Do Plans Matter?
Effects of Light Rail Plans on Land Values in Station Areas

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Abstract

In 1998, Knaap, Hopkins, and Donaghy developed a model in which plans serve as a means by which local governments provide information to landowners and thereby increase social welfare. In this paper we adapted their model to the announcement of light rail plans for the Western corridor of the Portland, Oregon, metropolitan area. We found that land values near planned station locations rose following the announcement of station location plans. From these results we infer that plans can serve as a means of coordinating transportation and land use investments and that plans can indeed matter.

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Introduction

Planning by local governments is commonplace. They plan land use, they plan transportation systems, they plan social services, they plan for economic development, and they often plan comprehensively—sometimes under the requirements of state law. Yet until recently, there has been little formal analysis of the logic and effects of plans. Knaap, Hopkins, and Donaghy (1998) presented a model in which planning is performed by a rational local government, provides signals to private land owners, and can increase land values and social welfare. They also suggested several strategies for testing the implications of their model but provided no empirical evidence.

In this paper we examine the effects of plans for light rail transportation on land values in the Portland, Oregon, metropolitan area. Our purpose is twofold: First, we provide new evidence that expectations about transportation investments can influence land values and thus land allocation. Second, and more importantly, we offer support for a model in which the effects of plans on land values serve to increase efficiency in the urban development process.

We proceed as follows. In the following section we review the results of previous research that examined the effects of light rail investments on urban land values. We then present the elements of a model in which land values can be affected by light rail plans. Then, after describing the study's context, data, and methods, we present empirical results, which show that plans for light rail investments can affect land values even before such investments have been made. Based on this evidence we conclude that planning by local governments can increase efficiency in the urban development process by changing expectations, increasing land prices, and thus discouraging premature, low-density development in future light-rail transit areas.

Previous Research

Many studies have examined the effects of light rail infrastructure on urban real estate markets (Huang 1996). Most of these studies examine changes in land values following transportation infrastructure investment. A few studies also examined the influence of investment announcements (Damm et al 1980, Ferguson, Goldberg, and Mark 1988; Gatzlaff and Smith 1993; and McDonald and Osuji 1995). The results, however, were mixed. McDonald and Osuji (1995) found large and significant impacts while Damm et al (1980) and Gatzlaff and Smith (1993) found moderate or insignificant impacts. The mixed results can be explained in a number of ways. First, land value effects take time and the time periods examined in some of the research may not have been long enough. Second, the information about station locations may not have been uniformly received by landowners. If so, then buyers may have been able to purchase property from uninformed sellers without transportation premiums. Third, research on land value effects relies on sales observations. Therefore, a sample selection bias may exist in studies that focus exclusively on parcels that have been sold.

Despite the volume of research on the effects of transportation investments—both existing and anticipated—none of that research has been framed in a manner that facilitates an examination of the role of planning. We attempt to do so here. Specifically, we present the elements of a model in which transportation planning not only facilitates the efficient construction of a light rail system but also serves as a signal to local land owners. Informed by transportation plans, local landowners anticipate increases in accessibility around light rail stations and bid up land values. These increases in land values—which occur even before the light rail system is operating—create a disincentive to develop at low densities, encourage land owners to delay development until the light rail system begins operation, and encourage high-density development. Through their effects on land values, then, transportation plans serve as a means of coordinating government investments in transportation infrastructure with private investments in urban form.

An Elementary Model of the Effects of Planning

The theoretical foundation for our empirical analysis is based on the model by Knaap, Hopkins, and Donaghy (1998). The essential features of their model are as follows. Landowners and a local government are specified as players of a dynamic game in which the local government is a Stackelberg leader. As the Stackelberg leader, the local government considers the reactions of land owners in making its decisions and plans but landowners, in their decision making processes, take the actions of the local government as given. The decisions of the local government and the community of landowners jointly determine a state variable, *x(t)*, which can be viewed as the state of urban development. The state variable in turn affects land values, which landowners seek to maximize, and social welfare, which the local government seeks to maximize. Plans influence the decisions of landowners through a belief function, which depends on the credibility of the plans. Formally, landowners maximize the following objective function.

Max $J_{t_0}^i$ with respect to $u^i(t)$ where

$$J_{t_0}^i = \int_{t_0}^{\infty} h\,(x(t), u^i(t), B(u^g(t) \,|\, u_\tau^p(t)))\, e^{-rt}\, dt \qquad (1)$$

where

$J_{t_0}^i$	=	value of land owned by land owner *i* at time t_0;
h	=	land rent function;
$u^i(t)$	=	vector of land development decisions by land owner *i* at time *t*;
$u^g(t)$	=	vector of government decisions implemented at time *t* (such as an investment in infrastructure);

$u_\tau^p(t)$	=	vector of government decisions planned for time *t* and announced at time τ;
τ	=	time at which planned actions are announced
r	=	discount rate; and
x(t)	=	state variable.

The expression $B(u^g(t) \mid u_\tau^p(t))$ yields the expected value of $u^g(t)$ at time *t*, evaluated at time t_0, and is based on the government plan formed at time τ. The extent to which plans influence the expected value of the government decision variable depends on the credibility of the plan. The credibility depends in part on the historical deviation between government plans and government actions, but might also depend on the political credibility of a given mayor, the percentage of federal funding of projects, and many other factors.

The local government maximizes social welfare, which can be specified as follows:

$$\text{Max } J_{t_0}^g \text{ with respect to } u^g(t) \text{ and } u_\tau^p(t)$$

$$J_{t_0}^g = \int_{t_0}^{\infty} w(x(t), \sum u^{i*}(x(t), B(u^g(t) \mid u_\tau^p(t)), t), u^g(t), u_\tau^p(t)) e^{-rt} dt \qquad (2)$$

where,	$J_{t_0}^g$	=	present value of social welfare;
	w	=	social welfare at time *t*; and
	u^{i*}	=	the optimum decision path of landowners given government plans and investment decisions.

Note that $J_{t_0}^g$ depends on the sum of landowner decisions and that the influence of any individual landowner on social welfare is trivial. Note also that the local government considers the direct effects of its plans and decisions on social welfare and the indirect effects that operate through the decisions of landowners.

The state variable is determined by the following equation:[1]

$$\frac{dx}{dt} = f(x, \sum u^i, u^g, u_\tau^p, t) \qquad (3)$$

The solution to the model is characterized by the *n* paths of individual landowner decisions, $u^{i*}(t) = U_i(x, B(u^g \mid u_\tau^p), u^g, u_\tau^p, t)$, for *i* = *1* to *n*, the time path of local government decisions, $u^{g*}(t) = U_g(x, \sum_i u^{i*}, B(u^g \mid u_\tau^p), t)$, and the time path of local government plans, $u_\tau^{p*}(t) = P(x, \sum_i u^{i*}, u^{g*}, t)$. Following the logic developed by Intriligator and Sheshinski (1986), local governments do not adjust their plans continuously but reformulate them at distinct points in time. As a result, the time paths of landowner decisions and land rents exhibit discontinuities at the times new plans are made.[2]

In the empirical analysis that follows, we explore the effects of the adoption of a plan for a light rail line on land values. If we define u^g as government investments in light rail stations at time *t*, and we define u_τ^p as government plans for station investments at time *t* adopted and announced at time τ, then in the framework presented above, we are

$$\frac{\Delta J^{i*}}{\Delta \tau} = \frac{\Delta u_\tau^{p*}}{\Delta \tau}\left[\frac{\Delta x}{\Delta u_\tau^{p*}} + \frac{\Delta u^{i*}}{\Delta u_\tau^{p*}} + \frac{\Delta B(u^{g*} \mid u_\tau^{p*})}{\Delta u_\tau^{p*}}\right]$$

interested in the change in land values that occurred at time τ. From equations 1 and 2, we are interested in (4)

The change in land values at time τ, when the plan is revised, equals the change in the plan at that time multiplied by the sum of the effects of the change in the plan on the state variable *x*, the decisions of landowners, u^{i*}, and the expected decisions of local governments, $B(u^{g*} \mid u_\tau^{p*})$.

Context

To examine the effects of plans we use data on land sales in Washington County, Oregon, which contains the Western corridor of the Portland metropolitan area. In this corridor a new light rail system began operation in 1998 connecting downtown Hillsboro and Beaverton with downtown Portland and the Eastern segment of the light rail system (see figure 1). Ambitious plans for the metropolitan area call for high-density development along the light rail corridor to relieve pressure for expanding the urban growth boundary. By focusing our analysis on this corridor of the metropolitan area, therefore, we seek to evaluate whether the information in plans is capitalized into land values and thus plays a role in altering development patterns. Although preliminary plans for the Western segment were developed in the early 1980s, the location of the far Westside line and stations were officially announced on 28 July 1993 (Tri-Met 1994). We use this date, therefore, as the relevant date of plan announcement, τ.

Data

Our data include all sales transactions of vacant parcels from January 1992 to August 1996 located inside the urban growth boundary. For each parcel sold we also obtained data from various sources on size of parcel in acres, expenditures per student in the pertinent school district, median income of the pertinent census tract, property tax rates, distance from the Portland and Beaverton CBDs, distance to the nearest sewer trunk line, distance to major and minor roads, distance to the nearest light rail station, and location of the parcel relative to the floodplain. Data sources include the Regional Land Information System developed by Metro, the Washington County Tax Assessor's files, and the Oregon Department of Education. To examine the effect of the plan, we created four dummy variables, *BEFORE, AFTER, ONEMI*, and *HALFMI. BEFORE* is set to 1 if the sale occurred before the plan was announced and set to 0 otherwise; AFTER is set conversely. *ONEMI* is set to one if the parcel is located within one mile of a planned light-rail station location and *HALFMI* is set to one if the parcel is located within one-half mile of a planned light rail station. Variable definitions and descriptive statistics are presented in Tables 1 and 2, respectively.

As shown in Table 2 the data include 1,537 observations for which all attributes could be obtained. The average sale price is about $51,400 per acre, while the average lot size is approximately 0.4 acres. Vacant lots sold and located within a half-mile of the station locations number 25 (or 1.6 percent); 18 of those were sold after the announcement. Vacant lots within one mile number 142 (or 9.2 percent); 95 of which were sold after the announcement.

Empirical Approach

To examine the effects of plans on land values we specify a regression equation as follows:

$$P_i = \beta_0 X + \beta_1 (BEFORE \times DIST) + \beta_2 (AFTER \times DIST) + \beta_3 TIME + e_i \qquad (5)$$

where, P_i = sales price per acre of land parcel *i*;

X = a vector of locational attributes;

DIST = dummy variable indicating whether a sale is located within a given distance of a light station. (In the regression equations we use the variables *HALFMI* and *ONEMI* in place of *DIST* (see Table 1 for their definitions).

BEFORE = a dummy variable set to one if the parcel was sold before the station locations were announced; (i.e., $t < \tau$)

AFTER = a dummy variable set to one if the parcel was sold after the station locations were announced (i.e., $t > \tau$).

TIME = date of sale.

The *X* vector includes standard site and neighborhood characteristics and a variety of accessibility (transportation network) measures and land use regulations that have been used in previous analyses of the Portland Metropolitan land market (Knaap 1985, Nelson 1988). The *TIME* variable is included to capture the effects of inflation. The coefficient on the interactive term, *BEFORE* x *DIST*, captures the value of proximity to a proposed rail station before the plan was announced. The coefficient of the interactive term, *AFTER* x *DIST*, captures the value of proximity to a proposed rail station after the plan was announced. If the plan changed the expectations of participants in the land market and increased the value of proximity to proposed light rail stations, then β_3 should be positive and significantly greater than β_2. If β_3 is not greater than β_2, then the plan did not increase land values in anticipation of light rail access.

Results

Table 3 presents the regression results. We cannot predict how far from planned station locations land values will be affected, but we expect that the effect will be very localized relative to the distribution of parcel sales throughout Washington County. Therefore, rather than trying to fit a particular distance function, we present results from two specifications: one with the ONEMI dummy variable and another with the HALFMI dummy variable. The distance effect from the station is thus discrete, either less than one mile or less than a half-mile. All variables, except for dummy variables, are transformed into log values. Coefficients therefore can be interpreted as elasticities.[3] The dependent variable is sale price per acre.

The relationships between sale price and most of the independent variables are highly significant and conform with expectations. Sale price per acre decreases with increases in parcel size, distance from a public park or open space, the property tax rate, and distance from downtown Portland. Price per acre decreases with increases in the maximum density allowed by zoning, which is counter to expectations but this relationship is insignificant. Sale prices per acre are lower for parcels located in a floodplain and for parcels adjoining a major or minor road. Sale price per acre increases with time, with increases in per-pupil school expenditure of the pertinent school district, and with increases in the median income of the pertinent census tract.

The relationships between sale price and the variables used to capture the effects of transportation plans also are significant and conform with expectations. As shown by the coefficients on the variables *BEFORE* x *ONEMI* and *BEFORE* x *HALFMI*, the prices per acre of parcels located near planned station locations were slightly but not significantly lower than others in the study area before the station locations were announced. As shown by the coefficients on the variables *AFTER* x *ONEMI* and *AFTER* x *HALFMI*, the prices of parcels located near a planned station were higher than others in the study area if they were sold after the plans were announced. Further, the difference in the coefficients on the variables *BEFORE* x *HALFMI* and *AFTER* x *HALFMI* is statistically significant at the 99 percent level. The difference in the coefficients of the variables *BEFORE* x *ONEMI* and *AFTER* x *ONEMI* is statistically significant at the 85 percent level.[4] Thus the evidence strongly suggests that the announcement of plans for the construction of light rail stations in Washington County increased the price per acre of parcels located near the proposed stations, especially for parcels located within one-half mile of proposed stations.

Summary and Conclusions

In 1998, Knaap, Hopkins and Donaghy developed a differential game model in which plans serve as a means by which local governments can provide information to land owners about government actions and thereby increase social welfare. In this paper we adapted their model to the announcement of light rail plans for the Western corridor of the Portland metropolitan area. Using this adaptation as a conceptual framework, we examined whether sales prices within one mile and one half mile of planned station locations increased after the locations of stations were announced. We found that they did.

Our empirical results add to the growing body of literature that suggests that investments in transportation infrastructure can affect land values and land allocation even before the infrastructure is in place. By framing our analysis in a theoretical model of planning, however, our results add more. Specifically, our results provide support for a model in which the information content in plans is observed by the development community and capitalized into land values. To the extent that these results hold in other transportation contexts they suggest that plans can serve as an unobtrusive means of coordinating transportation and land use investments. To the extent that these results hold more generally, they suggest that plans indeed matter.

Table 1: Variable Definitions

AMOUNT	sale amount of parcel in dollars
ACRES	parcel size in acres
EXP	school district expenditures in dollars per pupil in 1993
STRATIO	student teacher ratio in 1993
FLOOD	dummy variable indicating that a portion of the parcel lies within the flood plain (1 = inside)
DENSITY	measures allowable density for residential parcels in dwelling units per acres
ONMAJRD	dummy variable indicating that parcel lies within 150ft of a major road (1 = inside)
ONMINRD	dummy variable indicating that parcel lies within 150ft of a minor road (1 = inside)
MEDINC	median household income of the parcel's census tract
PUBDIS	distance in feet to nearest park or open space
LTDRATE	limited tax rate of parcel
SALE	month parcel sold; continuous variable ranging from 1 to 56, where 1 = Jan. 92 and 56 = Aug. 96
PORTCBD	distance in feet from parcel to Portland CBD
BEAVCBD	distance in feet from parcel to Beaverton CBD
SEWERDIS	distance in feet to nearest sewer line
BEFORE	dummy variable indicating parcel is sold before the announcement (1 = after)
AFTER	dummy variable indicating parcel is sold after the announcement (1 = after)
HALFMI	dummy variable indicating parcel lies within half-mine zone to proposed light rail stations
ONEMI	dummy variable indicating parcel lies within one-mine zone to proposed light rail stations

Table 2: Descriptive Statistics

	Mean	Maximum	Minimum	Std. Dev.
AMOUNT	51436.84	833000	1600	38381.97
ACRES	0.397908	18.33	0.0588	1.16286
EXP	5685.74	8360	4083	774.9963
STRATIO	20.74886	25.5	17.1	1.982032
FLOOD	0.03123	1	0	0.173994
DENSITY	5.436565	6	1	1.310034
ONMAJRD	0.116461	1	0	0.320881
ONMINRD	0.072219	1	0	0.258934
MEDINC	40362.11	52660	23117	7601.991
PUBDIS	2081.755	74302.06	117.13	3247.368
LTDRATE	15.67437	24.0908	0	4.11182
SALE	30.11776	56	1	14.12296
PORTCBD	52291.19	174311.2	17513.39	17043.52
BEAVCBD	26900.2	150797.6	2957.361	14607.33
SEWERDIS	844.7936	57822.19	0.699	2624.339
AFTER	0.752115	1	0	0.431926
HALFMI	0.016265	1	0	0.126536
HALFMI*AFTER	0.011711	1	0	0.107617
ONEMI	0.092388	1	0	0.289667

Table 3: Regression Results

	Dependent Variable: LOG(AMOUNT/ACRES)						
Variable	Coefficient		t-Statistic		Coefficient		t-Statistic
C	9.269		7.810		9.039		7.537
LOG(ACRES)	-0.640	****	-51.470		-0.637	****	-51.060
LOG(EXP93)	0.491	****	6.521		0.499	****	6.545
LOG(STRATIO)	0.108		0.978		0.099		0.884
FLOOD	-0.183	****	-4.023		-0.183	****	-3.940
LOG(DENSITY)	-0.012		-0.596		-0.010		-0.501
ONMAJRD	-0.121	****	-3.965		-0.120	****	-3.875
ONMINRD	-0.137	****	-4.619		-0.132	****	-4.460
LOG(MEDINC)	0.143	****	2.803		0.155	****	3.013
LOG(PUBDIS)	-0.038	****	-3.244		-0.039	****	-3.280
LOG(LTDRATE+0.5)	-0.029	**	-2.276		-0.030	**	-2.307
LOG(SALE)	0.108	****	9.502		0.107	****	9.139
LOG(PORTCBD)	-0.509	****	-12.316		-0.510	****	-12.263
LOG(BEAVCBD)	0.141	****	5.020		0.148	****	5.179
LOG(SEWERDIS)	0.008		1.311		0.009		1.432
HALFMI*BEFORE	-0.062		-0.546				
HALFMI*AFTER	0.286	****	3.947				
ONEMI*BEFORE					0.007		0.148
ONEMI*AFTER					0.085	**	2.466
R-squared	0.722				0.720		
Adjusted R-squared	0.719				0.717		

Endnotes

[1] The time element *t* is omitted from state and decision variables for simplicity from now on.

[2] See Knaap, Hopkins, and Donaghy (1998) and Intriligator and Shesinski (1986).

[3] To variables whose minimum values are zero, 0.5 was added before transformation into logs.

[4] In an alternative specification, in which the *increment* in land value is captured by a coefficient on the terms *HALFMI* x *AFTER* and *ONEMI* x *AFTER* , land values increased by 35 percent (t = 2.62) if they were located within one-half mile of planned station locations and by eight percent (t = 1.38) if they were located within one mile of the planned stations when the station locations were announced.

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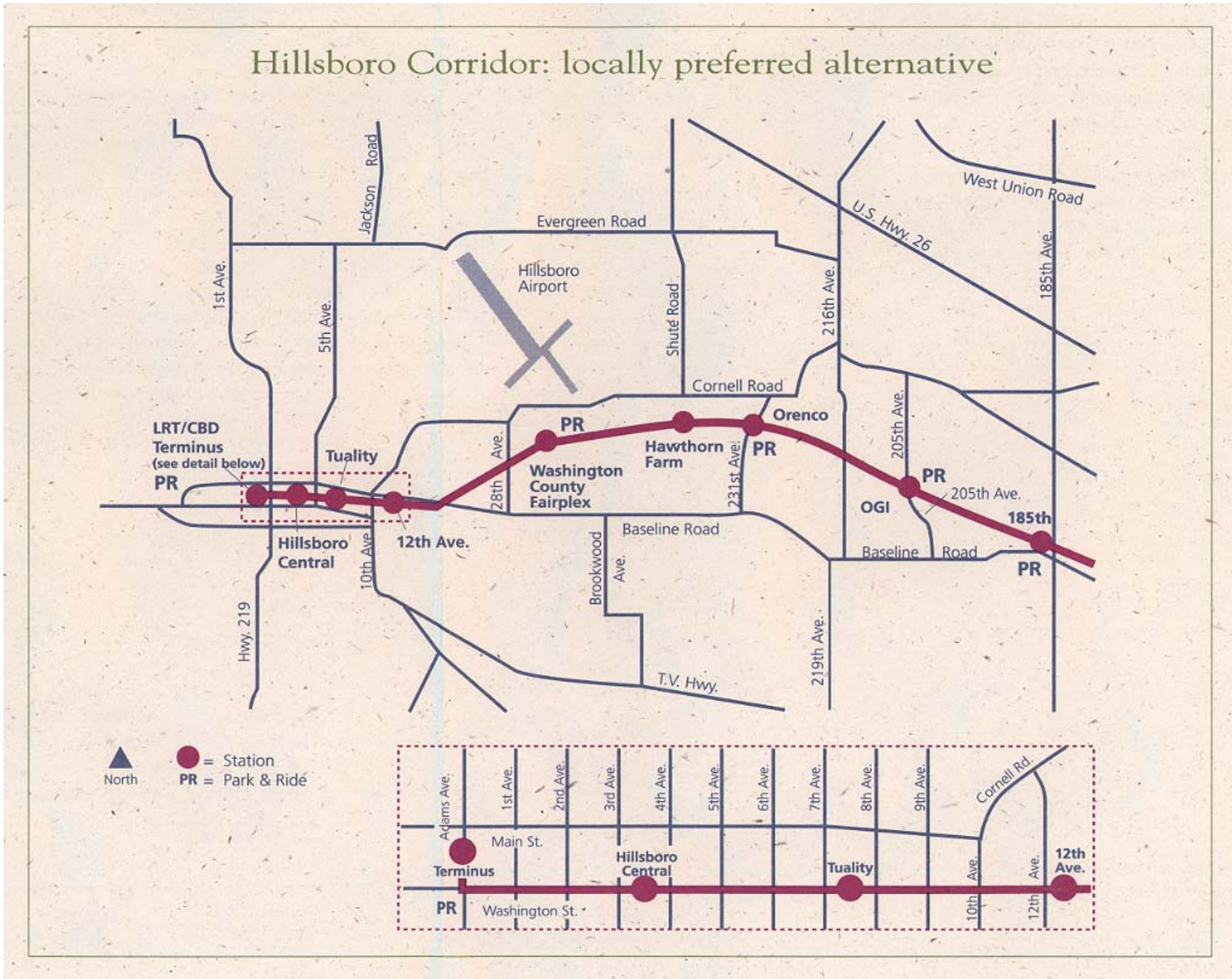
Hillsboro Corridor: locally preferred alternative
Jackson Road
Evergreen Road
West Union Road
U.S. Hwy. 26
185th Ave.
1st Ave.
5th Ave.
Hillsboro Airport
Shute Road
216th Ave.
Cornell Road
Orenco
205th Ave.
LRT/CBD Terminus (see detail below)
PR
Tuality
PR
Hawthorn Farm
PR
Washington County Fairplex
28th Ave.
231st Ave.
PR
205th Ave.
OGI
185th
Baseline Road
Baseline Road
PR
Hillsboro Central
10th Ave.
12th Ave.
Brookwood Ave.
Hwy. 219
219th Ave.
T.V. Hwy.
North
= Station
PR = Park & Ride
Adams Ave.
1st Ave.
2nd Ave.
3rd Ave.
4th Ave.
5th Ave.
6th Ave.
7th Ave.
8th Ave.
9th Ave.
Cornell Rd.
Main St.
Terminus
Hillsboro Central
Tuality
10th Ave.
12th Ave.
12th Ave.
PR
Washington St.