Estimating the Effects of Residential Joint-Development Policies on Rail Transit Ridership

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A study that examines the impact of residential growth management strategies on transit ridership on a proposed rail transit corridor is presented. An interactive corridor sketch-planning model was developed to replicate various residential density patterns in the corridor and estimate transit patronage for work trips. The model also estimates patronage for transit access modes, including walk-and-ride, park-and-ride, kiss-and-ride, and feeder bus. Automobile drive-alone, carpool, and vehicle miles of travel (VMT) statistics for work trips are also reported. The model allows the planner to test combinations of policies to concentrate growth in high-rise buildings, create clusters of medium-rise housing, and restrain growth in exurban portions of the corridor. The transit ridership impacts of these policies are compared with an unmanage growth base case. It was found that through stringent land use controls, rail transit modal split could be increased by almost 16 percent over the base case, with a reduction in overall VMT for central business district bound work trips. Other, less-stringent residential land use policies can achieve smaller, but still significant, favorable changes in transit ridership. The paper concludes with a discussion of the problems associated with implementing corridor land use management policies.

Planners and urban policymakers have long recognized that a strong relation exists between urban development forms and the existence of rapid transit systems in cities. In recent years, new rail transit systems have not led to significant positive changes in urban development. It is believed that the existing high level of automobile accessibility tends to obscure the increases in mobility achieved by rail transit. Many planners and policymakers believe that rail transit systems can be more effective in meeting the travel needs of the public, can be more energy efficient, and can require less subsidy if land use planning in transit corridors can be coordinated with the planning of the rail system itself.

In this paper, a case study is reported that attempts to quantify the effects of implementing several alternative residential land use policies on transit patronage. There are major questions that need to be answered about the kinds of policies that should be implemented. Planners need to know, for example, what kinds of housing should be encouraged in transit corridors. Should land close to transit stations be reserved for high-density apartments or be kept open to provide large lots for park-and-ride patrons? Given that land use regulations are difficult to enact and enforce, how does noncompliance with the plan affect the desired results? Because of the many unanswered questions, this research was directed toward the development of a quantitative tool that would provide planners with the ability to determine the likely effects of alternative land use plans on transit ridership.

RESEARCH OBJECTIVE

The objective of the research was to develop a model that would take as input various housing policies and translate these results into transit ridership figures. The model was designed to estimate the proportion of commuters traveling by transit; the modal split, given that population could be clustered at various densities; and distances from the transit stops. By changing the location of population clusters, one alters the relative travel times and costs encountered in traveling to both transit stations and to the central business district (CBD).

In this analysis, only residential development was considered and, because of data limitations, only the journey from home to work was considered in modal-split modeling. These restrictions were imposed because it was desired to limit assumptions and variables as much as possible in order to achieve a controlled modeling environment, in which selected parameters could be varied while all others could be held constant. It was also desired to keep the analysis as simple as possible.

Mass transit ridership is known to depend strongly on residential density, and residential land comprises much of any transit corridor. Yet none of the previous work in joint development or transit corridor planning has examined the consequences of managing residential growth. Because most trips begin at home, changing residential location patterns will result in changes in trip-making patterns. It is thought that a plan that concentrates residential density in the vicinity of a transit line will produce more transit trips than one that allows for more dispersed growth. The model developed in this research seeks to test this theory and to indicate the sensitivity of transit ridership (for work trips) to residential location policies. Also of interest was the effect of housing policy on access modal choice (i.e., the means of travel to the transit station) and the effect on automobile vehicle miles of travel (VMT) for work trips.

CORRIDOR SKETCH-PLANNING MODEL

To proceed with the testing of this hypothesis, a corridor sketch-planning model was devised that incorporated a wedge-shaped corridor centered on a large CBD. A housing-allocation model was developed that permitted the quantification of several dimensions of likely residential development policies. Policy zones were created within the corridor based on distance to stations and distance to the CBD. The table belows gives the distances used in developing policy zones:

	Policy Zone Definition by Distance to CBD		
Distance to Station (miles)	0-7 Miles	6-11 Miles	>11 Miles
0	1	2	3
0-1	4	5	6
1-2	7	8	9
>2	10	11	12

Target residential densities could be specified for these zones, and a policy effectiveness level could be specified for the corridor, to determine the amount of land available for allocating new growth according to the target density. Special development districts were created at each proposed station to permit examination of the effects of highly concentrated growth strategies. Because few transit lines are likely to be built entirely in vacant corridors, an initial starting allocation of housing was used that was based on actual data from the case study area.

To test the model, a case study area was chosen in southern New Jersey. A proposed branch-line extension to the existing Port Authority Transit Corporation (PATCO) rail rapid transit system is currently under study, and the corridor it is projected to serve was chosen as a test area for the model. The triangular transit corridor, 30 miles long and 15 miles wide at the maximum, covers parts of Camden and Burlington Counties in New Jersey and includes a population of about 450 000. The initial data set used by the model comprises 60 variables recorded in the 1970 census, population projections for the year 2000, and developable land areas for each of the 116 census tracts that comprise the corridor. For the purposes of the research, some of these tracts were further subdivided into subzones, which increased the total to 212 subareas or zones for analysis.

INTERACTIVE MODEL STRUCTURE

The nature of the research suggested that a number of alternative policies would be tested. This, coupled with the magnitude of the data base, led to the use of an interactive computer approach that permitted quick evaluation of many policy scenarios in a short period of time with minimum data manipulation (1).

The program is comprised of a transit line routine, a housing-allocation model, a modal-split mode, and a routine to produce graphic output. These four routines are managed by a conversational program that controls the sequence of model execution and accesses the various routines and subroutines.

Transit Line Model

The transit line input routine allows the user to input a new transit line route, to reset the program to the planned version, and to add or modify the number and location of stations. The functions of this program are to (a) calculate the distance between each zone centroid and each station, (b) select the station nearest each zone based on the least weighted distance to all stations, (c) create around each station a new special development district zone (0.5 mile^2) to be superimposed on the original zones, and (d) assign to each zone a classification code based on the zone's location relative to both the destination--in this case the Philadelphia CBD--and the nearest station. The 0.5-mile^2 zone is created in order to enable the user to apply special housing-allocation policies to those areas within walking distance of the stations.

Housing Allocation

The housing-allocation model simulates a 1990 housing distribution by allocating specific increments of dwelling units to the 1970 base year. A distinction is made between unmanaged growth and policy-directed growth in new dwelling units. The policy-directed number of dwelling units is set by the user to simulate policies to increase development at locations within the corridor. The user specifies the number of new dwelling units to be added to the corridor and the target densities and distribution, which define the desired residential plan to be tested. The unmanaged dwelling units replicate population gains and losses projected by the Delaware Valley Regional Planning Commission (DVRPC) if no transit-related development were to be induced. Housing units are allocated to zones until target densities have been reached, and they are based either on existing density levels or on the basis of user-specified growth policies.

Specifying Development Policy Zones

Because there is so much vacant land in the corridor within each policy zone, to meet the higher target densities it was necessary to specify the order of allocating housing to the zones. The user assigns each policy zone a priority index from 1 to 12, with 1 representing the highest priority. The model takes the group of zones with the highest priority index and allocates to those zones a number of dwelling units to fill the vacant land at the specified target density, but not greater than the pool of dwelling units available for allocation. If the allocation of dwellings to this class of zones exhausts the vacant land, the program goes to the next priority class, and so forth, until the pool of dwelling units is allocated. If the pool to be allocated is greater than the capacity of the developable land (given the user-specified densities), the user is informed and allowed to adjust the input. Because of the large amount of vacant land in the corridor, it was necessary to adjust the input only when low densities or large increments of dwelling units were input.

The housing-allocation model first asks the user to input the total growth projected for the corridor, then the "percent effectiveness," which limits the policy-directed housing allocation. The percent effectiveness was used to examine the impact of backing-off or not enforcing the land use policies to be tested. It was, in effect, a sensitivity-testing mechanism. Because land use regulation is parochial in New Jersey, it was thought that only some communities would accept such land use controls. The percent effectiveness is the percentage of land to which the land use regulation would apply. Results of the runs in which percent effectiveness was less than 100 percent are not reported here. However, they were used as a guide in selecting policies to be tested.

Modal-Split Model

The modal-split model is an eight-mode, access mode stochastic choice model. The core of the program is a weighted logit function that calculates the probability of choosing a given mode. The modes are automobile, carpool, express bus, rapid rail via park-and-ride access, rapid rail with kiss-and-ride access, rapid rail with feeder bus access, rapid rail with walk access, and rapid rail with bicycle access.

The modal-split program calculates the impedance of each commuting trip to the CBD at the zone level, including (a) travel time spent in vehicle, (b) travel cost (cost in dollars later transformed to income-earning minutes), and (c) excess time, that is, time spent waiting for, transferring to, or accessing a mode. Travel time, cost, and excess time are multiplied by weighting coefficients and the terms summed. This exponential sum represents the total trip impedance, or disutility. The probability of choosing one mode is the ratio of its disutility to the sum of all modal disutilities. The zonal mode choice is expressed as the population of the zone, multiplied by the probability that an individual will commute to the CBD, multiplied by the probability of selecting each mode.

SPECIFYING HOUSING POLICIES

In most local land use, land, and zoning codes, residential land is zoned by lot size and dwelling type, e.g., town house, single-family detached, garden apartment, and high-rise apartment or condominium. Each type of housing can be accommodated by a variety of densities, depending on the amount of space allocated for dwelling units, open space, and parking. For this analysis, four basic types of housing are considered for policy allocation: high-rise apartments, midrise garden apartments, town houses or row houses, and single-family detached homes.

Each housing type is assigned a net density based on the appropriate number of stories usually observed, at-grade parking space for at least one car per dwelling unit, and a nominal amount of open space. In addition, it is assumed that residential development will require other development types in each zone as well. Thus, net density is translated into a gross density specification to take into account streets, schools, shopping centers, commercial development, and the like. It is assumed that gross residential density per zone is approximately equal to one-half the net density. The table below indicates the various density classes, both net and gross, for the four types of housing analyzed:

Housing Type	General Description	Target Densities (dwelling units/acre) Gross	Net
High-rise apartments or condominiums	10-story buildings with at-grade parking	45	90
Medium-rise housing	3- to 4-story garden apartments or town houses	15	30
Cluster housing	Single-family row houses or town houses	3-3.5	6-7
Low density	Single-family detached homes with 0.25-acre lots	2	4

To define a residential policy scenario, the desired housing types for each policy zone were indicated and translated into gross densities.

The gross densities were supplied to the model. The model was run and the results compared with a base case and with other policies. Except for gross residential density by policy zone, all other input variables and parameters were held constant for all model runs. Results were compared on the basis of modal split, access modal split, and automobile VMT. Table 1 summarizes the relevant statistics for each housing policy. Figure 1 shows schematic diagrams for each housing policy.

Base Case: No Transit-Related Development Policy

For the base case, it was decided to use year 1990 population projections for the corridor. The base case would serve as a reference for comparing the effects of policies after a 20-year growth period, assuming that land development policies were implemented in 1970, the year in which the initial data base was collected. Year 2000 population projections were obtained by minor civil division from DVRPC. Year 1990 population was obtained through linear interpolation of year 2000 projections. It was assumed that gross residential densities would remain close to those that existed in 1970. According to DVRPC projections, most growth will occur in the outermost portions of the corridor. Some areas closer in to Camden are projected to lose population.

Total growth is set at 29 675 dwelling units, or 100 272 individuals, over the 20-year period. Some 4555 dwelling units will be lost, for a net growth of 25 120 dwelling units. Approximately 10 percent of the vacant land (204 927 acres in 1970) will be required to accommodate the new growth composed mainly of single-family dwellings. The gross residential density would decrease from 2.21 to 1.95 dwelling units/acre.

The 1970 base case was used to calibrate the modal-split model. The 1970 transit ridership was set at 13 116 for comparison with existing Lindenwold Line ridership and with independent estimates developed by consultants for the projected Mt. Laurel extension (2). For 1990, this produced a transit modal split of 29.5 percent, or 18 572 daily riders. It should be noted that modal split was performed only for individuals with work trip destinations accessible by transit, primarily in the Philadelphia CBD. Access modal split was calculated to compare it with current Lindenwold Line figures, with the exception that more feeder bus service would be provided to the Mt. Laurel extension. Thus, park-and-ride is used by 60 percent of the transit users, with 10 percent walking and 10 percent using the feeder bus service. Tables 2-5 indicate the relevant model results for the various policies and the base case.

Policy 1: High-Rise Development in Special Districts

The first policy tested examined the effect of confining all new growth to 0.25-mile^2 special development districts centered on each transit station. It was assumed that all new construction would occur in the form of 10-story buildings that contain apartments or condominiums at a target net density of 90 dwelling units/acre. Sufficient vacant land was available in the 12 special development districts to achieve a net density of 65 dwelling units/acre, which corresponds to a gross residential density of 32.5 dwelling units/acre.

Two further variations of this policy were tested in order to examine the relative changes in ridership when development was stressed at the outermost or innermost stations. The high-rise, outer-station policy groups most of the projected development at the four outer stations and the remainder at the four intermediate stations with a net target density of 90 dwelling units/acre. The high-rise, inner-station policy concentrates growth at the inner station (downtown Camden) and the four intermediate stations.

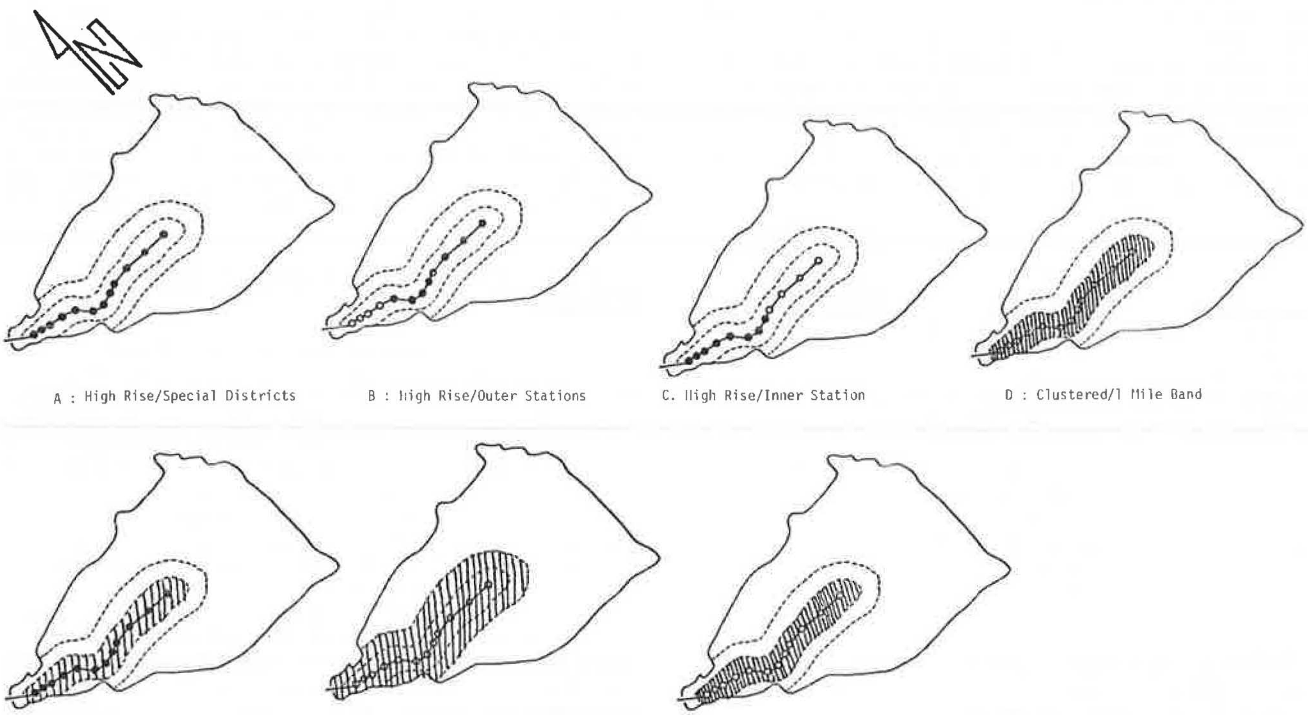
Concentration of all growth in the 12 station zones increases transit ridership by 2089 riders/day, or 11.2 percent over the base case. Significant changes in access mode distributions are seen as well. Most notably, park-and-ride users are down by 27.5 percent--a decrease of 3220 patrons. At an assumed averge automobile occupancy of 1.5, the model indicates that more than 2000 parking spaces could be eliminated. Walk-and-ride patronage more than doubles, and the numbers of feeder bus and kiss-and-ride patrons show significant increases as well. A sharp drop of 19.4 percent in total automobile VMT for work trips is seen. Automobile average trip length declines as well, which reflects decreased time spent in commuting to work, whereas transit passenger miles of travel (PMT) increase slightly.

Variations on the high-rise policy were tested because the target density is sufficiently high (net, 90 dwelling units/acre; gross, 45 dwelling units/acre) to permit housing to be concentrated in only 8 of the 12 station sites. To fill all 12 special districts, net and gross densities need only be 65 and 32.5 dwelling units/acre, respectively. The first variation examined the effect of developing

Table 1. Land use summary.

Policy	Land Consumed (acres)	Vacant Land Remaining (acres)	Avg Density in Growth Zones (dwelling units/acre)	
			Before	After
Base case	22 839	184 179	0.47	0.57
High-rise, all stations	913	206 104	3.25	15.61
High-rise, outer stations	659	206 358	1.71	25.74
High-rise, inner stations	659	206 358	4.39	19.60
Clustered, expanded density	8 768	198 249	1.65	3.01
Midrise and low density	8 709	198 308	3.25/1.49	9.2/2.41
Low density, 2-mile radius band	14 839	192 178	0.77	1.88
Clustered, 1 mile	7 927	199 091	1.67	3.10

Figure 1. Housing policies—schematic diagrams.



the outermost four stations at the target density and the middle four stations at a net density of 66 dwelling units/acre. Because the comparative advantage of transit versus automobile increases with trip length, the model produces even higher transit ridership, up 2918 over the base case for an increase of 15.7 percent. Park-and-ride space requirements decrease by 25.1 percent, and automobile VMT is down by 19.6 percent. Because of the increased concentration of riders at the outer stations, the total transit PMT increases by 9.8 percent, which reflects longer average transit trip lengths.

Concentrating housing at the stations closest to the CBD produces a less-dramatic increase in modal split of 8.2 percent, or 1530 patrons. Park-and-ride patronage drops by 28.5 percent, total automobile VMT decreases by 19.4 percent, and transit PMT decreases by 6.9 percent, which reflects a shorter average transit trip length.

Policy 2: Cluster Development

In defining the policy of cluster development, it was desired to examine the impact of clustered housing similar to that commonly associated with planned unit developments or urban row housing. The policy specified that new residential development could only take place within approximately one mile of the stations. An overall net residential density of 6.4 dwelling units/acre was achieved over 9273 acres of land. Within the special development districts, 2931 dwellings are accommodated.

Clustering housing within one mile of the transit stations increases transit patronage by 4.8 percent, or 8952 daily riders. Although the increase in transit ridership is not great, the policy still results in major reductions in park-and-ride patronage

Table 2. Model output for base case and alternative policies—base statistics.

Category	Transit (%)	Transit Ridership	Change Over Base (%)
Base case	29.5	18 572	0.0
High-rise in special districts			
All stations	32.8	20 661	11.2
Outer stations	34.2	21 490	15.7
Inner stations	32.0	20 102	8.2
Clustered expanded districts	31.0	19 469	4.8
Midrise and low density	31.7	19 930	7.3
Low-density, 2-mile radius band	29.8	18 772	1.1
Clustered, 1-mile radius ring	30.8	19 361	4.2

(23.4 percent) and automobile VMT (16.4 percent) for CBD-bound commuters.

Policy 3: Midrise Development

The policy of midrise development is an attempt to create gradations of density around the transit stations. Within the special station development districts, only midrise housing (3-4 stories) at a net density of 30 dwelling units/acre would be permitted to accommodate new growth. Within the one-mile rings, development at 4 dwelling units/acre would be permitted. Other portions of the corridor would be restrained from further growth. With this distribution of densities, 10 742 dwelling units are accommodated within the special development districts. The remaining net growth of 14 378 units can be accommodated within the one-mile rings around the station.

Developing the station development districts with midrise housing and concentrating low-density development around them provides more support for the transit line than the base case. A ridership increase of 7.3 percent (1358 daily riders) is projected. Park-and-ride patrons decrease by 25.1 percent, and total automobile VMT is down 17.6 percent.

Table 3. Model output for base case and alternative policies—access modal split.

	Park-and-Ride		Kiss-and-Ride		Feeder Bus		Walk-and-Ride	
Category	No.	Change Over Base (%)	No.	Change Over Base (%)	No.	Change Over Base (%)	No.	Change Over Base (%)
Base case	11 689	0.0	2804	0.0	1874	0.0	1852	0.0
High-rise in special districts								
All stations	8 469	-27.5	3648	30.1	2185	16.6	5611	202.9
Outer stations	8 638	-25.1	3785	35.1	2257	20.4	6017	224.9
Inner stations	8 353	-28.5	3556	26.8	2135	13.9	5341	188.4
Clustered expanded districts	8 952	-23.4	3764	34.2	2291	22.2	3815	106.0
Midrise and low density	8 752	-25.1	3711	32.3	2246	19.8	4533	144.7
Low density, 2-mile radius band	9 273	-20.7	3662	30.6	2281	21.7	3011	62.6
Clustered, 1-mile radius ring	9 009	-22.9	3782	34.9	2305	23.0	3627	95.8

Table 4. Model output for base case and alternative policies—automobile VMT.

	Automobile VMT										On-Line Transit (PMT)	
	Drive Alone		Carpool		Park-and-Ride		Kiss-and-Ride		Total			
Category	No.	Change Over Base (%)	No.	Change Over Base (%)	No.	Change Over Base (%)	No.	Change Over Base (%)	No.	Change Over Base (%)	No.	Change Over Base (%)
Base case	318 745	0.0	96 100	0.0	64 923	0.0	9052	0.0	488 821	0.0	213 914	0.0
High-rise in special districts												
All stations	285 627	-10.4	73 961	-23.1	27 257	-58.0	6886	-23.9	393 732	-19.4	215 539	0.7
Outer stations	284 186	-10.8	74 244	-22.7	27 298	-58.0	6954	-21.1	392 682	-19.6	234 877	9.8
Inner stations	287 360	-9.8	73 925	-23.1	27 228	-57.9	6841	-24.4	395 345	-19.1	199 154	-6.9
Clustered expanded districts	295 576	-7.3	76 879	-20.0	28 211	-43.4	7913	-12.6	408 577	-16.4	204 288	-4.5
Midrise and low density	291 652	-8.5	75 711	-21.2	27 822	-57.1	7490	-17.2	402 675	-17.6	208 780	-2.4
Low density, 2-mile radius band	301 160	-5.5	78 676	-18.1	29 742	-54.2	8862	-2.1	418 441	-14.4	199 154	-6.9
Clustered, 1-mile radius ring	296 625	-6.9	77 192	-19.6	28 311	-56.4	8032	-11.3	410 168	-16.1	203 218	-5.0

Table 5. Model output for base case and alternative policies—automobile average trip length.

	Automobile Avg Trip Length (miles)										On-Line Transit Avg Trip Length (miles)	
	Drive Alone		Carpool		Park-and-Ride		Kiss-and-Ride		Total			
Catogory	No.	Change Over Base (%)	No.	Change Over Base (%)	No.	Change Over Base (%)	No.	Change Over Base (%)	No.	Change Over Base (%)	No.	Change Over Base (%)
Base case	11.00	0.0	12.50	0.0	5.55	0.0	3.23	0.0	9.6	0.0	11.50	0.0
High-rise in special districts												
All stations	10.11	-8.1	10.57	-15.4	3.22	-42.0	1.89	-41.5	8.32	-9.0	10.47	-9.0
Outer stations	10.31	-6.3	10.75	-14.0	3.16	-43.0	1.79	-43.0	8.73	-5.1	12.08	5.1
Inner stations	10.03	-8.8	10.46	-16.3	3.26	-41.3	1.93	-41.3	8.30	-9.0	10.47	-9.0
Clustered expanded districts	10.19	-7.4	10.69	-14.5	3.15	-43.2	2.10	-34.9	8.35	-5.8	10.83	-5.8
Midrise and low density	10.15	-7.7	10.64	-14.9	3.18	-42.7	3.33	3.2	8.34	-4.4	10.99	-4.4
Low density, 2-mile radius band	10.21	-7.2	10.76	-13.9	3.21	-42.2	2.42	-25.1	8.41	-7.1	10.69	-7.1
Clustered, 1-mile radius ring	10.20	-7.3	10.69	-14.5	3.14	-43.4	2.13	-34.2	8.35	-6.0	10.81	-6.0

Policy 4: Restraints on Outer Corridor

The objective of the policy of restraints on the outer corridor is to prevent new growth from spreading to the outermost areas of the corridor by directing growth into areas within two miles of transit stations. Some 14 838 acres of land are required to accommodate the expected population increase at an average net density of 4 dwelling units/acre.

For each of the preceding policies, the model produced similar levels of reduction in park-and-ride patronage and automobile VMT reductions. This is largely due to the fact that all policies tested prevent growth in the outer exurban portions of the corridor and shift dwellings closer to the CBD. Policy 4 examines only the issue of restraining outward growth and provides a useful reference. The increase in transit ridership is only 1.1 percent, or 200 commuters. Thus, it is clear that outer-corridor development restraints alone will not significantly affect modal choice, although the access modal choice and automobile VMT figures have been affected significantly by the policy. Automobile VMT reduction (14.4 percent) due to this policy accounts for at least three-quarters of the VMT savings exhibited by the model for the other policies examined.

Policy 5: Residential Rings

The policy of residential rings examines the effect of preventing residential development in the station special development districts proper and creates medium-density rings within one mile of each station. Residential development would be prohibited in other locations. It is assumed under this policy scenario that the station special development districts would be devoted exclusively to nonresidential development. The rings are developed at a net density of 3.55 dwelling units/acre, which uses 8359 acres of vacant land.

By clustering new housing closely along the line, but outside the station districts, a 4.2 percent ridership increase is forecast. This policy is used as a further reference case for comparison with policy 3 (midrise development). The effect of controlling growth in the outer corridor and creating a band of housing, even at fairly low density, has a considerable effect on transit ridership. By comparing the access mode distributions, it can be seen that this policy favors the use of feeder bus and kiss-and-ride more than any of the other policies tested.

CONCLUSIONS

The model results show that residential land use policies have a significant impact on both transit ridership and access mode patronage. By necessity, the policies tested here embodied growth constraints on exurban land. The restraint policies are equally as important as the policies that increase densities in the areas near transit itself. Even without transit service, it is likely that the concentration of growth will have beneficial effects on CBD-bound VMT by reducing the average trip length. It should be noted, however, that the model does not consider trips to other destinations not served by transit. If large numbers of work trips are made to these other locations, it would be inappropriate to use the results of this model to infer a growth policy for the corridor.

Within the land envelope that surrounds the transit line there is a sharp increase in transit ridership as density increases in the immediate vicinity of the stations. Results produced by the model indicate that a maximum ridership increase of 15.7 percent can be attributed to growth concentration; lower densities produce smaller, but still significant, increases. Ridership is increased most when residential development is concentrated at the outermost stations because the comparative advantage of transit increases with distance. The target density of the first policy is clearly too high according to current norms for suburban development. Some, but surely not all, development could take place in high-rise buildings.

Implementation of a growth management policy similar to those tested here would inevitably present great problems. In the New Jersey study corridor, for example, strong home rule exists, and zoning and land use decisions are made largely by the municipalities with little interference from county, state, and regional planners. The decision to restrict or encourage growth in a community, although legally feasible, will be controversial and hotly opposed. When similar decisions must be made for a number of communities, the likelihood that a consensus could be achieved on an appropriate growth management policy becomes slim indeed.

However, in areas where political jurisdictions are more homogeneous and enlightened public officials are concerned about efficient patterns of urban form, it may be possible to link a strong land use management policy to transit development. In many of the urban areas where transit systems are under construction today, such political conditions do exist, because they are the same conditions needed to promote the construction of a transit line.

Although the results of this analysis are far from definitive, they provide a direction for further research. The eventual goal should be a method for quantifying and evaluating the effects of joint development on a community. In the model developed in this research, only a limited number of factors were examined: modal split, access mode split, VMT, and transit PMT. Many other factors should be included as well, and the analysis extended to the entire trip-making pattern of an area. Also, capacity constraints were not included, nor were effects of congestion. The simplified model presented here allows the examination, in isolation, of the effect of density on modal split. As more information is accumulated, UMTA may well find evidence that would justify the requirement for a transit corridor land use management program that involves joint development as a prerequisite for transit construction funding.

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