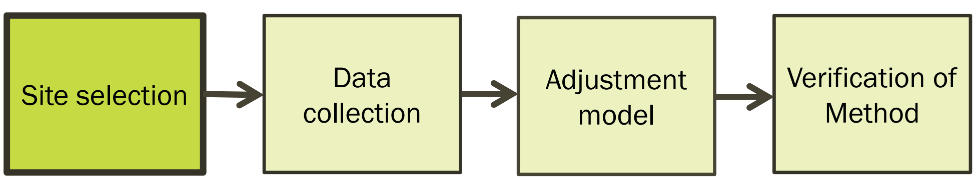
- To understand the influence that context has on trip generation, with emphasis on desired futures;
- Develop a consistent approach to adjusting trip generation rates (ITE) in the Portland metropolitan area; and
- Determine adjustment rates for three specific land uses.

METHODOLOGY

Methodology Overview

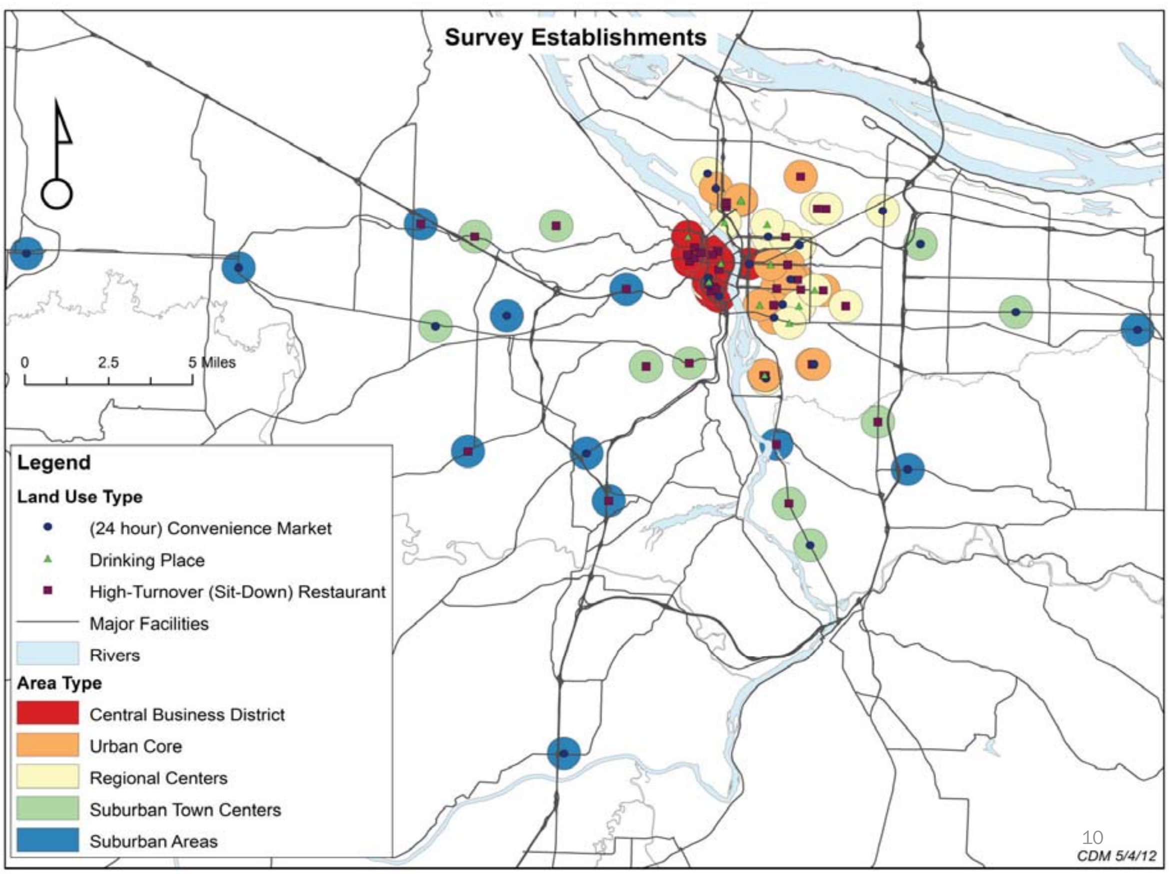


Methodology Overview



Site Selection

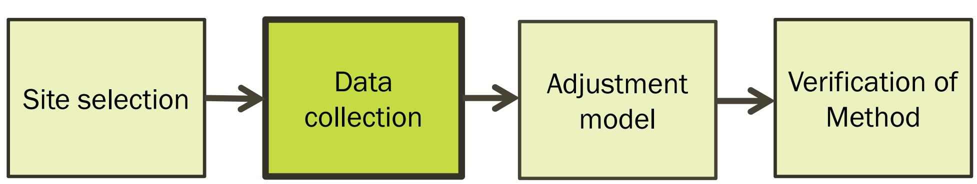
- Common land use types
  - Convenience Market (24-hours) – LU 851
  - High-Turnover (Sit-Down) Restaurant – LU 932
  - Drinking Place – LU 925
- Use built environment to help define area type
- Evening peak hour time period
  - Weekday, PM Peak Hour (5-7PM)
  - Attempt to include some of peak hour of generator (5-7PM) and facility (4–6PM)



Location Summary

Area Type	# Restaurant Locations	# Convenience Locations	# Bar Locations	Total
Central Business District	12	4	3	19
Urban Core Neighborhoods	10	5	6	21
Neighborhood and Regional Centers	6	6	4	16
Suburban Town Centers	5	7	0	12
Suburban Areas	6	4	0	10
Total	39	26	13	78

Methodology Overview



Data Collection

Long-Form Survey (Tablet)
Short-Form Survey

Monday – Thursday
5 – 7PM

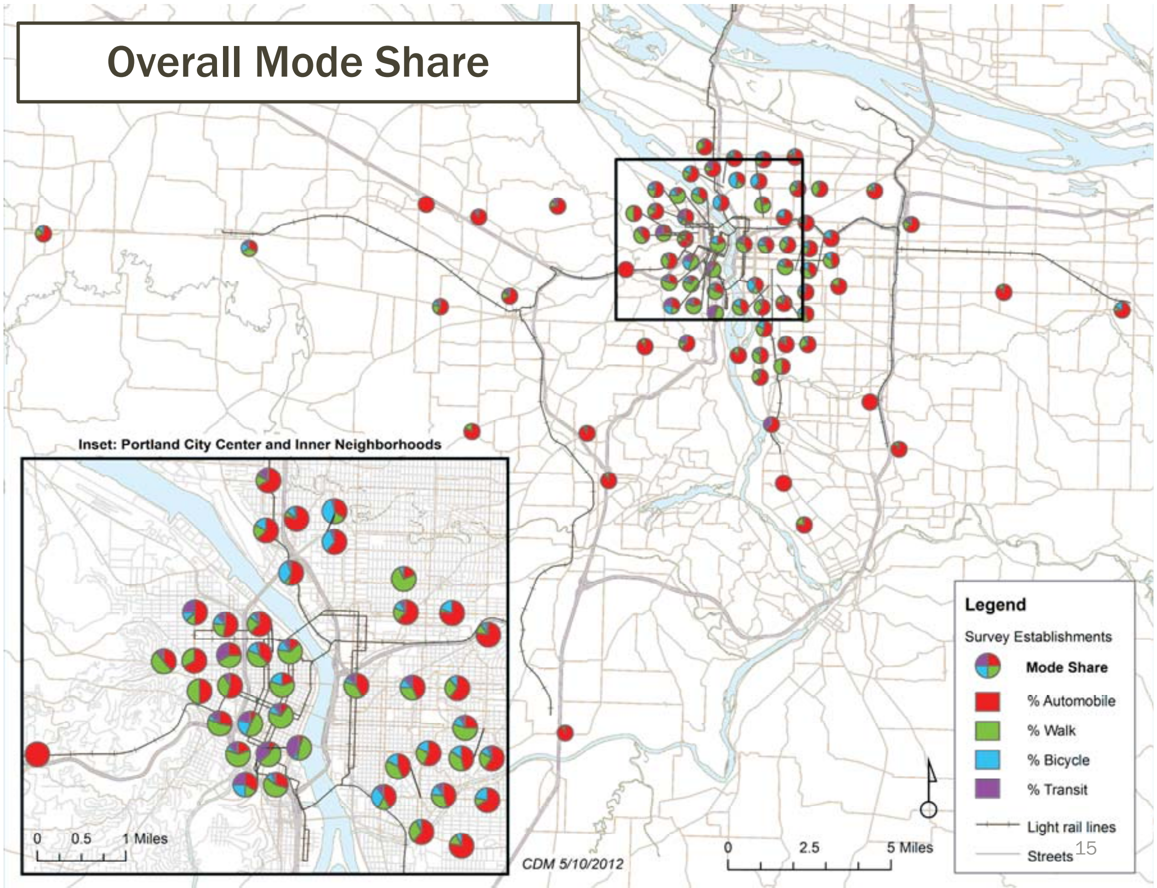
May through October

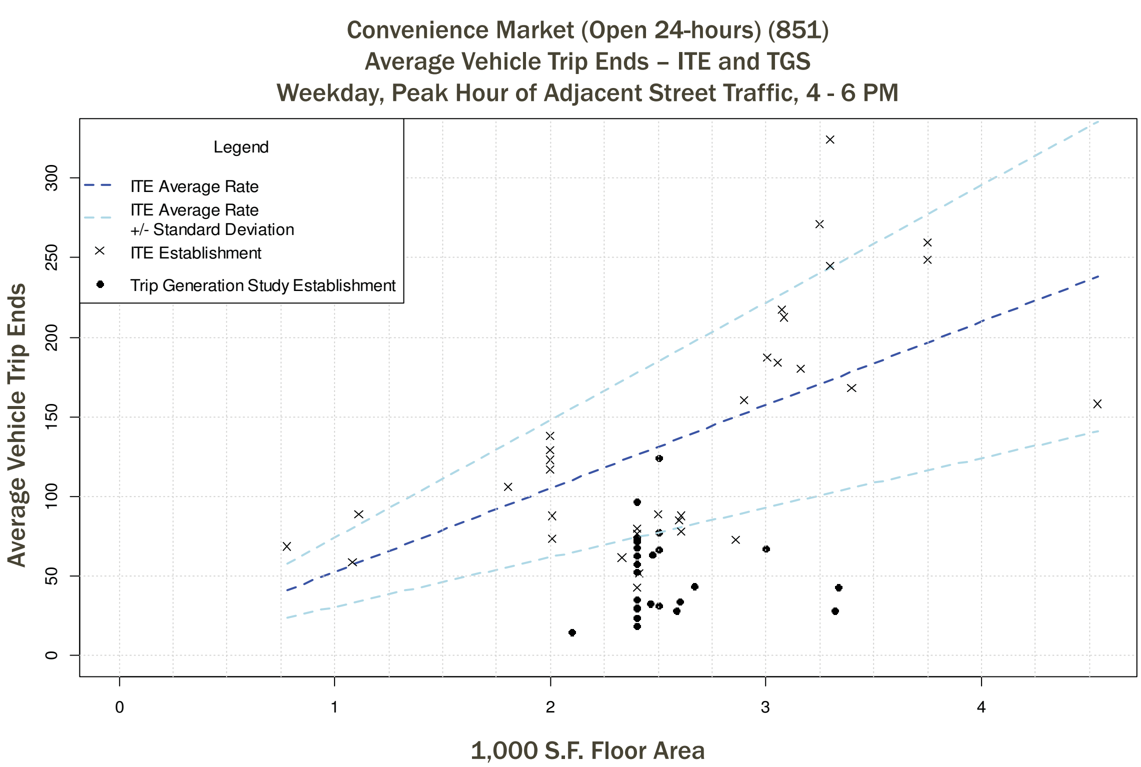
No data collection during rainy weather.

Data Collection Summary: Response Rate

Land Use	Establishments (N)	Long Surveys (N)	Short Surveys (N)	Response Rates		Total
				Long Survey*	Short and Long Survey**	
Drinking places	13	107	108	30%	50%	215
Convenience	26	281	710	14%	61%	991
Restaurants	39	309	369	24%	52%	678
Total	78	697	1187	19%	52%	1884

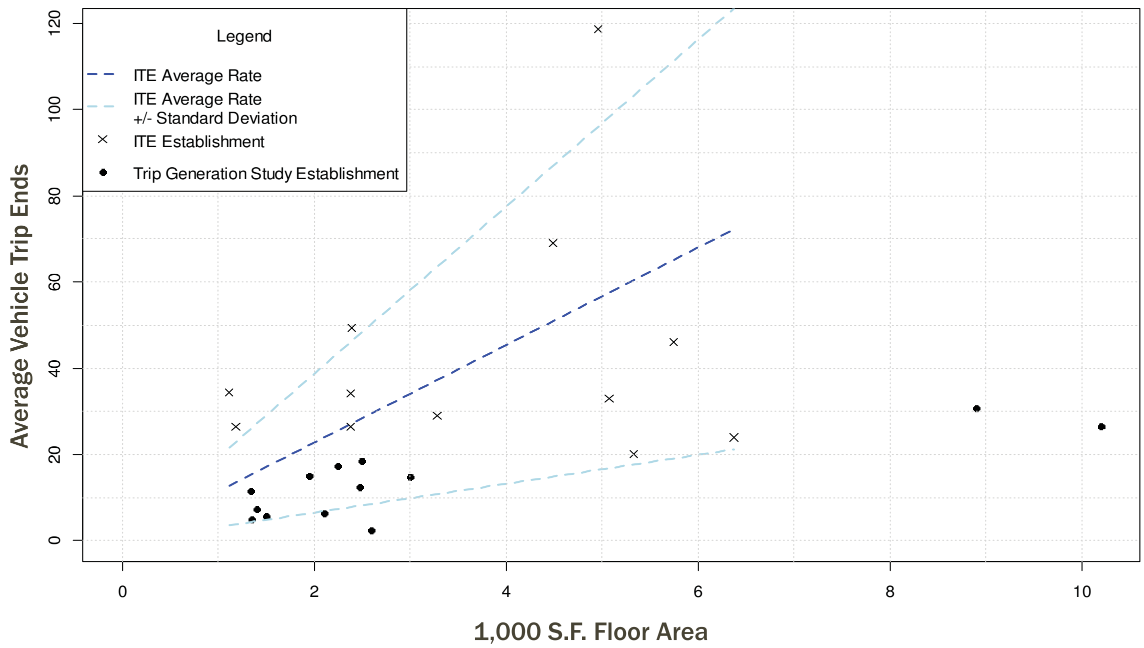
*Long survey response rate = $N_{long\ survey}$ / ($N_{long\ survey}$ + $N_{short\ survey}$ + refusals)
**Short and long survey response rate = ($N_{long\ survey}$ + $N_{short\ survey}$) / ($N_{long\ survey}$ + $N_{short\ survey}$ + refusals)





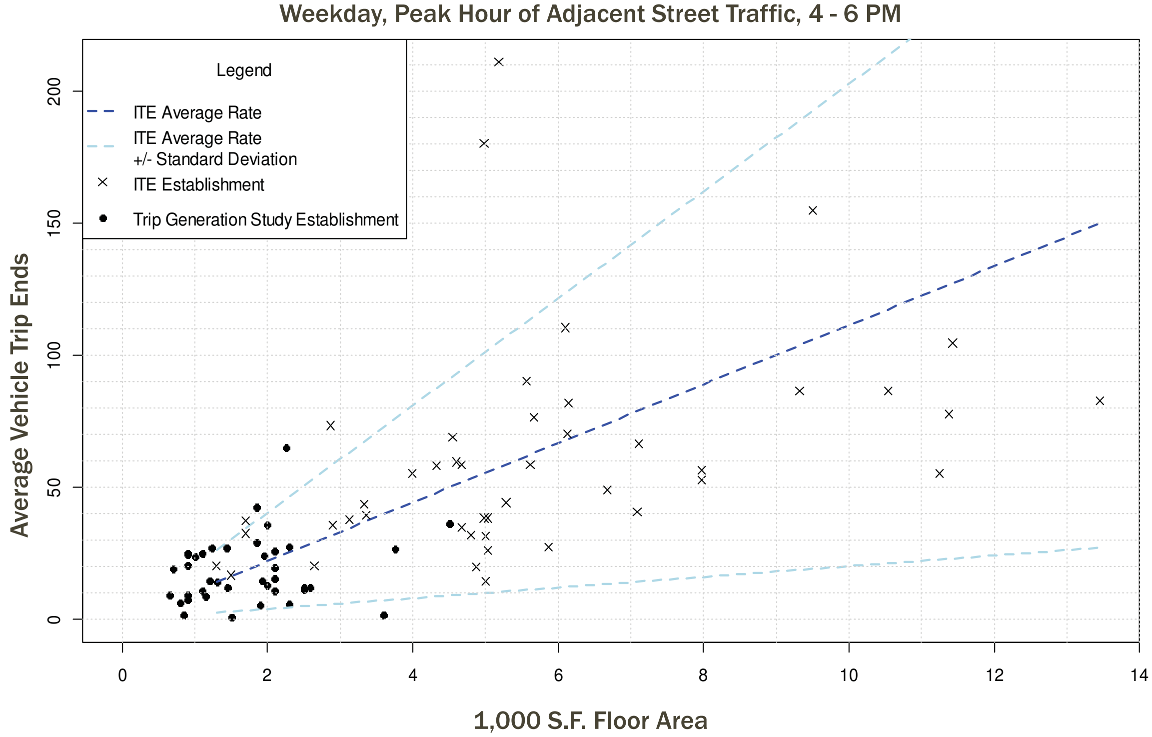
Note: TGS data includes weekday, 5-6PM.

Drinking Place (925)
Average Vehicle Trip Ends – ITE and TGS
Weekday, Peak Hour of Adjacent Street Traffic, 4 - 6 PM



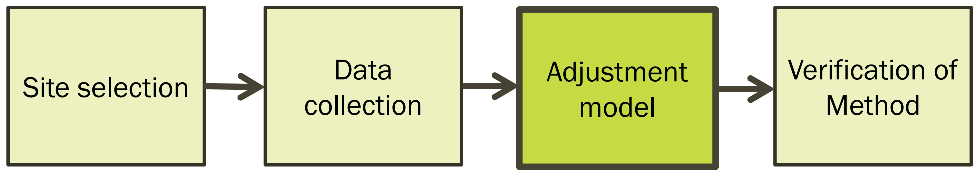
Note: TGS data includes weekday, 5-6PM.

High-Turnover (Sit-Down) Restaurant (932)
Average Vehicle Trip Ends – ITE and TGS
Weekday, Peak Hour of Adjacent Street Traffic, 4 - 6 PM



Note: TGS data includes weekday, 5-6PM.

Methodology Overview



Analysis of Adjustment by Context

- Built environment information was gathered from archived data sources at ½-mile buffer around establishments
- Measures associated with trip generation and mode choice (from literature review)
- Variety of statistical tests to determine best measure(s) to use in adjustment model
- Developed and estimated a model that improves ITE's predictive ability

Measure	Units	Data Source*
Number of Transit Corridors	# Trimet lines within ½-mile	Light-rail and Bus Stop layer (RLIS, 2010)
People Density	Residents and employees per acre	ESRI Business Analyst (2010) and Multifamily/Household layers (RLIS, 2010)
Number of High-Frequency Transit Stops	# stops within ½-mile with headways under 15 Minutes	Bus Stop layer (RLIS, 2010) and TriMet schedules (2011)
Employment Density	Employees per acre	ESRI Business Analyst (2010)
Lot Coverage	Percent	Tax lot and Building Layers (RLIS, 2010)
Length of Bike Facilities	Miles	Bike Route layer (RLIS, 2010)
Access to Rail	Presence of rail station within ½-mile	Light-rail Stop layer (RLIS, 2010)
Intersection Density	Intersections per million square feet	Lines file (TIGER 2009)
Median Block Perimeter	Miles	Faces file (TIGER 2009)
Urban Living Infrastructure	1 to 5 index	Metro Context Tool

Urban Context Adjustment Model

$$ADJ = 0.643 - 3.286 * ULI + 7.412 * REST - 26.043 * CONV$$

$$ADJ = VEH\ TRIPS_{TGS,LU} - VEH\ TRIPS_{ITE,LU} \equiv \text{Difference in vehicle trip rates}$$

$$ULI \equiv \text{Average of ULI values from Metro Context Tool within 1/2 mile buffer}$$

$$REST = \begin{Bmatrix} 1, \text{if ITE Land Use} = 932\text{: High}-\text{Turnover Restaurant} \\ 0, \text{if ITE Land Use} \neq 932\text{: High}-\text{Turnover Restaurant} \end{Bmatrix}$$

$$CONV = \begin{Bmatrix} 1, \text{if ITE Land Use} = 851\text{:Convenience Market} \\ 0, \text{if ITE Land Use} \neq 851\text{:Convenience Market} \end{Bmatrix}$$

$$Adjusted\ R^2 = 0.763$$

Note: Drinking places are the base case for the model

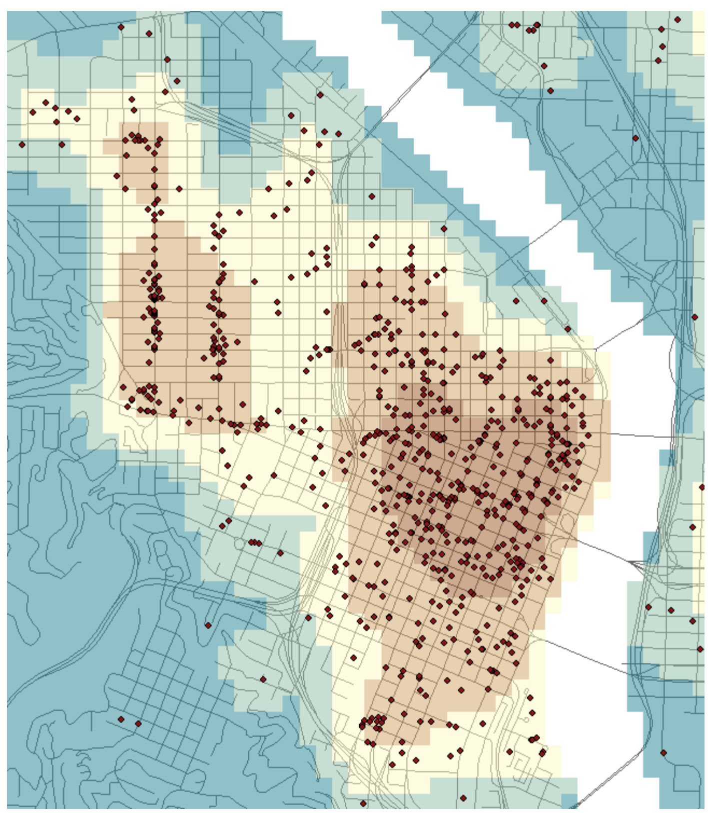
Urban Living Infrastructure (ULI)

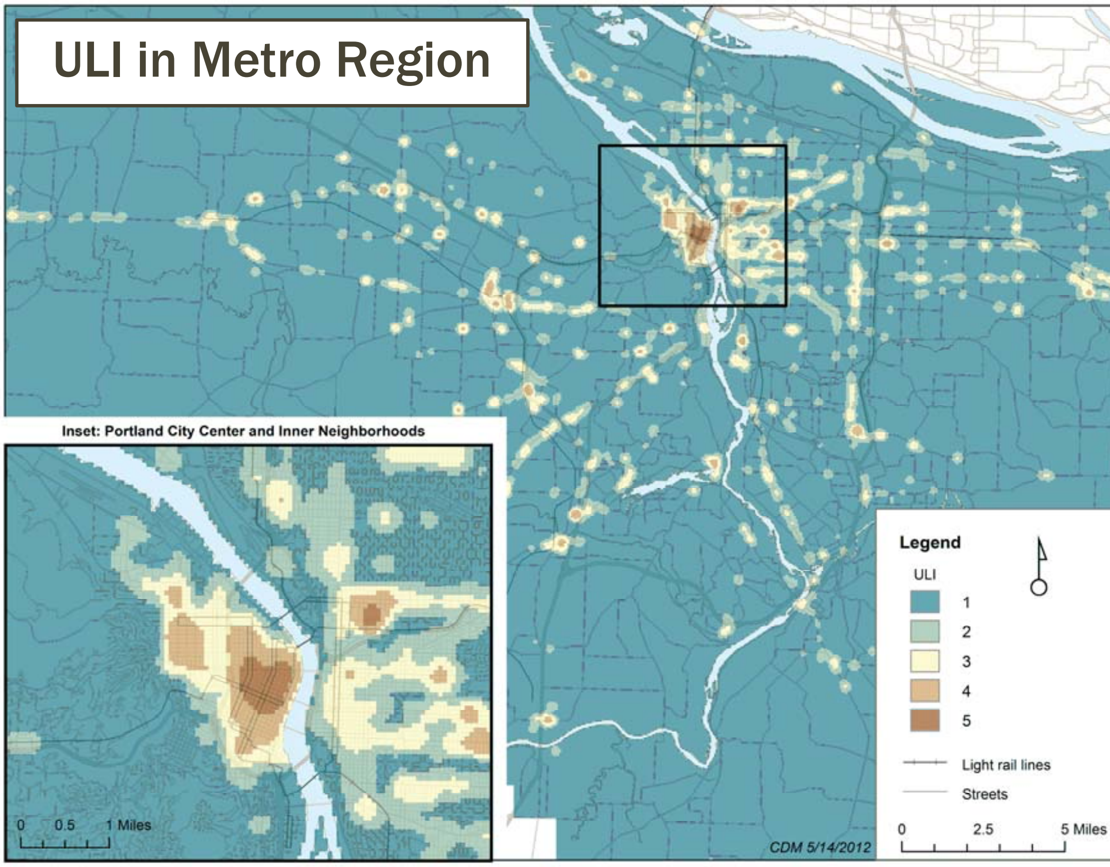
- Good model fit
- Correlated with other built environment measures
- Associated with non-automobile mode shares
- Available for the entire Metro region
- Can be used for transportation impact evaluation or long-range planning

What is ULI?

- Weighted index of density & diversity for retail/service businesses

- Areas with higher densities of desirable business types have higher ULI indices





ULI Category 1
Raleigh Hills

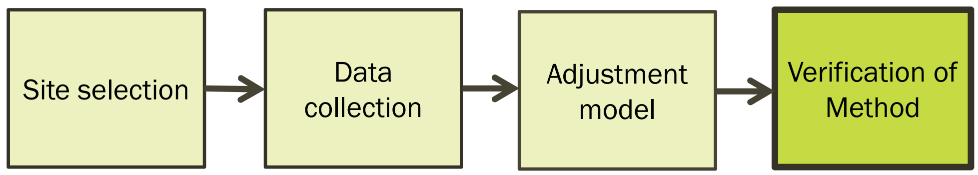
ULI Category 2
Hillsdale

ULI Category 3
Westmoreland/Clinton

ULI Category 4
Nobb Hill/NW 23rd

ULI Category 5
Downtown

Methodology Overview



Verification

- Test adjustment method using new locations
- Data collected at 34 establishments
- Vehicle Counts, PM Peak, April-May 2012
- UCA improves estimates for Convenience Markets and Drinking Places
- UCA and ITE estimates for Restaurants are comparable

Verification

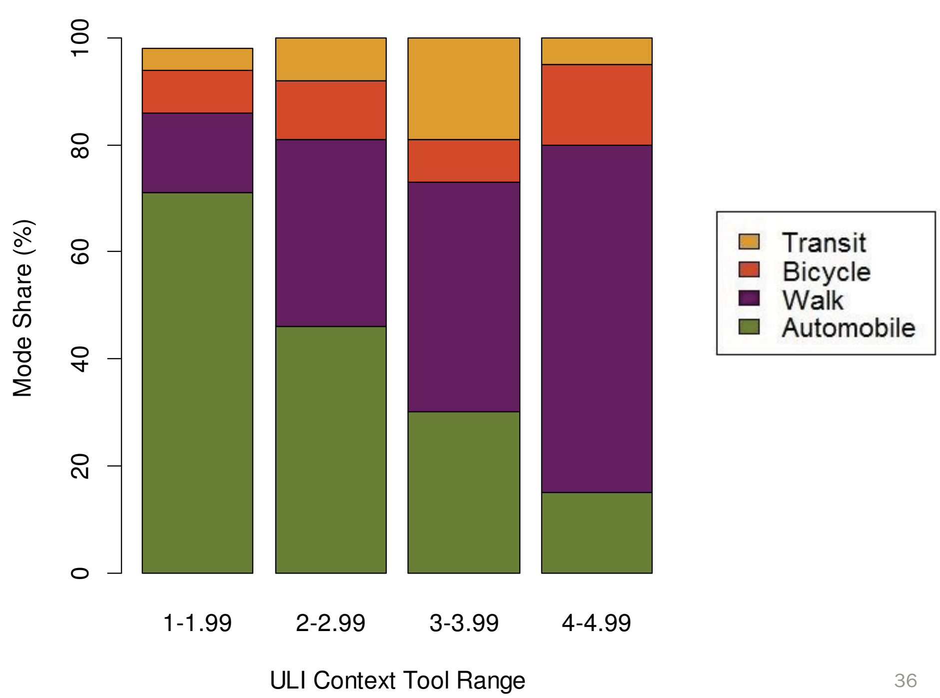
		Convenience Market (Open 24-hours)	Drinking Place	High-Turnover (Sit-Down) Restaurants
		LU (851)	LU (925)	LU (932)
Sample Size		10	12	12
Mean Squared Error	UCA	38	10	29
	ITE	1120	30	33
Average Percent Error	UCA	32%	31%	68%
	ITE	195%	119%	63%

IMPLICATIONS FOR PLANNING & POLICY

Applications

- Information and methods can be used for:
  - Analyzing transportation impacts of new development
  - Establishing planning targets based on desired mode shares
- Can relate to a variety of context measures that are influenced by planning & policy

ULI Ranges and Mode Splits



ULI & Other Built Environment Measures[1]

	Avg. Built Environment Measure				
Range of ULI Score:	1 - 1.99	2 - 2.99	3 - 3.99	4 - 4.99	ALL
Employment Density (employees per acre)	6	24	66	37	21
People Density (residents + employees per acre)	16	38	90	158	34
Lot Coverage (%)	20%	33%	50%	66%	28%
Intersection Density (per 1,000,000 sq. ft.)	6	10	12	14	8
Median Block Perimeter (mi.)	2.5	1.6	1.6	1.5	2.1

[1]Built environment variables correlated with ULI and also significant in predicting adjustment to ITE.

ULI & Other Built Environment Measures[1]

	Avg. Built Environment Measure (units)				
Range of ULI Score:	1 - 1.99	2 - 2.99	3 - 3.99	4 - 4.99	ALL
Length of Bike Facilities (mi.)	5.2	7.3	11.3	13.3	6.7
Rail Access (within buffer)	30%	53%	90%	100%	45%
Number of Transit Corridors (count)	9	26	72	98	24
Number of High-Frequency Bus Routes (count)	19	58	125	200	47

[1]Built environment variables correlated with ULI and also significant in predicting adjustment to ITE.

Conclusions

- Person counts combined with intercept survey data are basis of method
- Simple, verified method for adjustment to ITE
- Can be applied anywhere
- First step in addressing ITE's deficiencies in in-fill, TOD and smart growth developments

Limitations

- Limited land uses
- Sample size small (although comparable to ITE's)
  - No segmented adjustment models by land use type
  - Too much variation in micro-scale environment for inclusion in statistical analysis
- Built environment measures highly correlated
- ULI is Metro specific; cannot (easily) extend model off the shelf

Recommendations

- Establish local rates or method for Metro region
- Collect data on all modes and on person trips
- Build evidentiary database of local transportation impact analysis studies
- Make local data available online (PSU)
- Advocate to ITE for these changes nationally

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Questions?

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