Transit Ridership and the Built Environment

Del Peterson
Associate Research Fellow
Transportation Seminar Series
October 18, 2011

Small Urban & Rural Transit Center
NDSU NORTH DAKOTA STATE UNIVERSITY
UGPTI Upper Great Plains Transportation Institute
North Dakota State University

Outline

- Objective
- Variables
- Literature Review
- Study Area
- Methodology
- Data Analysis
- Findings and Conclusions

Objective

- Determine what built environment variables play an important role in determining the land use/transit ridership relationship in the Fargo-Moorhead community.

- Demographic and level-of-service variables were also considered.

The Built Environment

- Consists of everything humanly made, arranged, or maintained

  (Bartuska and Young 1994)

Variables

Label	Type
Bus Ridership (2010)	Ridership
Bus Wait Time	Level-of-Service
Income	Demographic
No-vehicle Households	Demographic
Percent Female	Demographic
Percent Minority	Demographic
Percent Youth	Demographic
Percent Elderly	Demographic
Percent Renters	Demographic
Housing Units per Acre	Built Environment
Intersection Density	Built Environment
Land-use Mix	Built Environment
Walkability	Built Environment

Literature Review

- Ewing and Cervero (2001)
  - Total household vehicle travel is a function of accessibility
  - A mixed-use development in the middle of nowhere does not guarantee travel benefits for its inhabitants
- Handy et al. (2005)
  - Miles driven in suburban neighborhoods (built recently) were 18% higher compared to traditional neighborhoods (pre-World War II era)
- Ryan and Frank (2009)
  - Support for transit planning with centrally-located stops within dense, mixed-use activity centers, rather than stops on the edges of activity centers that appease residents

Study Area

- Fargo, Moorhead, West Fargo

City	Population	White	Minority	No Vehicle Households	Travel Time to Work	Drive Alone to Work	Alternative Travel to Work
Fargo	103,000	92%	8%	7%	14.7 min	84%	6%
Moorhead	35,000	92%	8%	8%	14.4 min	76%	11%
West Fargo	25,000	95%	5%	4%	15.7 min	87%	<2%

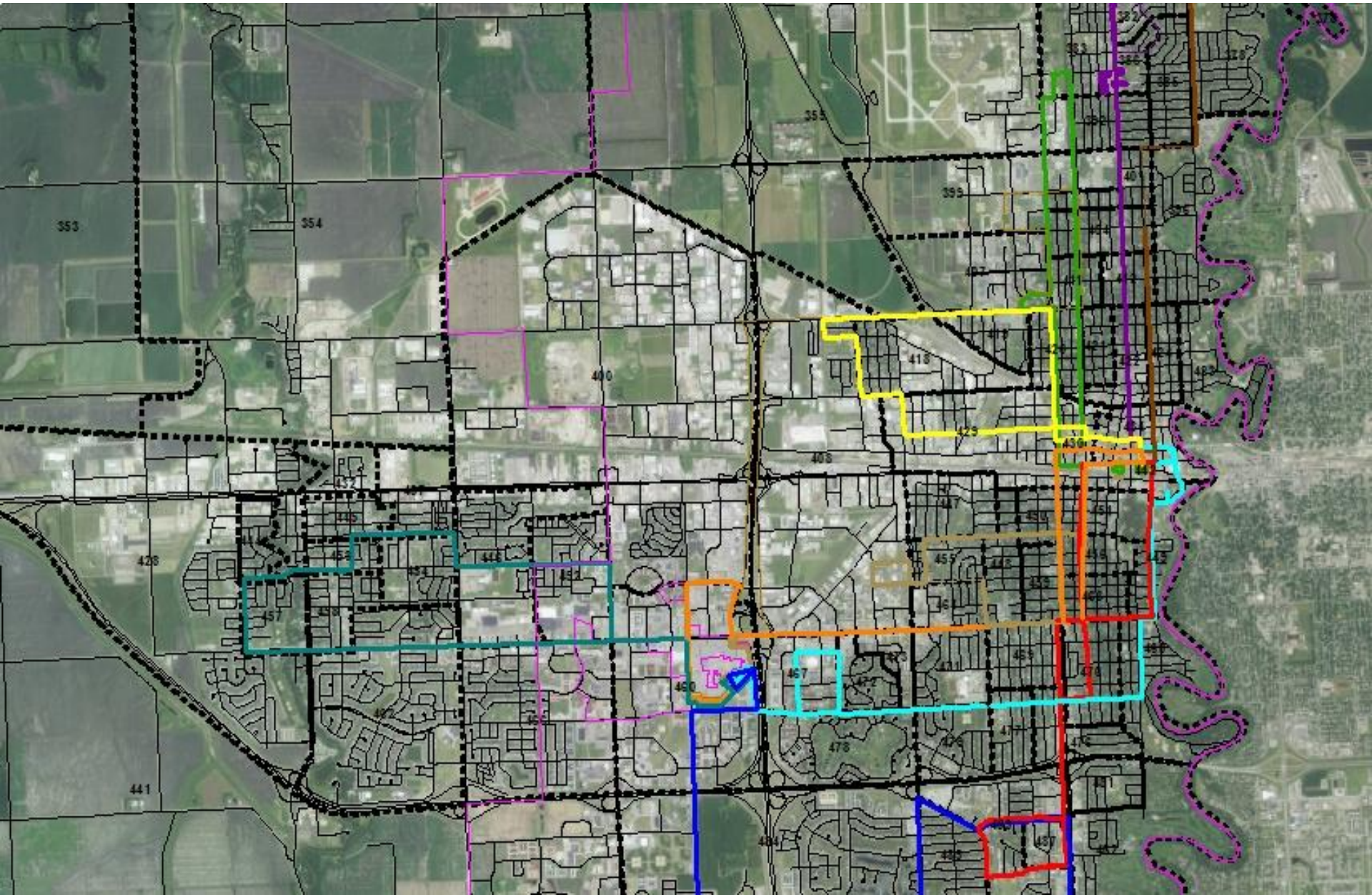
U.S. Census (2005)

Studied the 15 “Traditional” Fixed-Routes

Methodology

Variable	Description	Sources
Bus Ridership (2010)	Weekly number of passengers boarding buses on a particular route	Metro Area Transit
Level of Service	Wait time between buses on a particular route	Metro Area Transit
Income	Median Household Income	U.S. Census
No-vehicle Households	Number of total households that do not have a vehicle	U.S. Census
Percent Female	Percent of total population that is female	U.S. Census
Percent Minority	Percent of total population that is not white	U.S. Census
Percent Youth	Percent of total population age 17 and younger	U.S. Census
Percent Elderly	Percent of total population age 65 and older	U.S. Census
Percent Renters	Percent of total households that rent	U.S. Census
Housing Units per Acre	Number of housing units per residential acre	U.S. Census, Cities of Fargo, Moorhead, West Fargo Land-use Shapefiles
Intersection Density	Number of intersections per acre	Cities of Fargo, Moorhead, West Fargo Road Network Shapefiles
Land-use Mix	Proportion of eight land-use types within route area	Cities of Fargo, Moorhead, West Fargo Land-use Shapefiles
Walkability	Combination of residential density, intersection density, and land-use mix	U.S. Census, Cities of Fargo, Moorhead, West Fargo Land-use Shapefiles

Data Development (GIS)



Data Development (Land Use Mix)

- Land Uses: Residential, Park/Rec, Industrial, Commercial, Institutional, Office, Mixed-Use, Vacant
- $MIX = \frac{-\sum[Pn * \ln(Pn)]}{\ln(N)}$

  N= the number of different land uses in the route buffer area

  Pn= the proportion of acres on the n^{th} land use within the route buffer area

Example 1: 92% Residential 8% Institutional **MIX=0.41**

Example 2: 4% Residential 22% Institutional
21% Commercial 53% Mixed-Use **MIX=0.82**

Data Development (Walkability)

- W= 2x[Z(Land-use Mix) + Z(Residential Density) + Z(Intersection Density)]
- Z-Score= $\frac{x-\mu}{\sigma}$

  X= observation value

  μ= mean of the dataset

  σ= standard deviation of the dataset

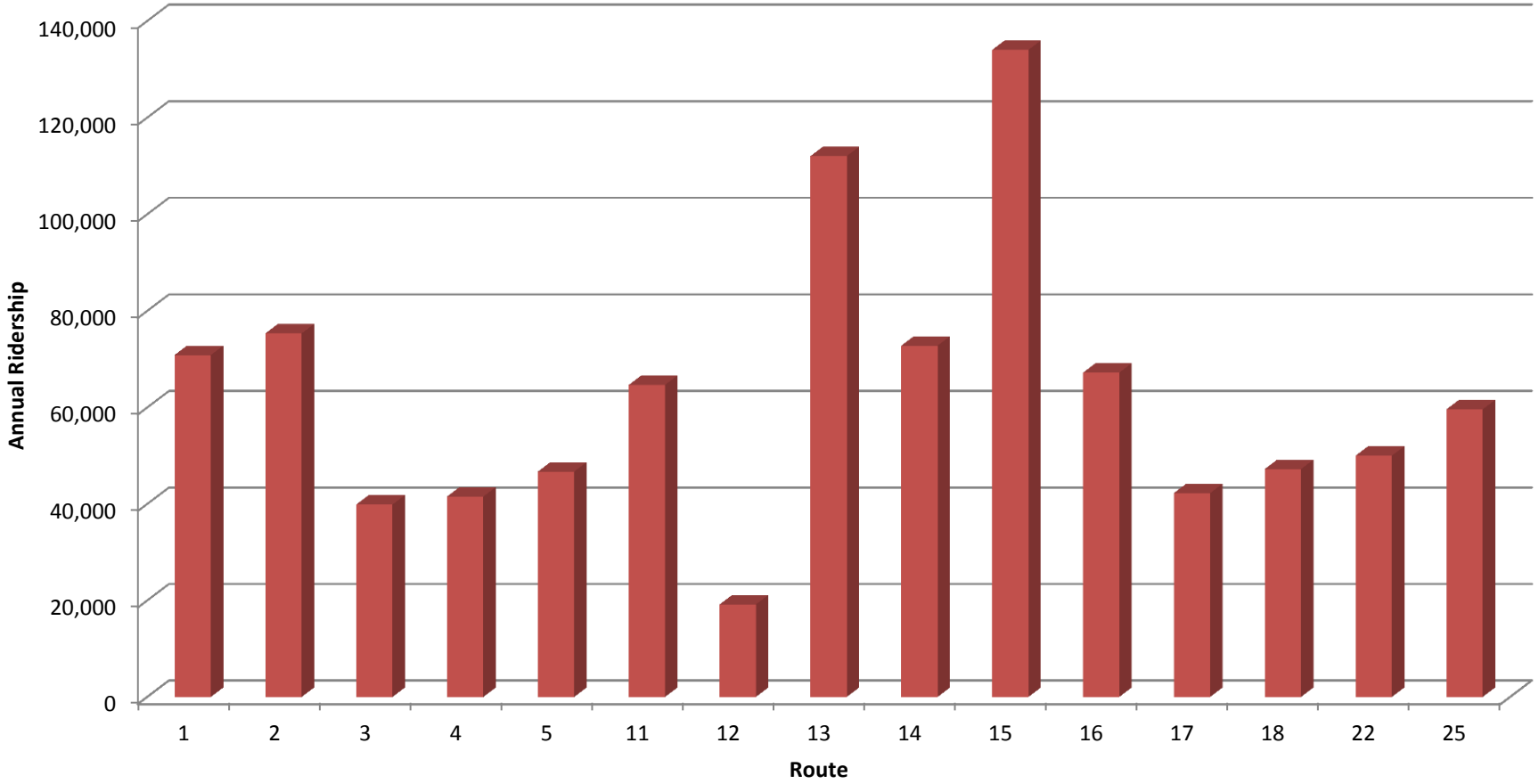
Example 1: (0.71)Land-use Mix (-0.14)Residential Density (-0.04) Intersection Density **W= 1.05**

Example 2: (-0.01) Land-use Mix (-0.83)Residential Density (-1.34) Intersection Density **W=-4.36**

Data Analysis (Descriptive Statistics)

Variable	Units	Range	Mean	Std. Dev.
Bus Ridership	Weekly passengers	99–3219	1252	634
Level of Service	Minutes	30–60	40	14
Income	U.S. Dollars	$8,646–$84,145	$35,452	$14,499
No-Vehicle Households	Households	3–508	53	56
Percent Female	Percent	31%–61%	50%	5%
Percent Minority	Percent	1%–78%	7%	8%
Percent Youth	Percent	1%–39%	20%	8%
Percent Elderly	Percent	0%–39%	12%	8%
Percent Renters	Percent	0%–90%	23%	19%
Housing Units per Acre	Housing units/acre	0–12.9	3.7	2.1
Intersection Density	Intersections/acre	0–0.46	0.22	0.11
Land-use Mix	Index	0–1	0.57	0.27
Walkability	Index	-10.06–10.12	0	3.87

Metro Area Transit (MAT) 2010 Ridership by Route



Income and Minority Results

Route	Annual Ridership	Median Household Income	Income Rank	% Minority	Minority Rank
15	134,011	$34,116	9	6	10
13	112,032	$26,637	14	18	1
2	75,337	$32,319	10	11	2
14	72,807	$37,312	6	7	8
1	70,856	$29,102	13	9	4
16	67,213	$43,007	3	4	14
11	64,673	$31,065	12	5	11
25	59,607	$48,983	1	5	11
22	49,998	$44,319	2	4	14
18	47,223	$31,464	11	8	6
5	46,707	$41,401	4	7	8
17	42,246	$20,990	15	9	4
4	41,539	$34,763	8	10	3
3	39,880	$37,178	7	8	6
12	19,171	$41,000	5	5	11

Residential Density Results

Route	Annual Ridership	Housing Units/Acre	Density Rank
15	134,011	5.2	1
13	112,032	5.1	2
2	75,337	3.4	9
14	72,807	4.8	4
1	70,856	3.6	7
16	67,213	3.5	8
11	64,673	5.0	3
25	59,607	2.5	12
22	49,998	2.9	10
18	47,223	4.6	5
5	46,707	2.0	15
17	42,246	2.6	11
4	41,539	2.2	14
3	39,880	2.4	13
12	19,171	3.8	6

Land-use Results

Route	Annual Ridership	Land-use Mix	Land-use Mix Rank
15	134,011	0.57	8
13	112,032	0.49	11
2	75,337	0.70	3
14	72,807	0.46	12
1	70,856	0.73	2
16	67,213	0.57	8
11	64,673	0.45	13
25	59,607	0.62	6
22	49,998	0.67	5
18	47,223	0.42	14
5	46,707	0.68	4
17	42,246	0.55	10
4	41,539	0.80	1
3	39,880	0.58	7
12	19,171	0.31	15

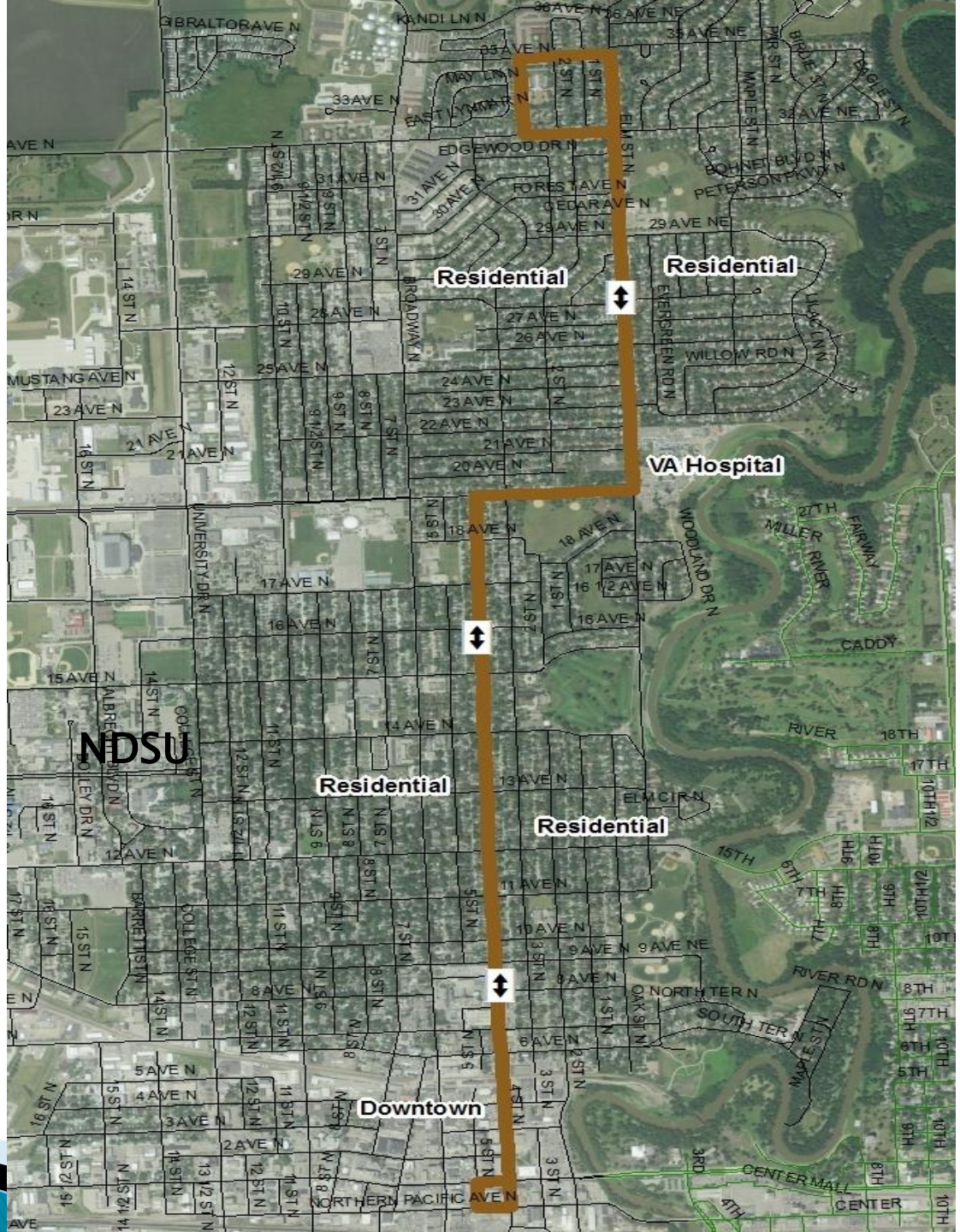
Walkability Results

Route	Annual Ridership	Walkability	Walkability Rank
15	134,011	1.74	2
13	112,032	1.21	5
2	75,337	2.58	1
14	72,807	0.62	7
1	70,856	1.74	2
16	67,213	-1.90	13
11	64,673	1.39	4
25	59,607	-3.06	15
22	49,998	-0.78	9
18	47,223	0.67	6
5	46,707	-1.96	14
17	42,246	-0.85	10
4	41,539	-0.21	8
3	39,880	-1.89	12
12	19,171	-1.32	11

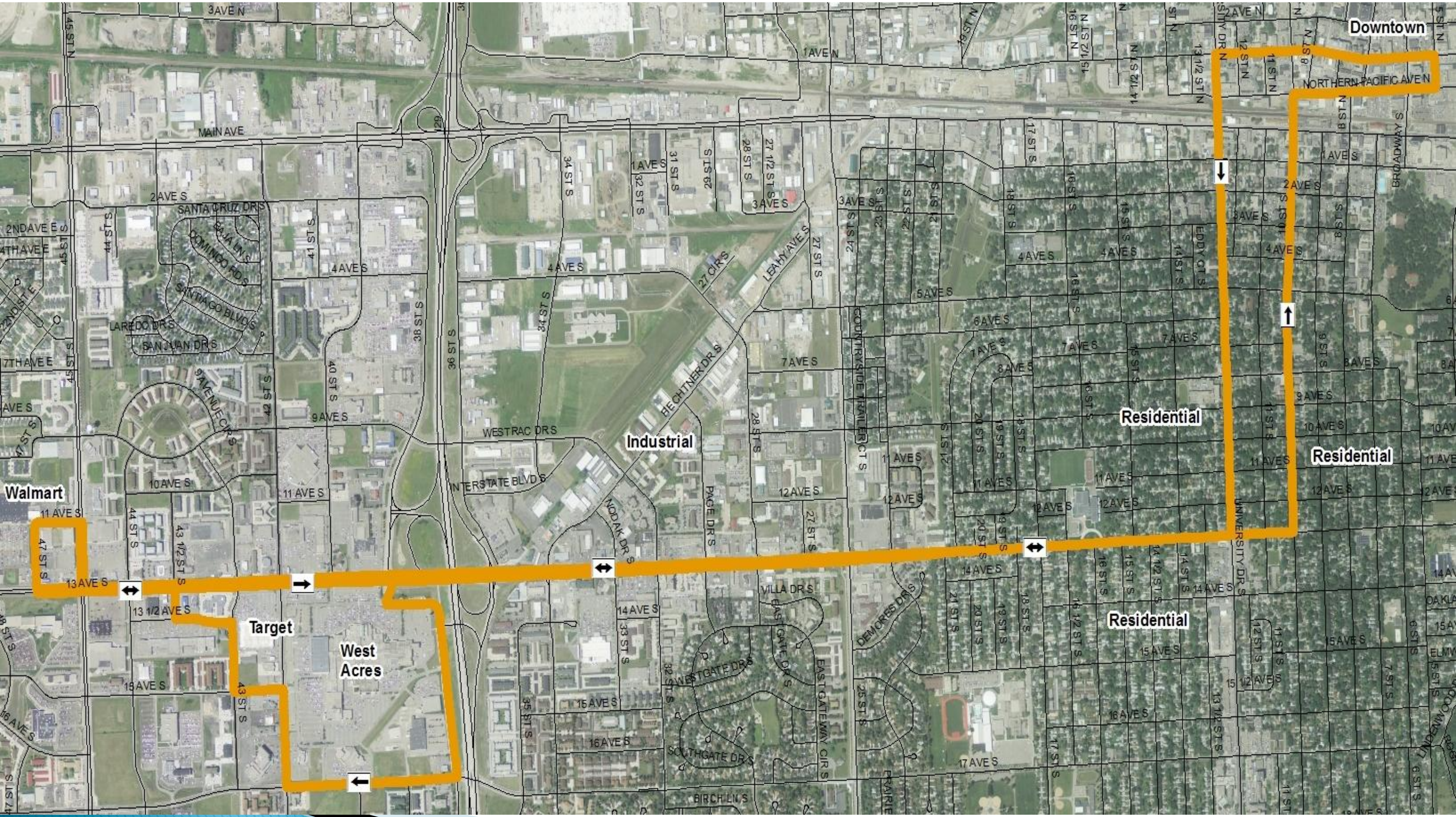
Routes 12 and 15 Built Environment Data

Variable	Route	
	12	15
Annual Ridership	19,171	134,011
Housing Units/Acre	3.8	5.2
Intersections/Acre	0.20	0.21
Land-use Mix Index	0.31	0.57
Walkability Index	-1.32	1.74

Route 12


Residential
Residential
VA Hospital
NDSU
Residential
Residential
Downtown

Route 15



Downtown
Residential
Residential
Residential
Industrial
Walmart
Target
West Acres
MAIN AVE
NORTHERN PACIFIC AVE N
UNIVERSITY DR S
13 AVE S
43 ST S
47 ST S

Regression Analysis

- Transit Ridership=f(Demographics, level-of-service, built environment)
- Semilog model
  - (Variables using natural log)
  - Transit Ridership, Income, No Vehicle
  - (Variables using standard form)
  - %Female, %Minority, %Youth, %Elderly, %Renters, Wait Time, Housing Units/Acre, Land-use Mix, Walkability

Estimations for Transit Ridership Using Housing Units/Acre and Land-use Mix

Variable	Estimate	t-value
ln Income	0.458	17.291
ln No Vehicle	0.067	7.751
% Female	1.260	7.668
% Minority	-0.688	-6.066
% Youth	-1.932	-12.957
% Elderly	-1.989	-20.458
% Renters	0.558	8.726
Wait Time	-0.017	-34.227
Housing Units/Acre	0.011	2.761
Land-use Mix	0.247	9.793
Summary Statistics		
Adjusted R-squared	0.261	
F	210	
N	5916	

Estimations for Transit Ridership Using Walkability

	Estimate	t-value
ln Income	0.438	16.695
ln No Vehicle	0.053	6.267
% Female	1.642	10.523
% Minority	-0.549	-5.113
% Youth	-1.824	-12.370
% Elderly	-2.165	-22.052
% Renters	0.561	9.682
Wait Time	-0.016	-32.928
Walkability	0.015	8.337
Summary Statistics		
Adjusted R-squared	0.258	
F	229	
N	5916	

Findings and Conclusions

- Built Environment results indicated that residential density and walkability were significant in predicting transit ridership
- Land-use mix was also significant, but results were mixed with respect to transit ridership
- Route 15 more transit friendly serving wider range of land uses with high-demand destinations compared to route 12
- Regression analysis indicated all three built environment variables significant
- Income and minority also significant, but showed unanticipated signs
- Planning techniques that give travelers multiple options should be considered

QUESTIONS?