

Getting Around a Traditional City, a Suburban Planned Unit Development, and Everything in Between

REID EWING, PADMA HALIYUR, AND G. WILLIAM PAGE

Beyond some studies relating density to mode choice, vehicle miles of travel, or gasoline consumption, little is known about the relationship of location and land use to household travel patterns. Against this backdrop a 16,000-record travel survey for Palm Beach County, Florida, was analyzed. Six communities were culled from the larger data base, and household travel data were then tested for statistically significant differences in trip frequency, mode choice, trip chaining, trip length, and overall vehicle hours of travel. Households in a sprawling suburb generate almost two-thirds more vehicle hours of travel per person than comparable households in a traditional city. Although travel differences are significant, they are smaller than one might expect given the more than 10-fold difference in accessibility among the communities. Sprawl dwellers compensate for poor accessibility by linking trips of household members in multipurpose tours. Implications for land planning are more complex than simply pedestrianizing or transitizing the suburbs. Communities should internalize as many facilities and services as possible. This is true even where the automobile reigns supreme. Communities should concentrate facilities and services in centers and corridors. This will facilitate efficient automobile trips and tours. The more sprawling the area, the more important this becomes, for through activity centers, linked accessibility to activities can be maintained even as direct accessibility falls off.

As traffic problems have grown and proven resistant to transportation solutions, interest in land planning has also grown. Neotraditional towns, pedestrian pockets, urban villages, and other models of compact, mixed-use development have been advanced as the answer to automobile dependence, excessive vehicle miles of travel (VMT), and intractable traffic congestion.

Beyond some studies relating density to mode choice, VMT, or gasoline consumption, little is known about the relationship of location and land use to household travel patterns (1-7). Even the sacrosanct belief in compact development has been challenged by those claiming that decentralization brings activities closer together and that the ubiquitous automobile-highway system has rendered accessibility a minor factor in location and travel decisions (8-13).

Against this backdrop, a 16,000-record travel survey for Palm Beach County, Fla., was analyzed. Six communities were culled from the larger data base, and household travel data were then tested for significant differences in trip frequency, mode choice, trip chaining, trip length, and overall vehicle hours of travel. The purpose of the study was to determine whether, after controlling for household income and size, location and land use influence household travel patterns and, if so, in what ways.

R. Ewing, Joint Center for Environmental and Urban Problems, Florida Atlantic University/Florida International University, Miami, Fla. 33199. P. Haliyur and G. W. Page, Department of Urban and Regional Planning, Florida Atlantic University, Boca Raton, Fla. 33432.

HOUSEHOLD TRAVEL ACTIVITY PATTERNS

Household members have both individual and common needs that are met through activities. Many of the activities are outside the home and so involve travel. Household members have the ability to defer or advance the times of certain discretionary activities and may also have a choice of activity sites. They can reduce overall travel by scheduling activities as part of trip tours or chains instead of making a larger number of single-stop trips that produce a greater volume of travel in toto. The ability to link trips in tours cuts household travel by an estimated 15 to 22 percent relative to separate trips for the same purposes (14). The flexibility of the automobile makes it all possible.

DIFFERENT ANGLES ON ACCESSIBILITY

Accessibility influences the ways that household needs are met through travel. Residential accessibility—the distribution of activities around the place of residence—determines the destination, mode, and arguably, even the frequency of home-based trips (15-19). It is the primary concern of neotraditionalists, travel demand modelers, central-place theorists, and just about everyone else with an interest in land use and transportation.

Given the large number of linked trips, destination accessibility—the distribution of activities around each other—is another important determinant of household travel patterns (15-17, 20-21). A “shop which is close to a decision-maker’s place of employment may be quite accessible (as indicated by the frequency of use) even though it may be quite distant from the decision-maker’s place of residence” (20).

STUDY AREA

Palm Beach County, Florida, was chosen as the study area because it is the site of a recent diary-based travel survey, the only general travel survey in Florida to ask about walking and bicycling trips. Other surveys have focused exclusively on vehicular travel (being undertaken for purposes of highway and transit planning).

Palm Beach County has another advantage as a study area. It is a large county that offers some diversity of development within an urban form often characterized as “sprawl.” Six communities within Palm Beach County have been singled out. It is for the residents of these communities that travel patterns are compared.

To control for differences in household income, 18 households reporting annual incomes of less than \$20,000 had to be dropped

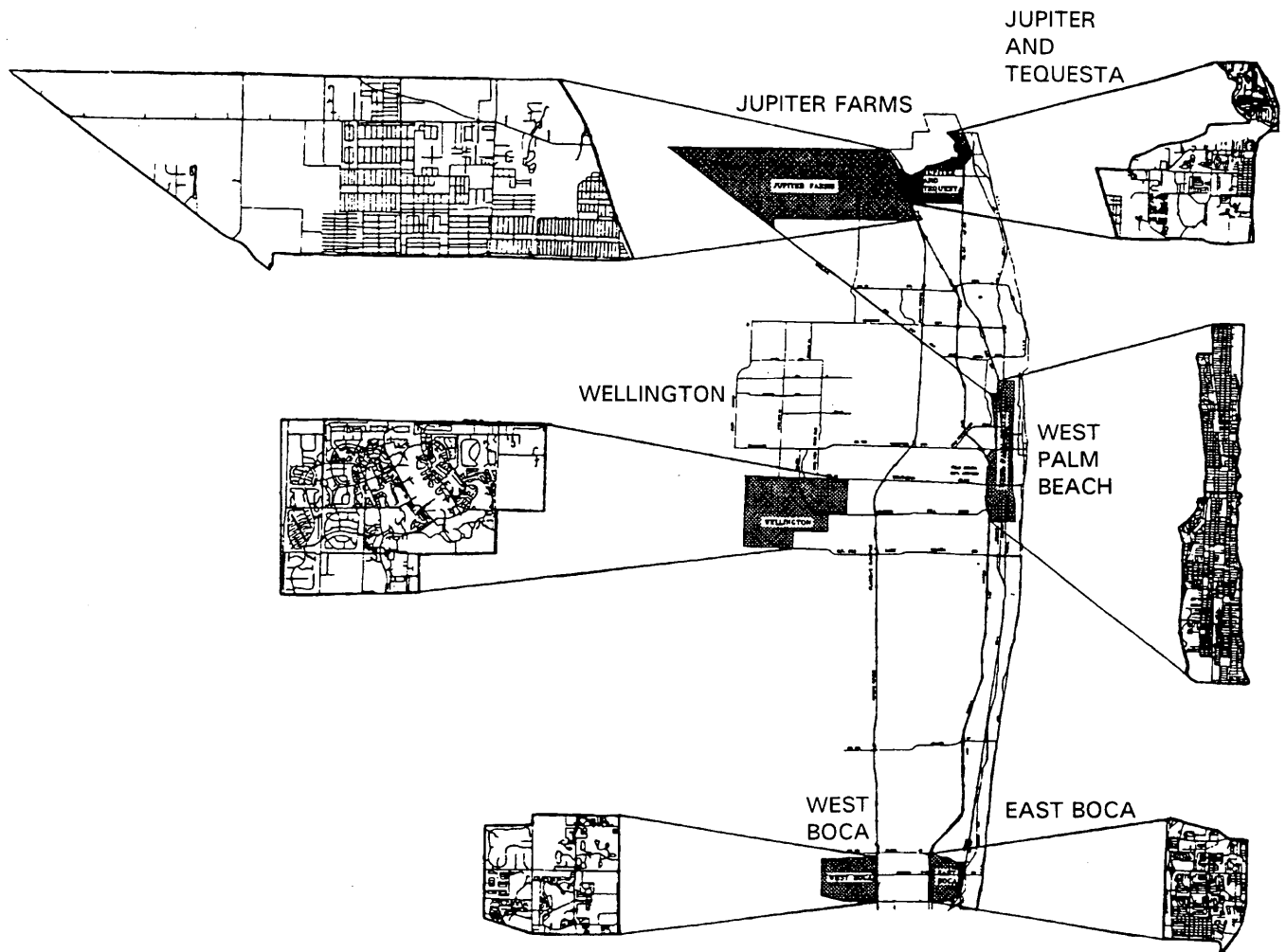


FIGURE 1 Communities of Palm Beach.

from the samples. They are nearly all from West Palm Beach, Jupiter/Tequesta, or West Boca. Three additional households that refused to disclose household income and reported owning no automobile were also dropped. They almost certainly fall into the lowest income categories. With these households out, samples from the six communities show no significant differences in either household income or household size (in chi-square tests). (The chi-square for household income, 24.6 with 25 degrees of freedom, corresponds to the 0.49 significance level. The chi-square for household size, 12.07 with 20 degrees of freedom, corresponds to the 0.91 significance level.)

Figure 1 locates the communities in relation to each other and shows their street networks. All are plotted at the same scale to emphasize how different they are. Table 1 provides a complete set of land-use statistics for the six communities, including accessibility indexes estimated with standard gravity models for work trips and non-home-based trips. (The accessibility index is the denominator of the gravity model used in the standard four-step regional travel modeling process to distribute trips. The index represents the distribution of trip attractions around each zone producing trips. The higher the index, the more accessible the attractions. The index is

computed by multiplying the number of trip attractions by the interzonal friction factor, which declines with interzonal travel time, and summing the result over all attraction zones.) Accessibility indexes have been reduced to a common base by dividing values for each community by values for West Palm Beach, the most accessible of the six communities.

Brief descriptions of the communities follow. West Palm Beach is as traditional (not neotraditional, but the real thing) as any place in the county. Its housing stock varies from detached single-family homes to high-rise apartments, all within view of each other. Streets form a dense grid and are narrow by today's standards. The community has corner stores, small building setbacks, rear parking, alleys, accessory apartments, and other hallmarks of traditional development. It is the only community with significant mass transit service and the only one with a real central business district. In terms of densities and accessibilities, it is the most urban of the six communities.

Wellington is a classic 1970s planned unit development (PUD). It has curvilinear streets, loop roads, and cul-de-sacs galore. It has pods of residential development that are walled off and inward facing, with only one way in and out. It has beautifully landscaped

TABLE 1 Characteristics of Palm Beach Communities

	East Boca	West Boca	West Palm Beach	Wellington	Tequesta & Jupiter	Jupiter Farms
Residential Density (dwellings/land acre)	3.15	2.63	3.76	0.76	2.00	0.12
Employment Density (jobs/land acre)	2.58	0.46	6.65	0.24	1.27	0.01
Jobs-Housing Ratio (jobs/dwelling)	0.82	0.17	1.77	0.32	0.64	0.10
% Multifamily Dwellings	37	49	43	21	33	2
Accessibility Index for Work Trips	0.49	0.22	1.00	0.14	0.31	0.21
Accessibility Index for Nonhome-Based Trips	0.72	0.43	1.00	0.27	0.40	0.08

collector roads with meandering sidewalks. In short it has everything that neotraditionalists love to hate. At the same time Wellington has a good mix of attached and multifamily housing and comes complete with its own shopping centers, schools, recreational facilities, and medical offices, making it self-contained with respect to all daily activities except basic employment. For employment, residents must make the long trek into the urbanized area.

East Boca is one of Florida's early master-planned communities, dating back to Addison Mizner and Florida's land boom of the 1920s. It has a small, walkable downtown, historic neighborhoods on a rectilinear grid, and newer neighborhoods on a modified grid. It is well endowed with public recreational facilities, schools, and small shopping centers. Its streets are tree lined, often with sidewalks, making walking an option for some utilitarian trips (even though distances are longer than ideal for walking). Employment centers are located nearby at Florida Atlantic University, in a large industrial area just west of I-95, and to the south in Broward County. In terms of densities and accessibility, it is the second most urban of the six communities.

West Boca is a suburb of residential PUDs—each well designed and well landscaped but inward oriented and independent of the others. The community has a fair number of schools and parks, four golf courses within a remarkably small area, and several large community shopping centers within the community or nearby. Subdivision and PUD streets are discontinuous to exclude through traffic, but arterials form a grid with good connections to the rest of the region. Although it is farther from employment centers than East Boca, West Boca is accessible to the same employment centers.

Jupiter and Tequesta are twin strip cities; small strip centers line their major thoroughfares, Indiantown Road and Federal Highway. Streets are strictly for automobiles; landscaping, medians, sidewalks, and pedestrian amenities are in short supply. Basic employment opportunities are limited, as are recreational facilities, but the community is well supplied with schools and local service employment, is reasonably dense, and mixes land uses in a fashion (with

residential areas running up to the edges of the commercial strips).

Jupiter Farms is the epitome of urban sprawl. It has nothing but large-lot, single-family homes; only one school, one park, and one convenience shopping center; and no employment centers nearby. Almost regardless of their trip purposes, residents must travel to Indiantown Road and then head for the Florida Turnpike or I-95. Jupiter Farms is closer to the ocean and the county's urbanized area boundary than is Wellington but is even less accessible for most purposes since it sits across from the relatively minor urban centers of Jupiter and Tequesta.

TRAVEL PATTERNS

In the discussion that follows, the classification of trips deviates from standard practice. Standard practice, which has its origin in conventional travel modeling, classifies trips as either home-based or non-home based. Trip purposes are defined only for home-based trips. Non-home-based trips are lumped together as a separate, single-trip purpose. Home-based and non-home-based trips are treated as if they were independent, when in fact they are necessarily linked.

In standard practice a trip from home to work without a stop is classified as a home-based work trip. However, if the commuter stops along the way to pick up a newspaper and then proceeds to work, the first leg is classified as a home-based shopping trip and the second leg is classified as a non-home-based trip. The primary purpose of the trip—work—is lost in the classification process.

In the present study trips are classified as parts of tours. By common convention tours begin and end at home. A tour may have only one stop away from home or may have many stops. If at least one stop is for purposes of work, the tour is classified as a work-related tour. Otherwise it is classified as a non-work-related tour. When individual trips (legs of a tour) must be identified by purpose, it will be in terms of the purpose at the destination and the type of tour.

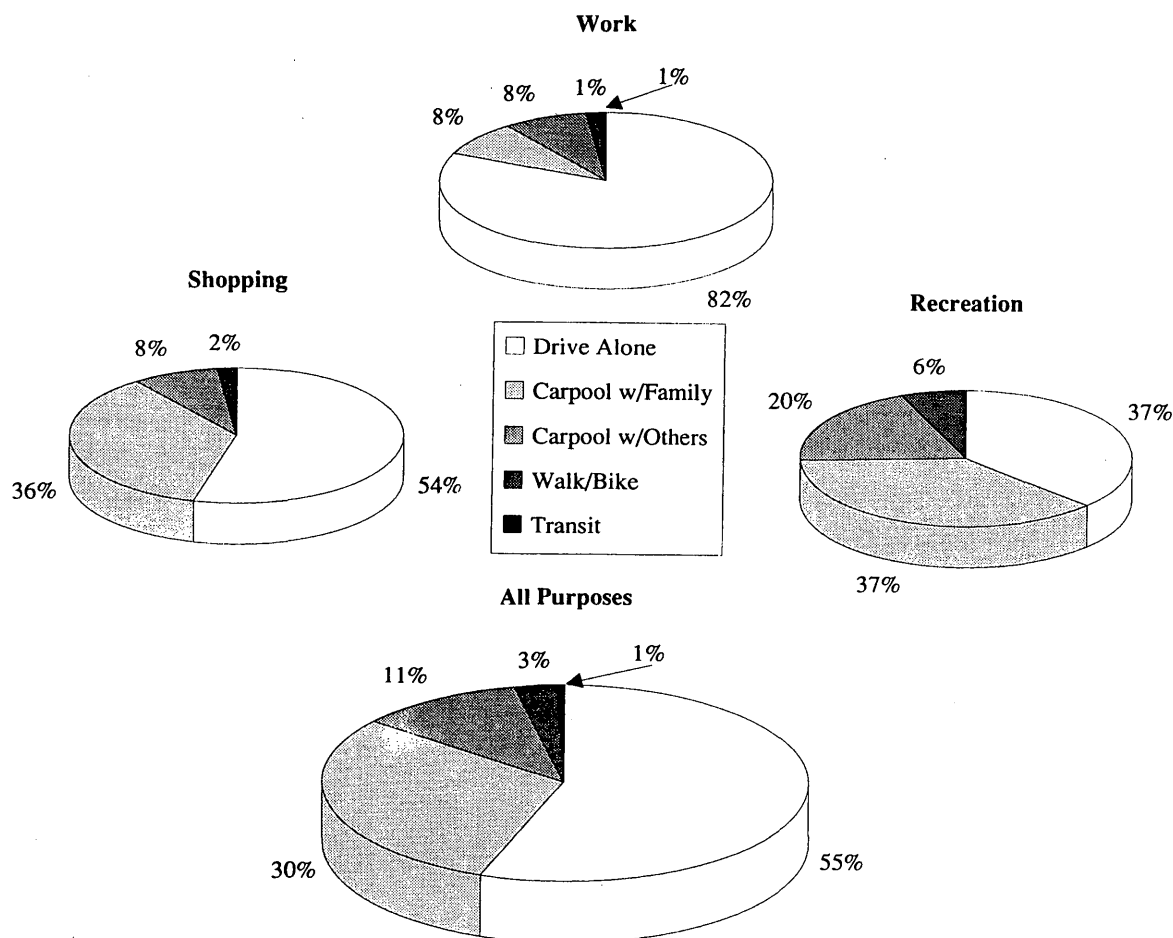


FIGURE 2 Mode splits in Palm Beach County.

Thus, in the previous home-to-shop-to-work example, a shopping trip and a work trip are linked in a work-related tour. This is not a perfect classification scheme, but it makes more sense than the standard classification scheme.

Travel Patterns Countywide

For the entire sample of surveyed households, two travel features stand out. First, Palm Beach County is automobile oriented in the extreme (Figure 2). Only 2.7 percent of the total trips are by walking/biking, whereas a mere 0.5 percent are by transit. Even for recreation only 6 percent of the trips in Palm Beach County are by alternative modes. Mode splits for walking/biking and transit are about one-third the national averages (Figure 3).

Unlike transit and walking/biking, carpooling is a significant mode of travel countywide. Carpooling with members of the same household, which is not even acknowledged as a travel option in most studies, represents 30 percent of all trips. Carpooling with members of other households, generally acknowledged as a travel option only for work trips, represents another 11 percent. Carpooling is much more common for shopping, recreation, and other purposes than it is for work.

Carpooling figures are important because carpooling occurs mostly on multipurpose trips, in which the needs of different trav-

elers are met at different stops. Thus, the accessibility of destinations to one another (what we are calling destination accessibility) becomes an important determinant of tour efficiency and vehicle miles or hours of travel.

The other outstanding fact about countywide travel is the sheer volume of linked trips. The need to overcome poor residential accessibility makes trip chaining a natural in sprawling, automobile-dependent Palm Beach County. Almost half of all work trips are linked to side trips for other purposes (Figure 4). A high percentage of non-work-related trips are also part of multipurpose tours (Figure 5). On balance, 61 percent of the trips made by surveyed households are part of multistop (and usually multipurpose) tours. That is as high a percentage as any reported in the literature (14,21-29).

Travel Patterns Across Communities

Travel characteristics for households in the six communities are summarized in Table 2 and Figures 6 through 8. All statistics relate to the 2-day period covered by the travel diaries. Mode splits vary only slightly across communities, less than one might expect given the differences in land-use patterns (Figure 6). Average travel times show more variation, particularly for work trips (Figure 7). Total vehicle hours of travel (VHT) per person also vary considerably, mostly because of differences in average travel times (Figure 8).

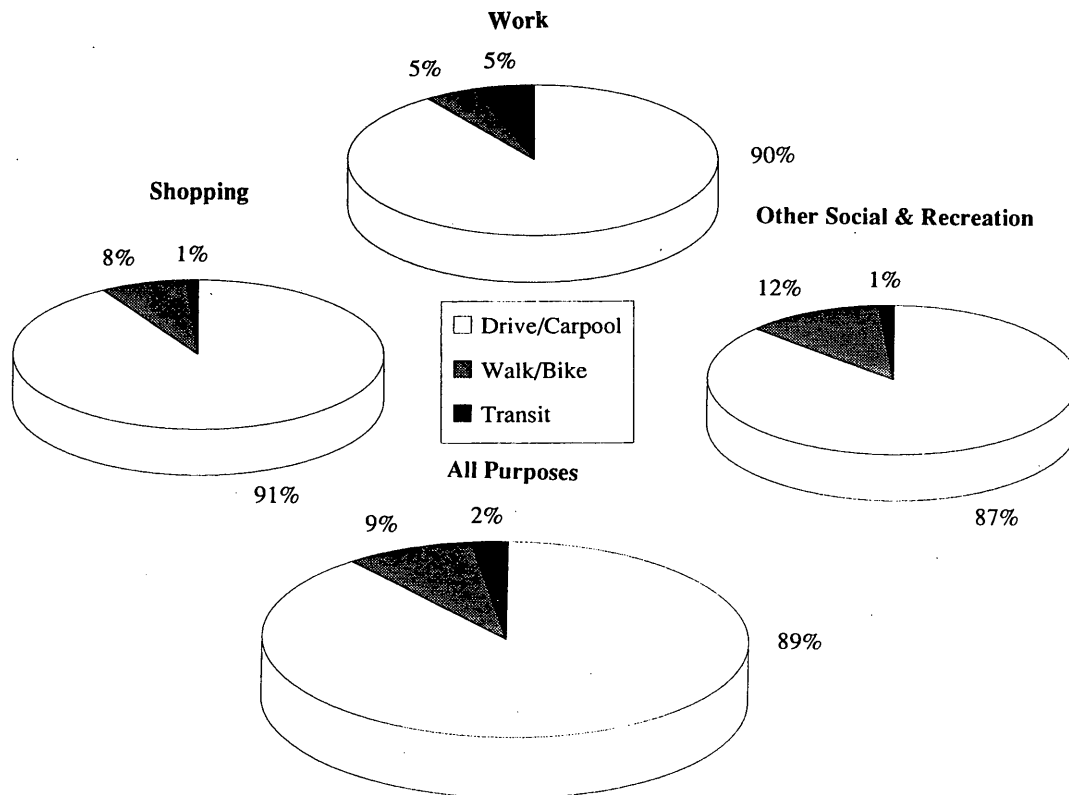


FIGURE 3 Mode splits in the United States (source: unpublished tabulations from 1990 Nationwide Personal Transportation Survey).

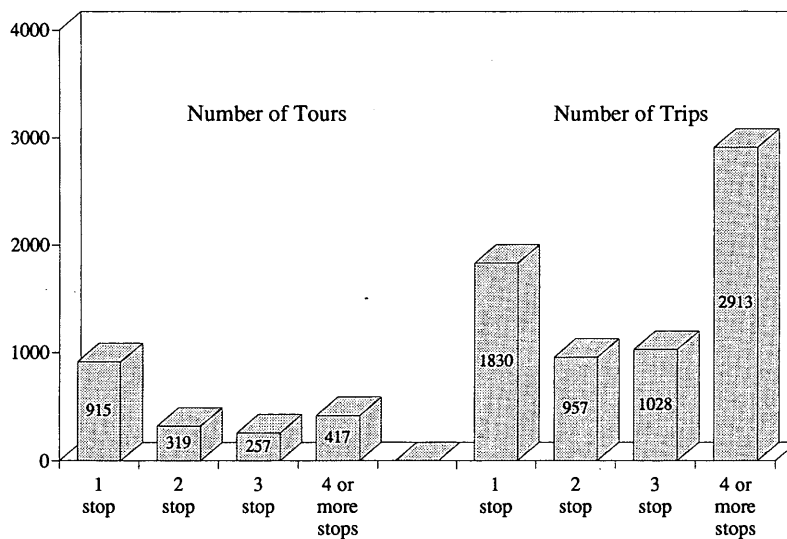


FIGURE 4 Work-related trip chaining in Palm Beach County.

VHT was computed from travel times assuming standard vehicle occupancies of 2.5 persons/vehicle for carpools and 30 persons/vehicle for transit.

VMT could not be easily derived from the travel survey data files since the traffic analysis zones of destinations were not geocoded for one-third of all trips. Differences in VMT are almost certainly even more pronounced than differences in VHT since vehicle travel

speeds are highest in areas of high VHT and lowest in areas of low VHT.

The samples in this study are small, and there is considerable variation from household to household within each community. Thus apparent differences among communities could be solely due to chance (sampling variability). To test for significant differences, analysis of variance was performed on the samples. *F*-statistics and

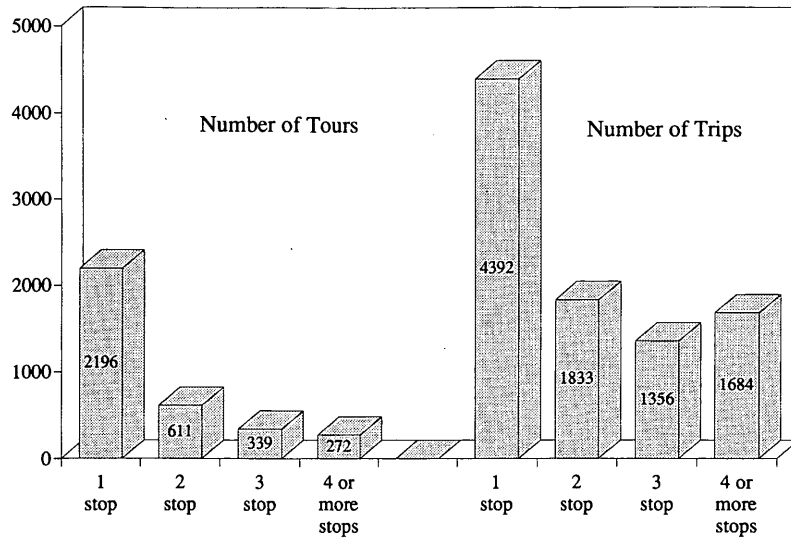


FIGURE 5 Non-work-related trip chaining in Palm Beach County.

TABLE 2 Trips per Person and per Tour in Different Communities

	East Boca	West Boca	West Palm Beach	Wellington	Tequesta & Jupiter	Jupiter Farms
Households in Sample	32	29	29	25	23	25
Trips/Person (Work-Related)	3.70	2.85	3.16	2.48	2.63	3.21
Trips/Person (Nonwork-Related)	2.66	2.85	3.18	3.71	2.73	3.08
Trips/Tour (Work-Related)	2.64	2.51	3.02	2.80	2.47	3.32
Trips/Tour (Nonwork-Related)	1.98	1.76	1.63	1.63	1.90	1.95

significance levels are reported in Table 3. At the 0.05 level, mean values of only three travel characteristics differ significantly across communities:

- travel time for work-related trips,
- travel time for non-work-related trips, and
- total hours of travel per person.

A fourth characteristic, vehicle hours of travel per person, approaches significance at the 0.05 level.

One other important difference is evident among the communities. The time savings realized through trip chaining appear to be much greater for the less accessible communities. For the county as a whole, average travel time per trip declines only modestly as extra stops are added to tours. However, for Jupiter Farms residents on work-related tours, the average time drops from 32.6 min for one-stop tours to 19.3 min for three-or-more-stop tours (Table 4). Declines are also substantial for non-work-related tours made by Jupiter Farms residents and work-related tours made by Wellington residents, workplaces being relatively inaccessible to Wellington.

INTERPRETATION

Stepping back from the statistical tests and eyeballing the community averages, the understanding of travel patterns can be refined even as the conclusions become less confident. West Palm Beach's relative accessibility fails to induce large numbers of automobile users to switch to walking, biking, or transit; apparently, even the best accessibility in Palm Beach County is not good enough for travel by these modes. Yet because of their short automobile trips, West Palm Beach residents still save on VHT.

The community with the worst accessibility, Jupiter Farms, produces the highest average vehicle hours per person. What saves Jupiter Farms from even more VHT is its longer-than-average trip chains and, more importantly, the time savings realized with each additional stop in these chains.

Wellington is an interesting case study. It has the longest work trips by far, yet it still manages to generate fewer vehicle hours per person than West Boca or Jupiter Farms. Internal shopping and recreational facilities produce the shortest shopping and recreational trips of any community, more than offsetting the longer work trips.

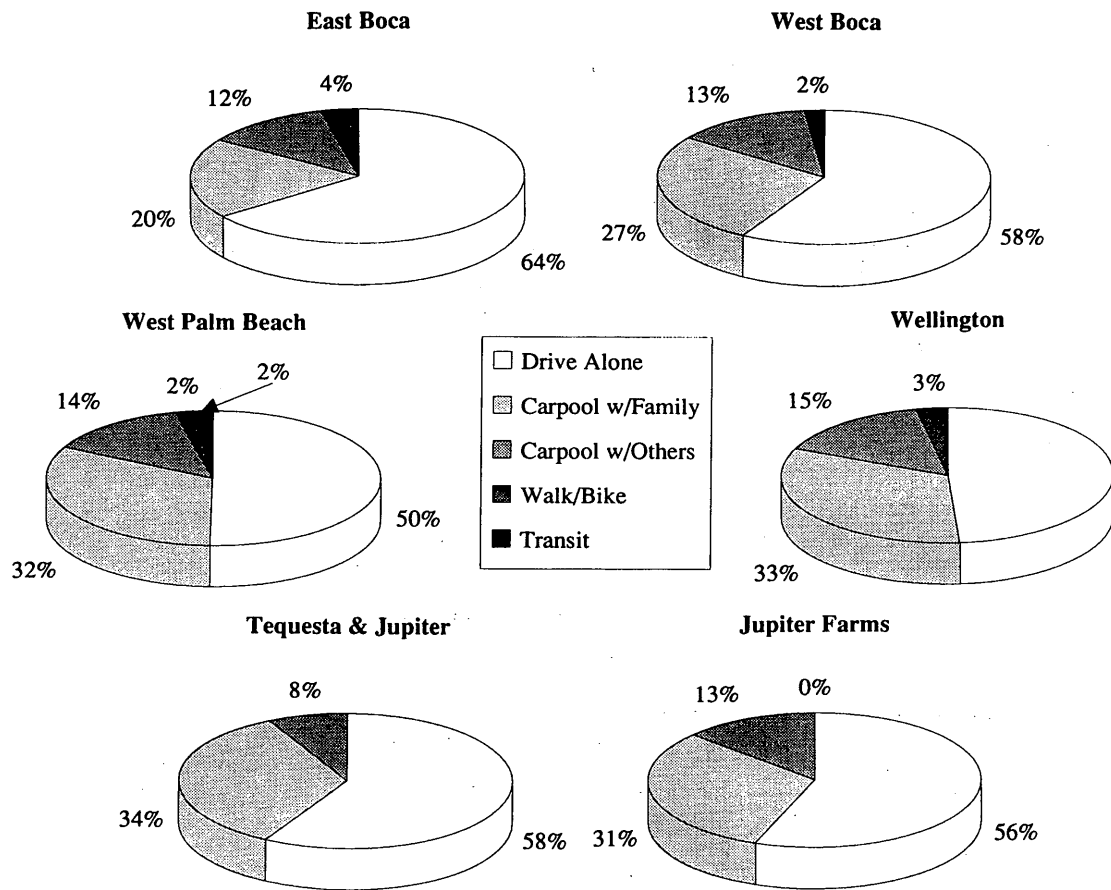


FIGURE 6 Mode splits in different communities.

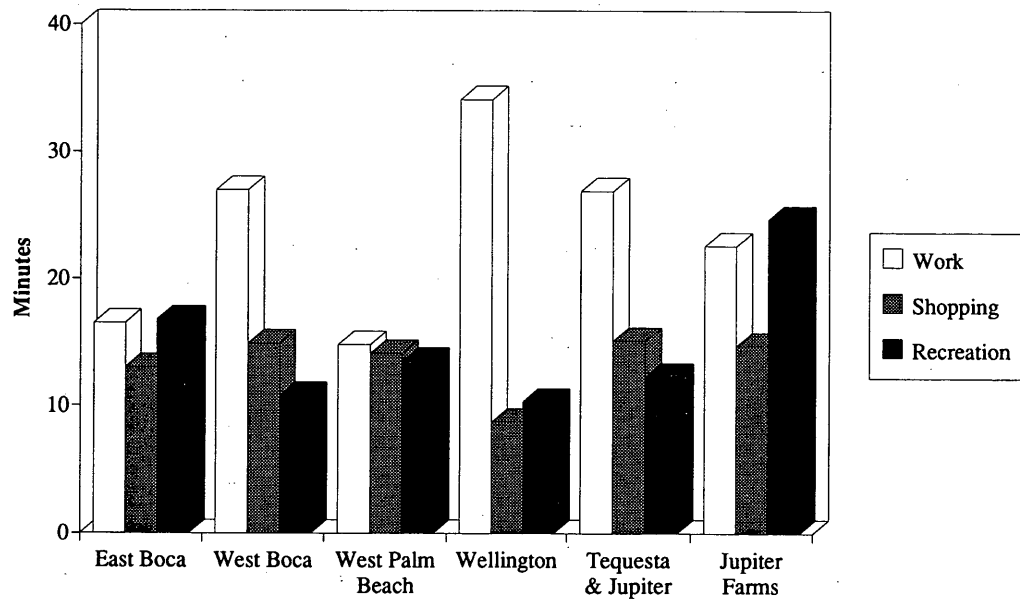


FIGURE 7 Average travel times in different communities.

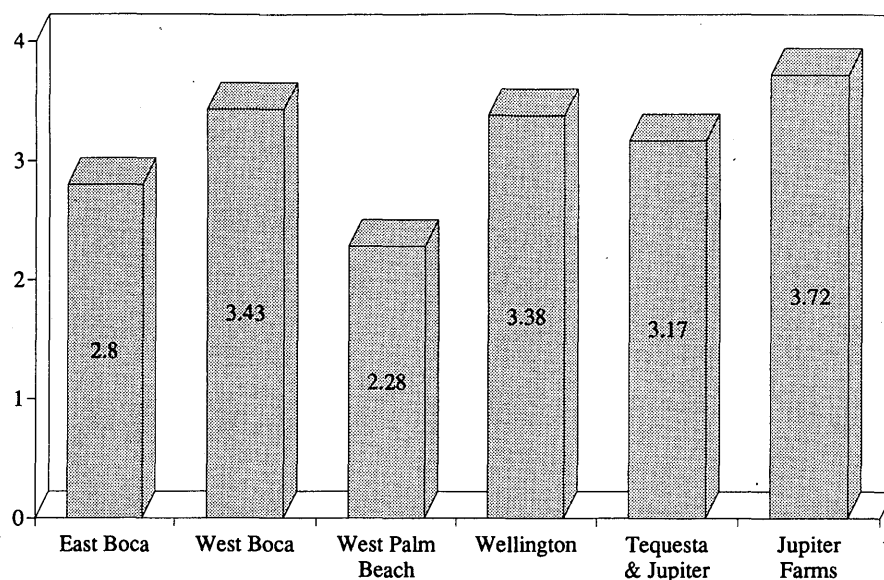


FIGURE 8 Vehicle hours per person in different communities.

TABLE 3 Analysis of Variance for Travel Characteristics Across Communities

Variable Tested	F-Statistic	Significance Level
Trips/Person (Work-Related)	0.76	0.58
Trips/Person (Nonwork-Related)	1.02	0.41
Trips/Tour (Work-Related)	0.65	0.66
Trips/Tour (Nonwork-Related)	0.53	0.75
% Drive Alone	1.26	0.29
% Carpool w/ Others	0.34	0.89
% Walk or Bike	1.51	0.19
Travel Time (Work)	2.79	0.02
Travel Time (Nonwork)	3.12	0.01
Total Hours of Travel/Person	2.72	0.02
Total Vehicle Hours of Travel/Person	2.16	0.06

Jupiter and Tequesta generate some very long non-work-related trips, a result no doubt of their strip development patterns. Even so Jupiter and Tequesta produce fewer vehicle hours per person than the best of the outlying communities. This makes the case for infill development generally, although one might prefer it take the form of East Boca or West Palm Beach.

CONCLUSIONS

In the study area, Palm Beach County, there is an inverse relationship between accessibility and VHT per person (Figure 9). Density, mixed use, and a central location all appear to depress vehicular travel. Even so, VHT does not reflect accessibility to the extent that

one might expect. Although Jupiter Farms has 1/10th the accessibility of West Palm Beach, it generates only two-thirds more VHT. Urbanites drive a lot whether they need to or not, and sprawl dwellers can reduce the amount of driving they do through careful trip scheduling.

What saves Wellington from horrendously high VHT is great accessibility to internal shopping, recreation, and school facilities. What keeps Jupiter Farms from being an unmitigated traffic disaster is the accessibility of linked activities once residents make the long trip into town.

Implications for land planning are more complex than simply pedestrianizing or transitizing the suburbs. Communities should internalize as many facilities and services as possible. This is true even where the automobile reigns supreme, as in Wellington.

TABLE 4 Average Travel Time per Trip for Different Chain Lengths and Communities (in minutes)

	East Boca	West Boca	West Palm Beach	Wellington	Tequesta & Jupiter	Jupiter Farms	County-wide
Work-Related Tours							
1-Stop	14.4	23.6	16.1	39.1	27.1	32.7	23.9
2-Stops	17.2	17.4	17.3	19.5	24.5	25.6	21.6
3+-Stops	15.3	24.5	12.8	24.0	24.0	19.3	18.1
Nonwork-Related Tours							
1-Stop	11.3	12.5	15.3	14.0	14.4	15.5	16.8
2-Stop	13.6	17.9	13.5	13.1	14.1	31.5	18.6
3+-Stops	12.8	20.7	10.7	11.8	12.4	16.0	15.3

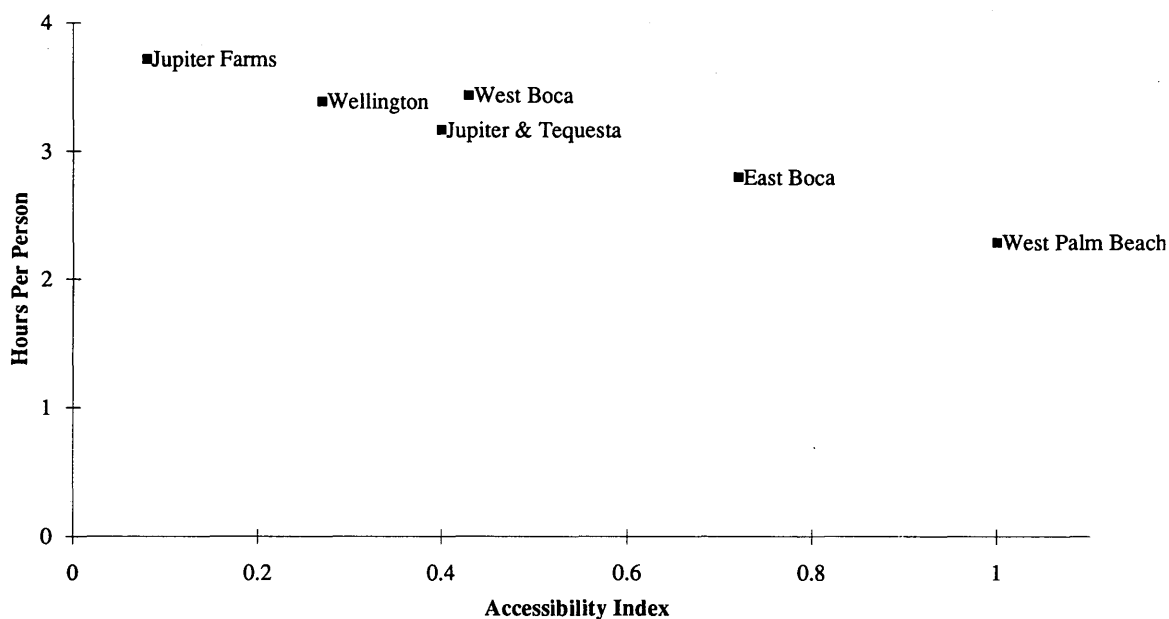


FIGURE 9 VHT per person versus accessibility.

Communities should concentrate facilities and services in activity centers. This will facilitate efficient automobile trips and tours. The more sprawling the area, the more important this becomes, for through activity centers, linked accessibility to activities can be maintained even as direct accessibility falls off.

REFERENCES

1. Deacon, J. A., et al. *Urban Transportation and Land Use*. U.S. Department of Transportation, 1976, pp. 55-78.
2. Neels, K., et al. *An Empirical Investigation of the Effects of Land Use on Urban Travel*. Working Paper 5049-17-1. The Urban Institute, Washington, D.C., 1977, pp. 56-60.
3. Zehner, R. B. *Access, Travel, and Transportation in New Communities*. Ballinger Publishing Company, Cambridge, Mass., 1977, pp. 75-109.
4. Newman, P. W. G., and J. R. Kenworthy. *Cities and Auto Dependence: A Sourcebook*. Gower Technical, Brookfield, Vt., 1991, pp. 34-68.
5. Holtzclaw, J. *Explaining Urban Density and Transit Impacts on Auto Use*. Sierra Club, San Francisco, 1991.
6. Cervero, R. Congestion Relief: The Land Use Alternative. *Journal of Planning Education and Research*, Vol. 10, 1991, pp. 119-129.
7. Downs, A. *Stuck in Traffic—Coping with Peak-Hour Traffic Congestion*. The Brookings Institution, Washington, D.C., 1992, pp. 79-120.
8. Lowry, I. Planning for Urban Sprawl. In *Special Report 220: A Look Ahead: Year 2020*, TRB, National Research Council, Washington, D.C., 1988, pp. 275-312.
9. Gordon, P. A. Kumar, and H.W. Richardson. The Influence of Metropolitan Spatial Structure on Commuting Time. *Journal of Urban Economics*, Vol. 26, 1989, pp. 138-151.
10. Gordon, P., H. W. Richardson, and M. Jun. The Commuting Paradox—Evidence from the Top Twenty. *Journal of the American Planning Association*, Vol. 57, 1991, pp. 416-420.

11. Giuliano, G. Research Policy and Review 27. New Directions for Understanding Transportation and Land Use. *Environment and Planning A*, Vol. 21, 1989, pp. 145-159.
12. Giuliano, G. Is Jobs-Housing Balance a Transportation Issue?" In *Transportation Research Record 1305*, TRB, National Research Council, Washington, D.C., 1991, pp. 305-312.
13. Giuliano, G., and K. Small. Is the Journey to Work Explained by Urban Structure?" *Urban Studies*, Vol. 30, 1993, pp. 1485-1500.
14. Oster, C V. Household Tripmaking to Multiple Destinations: The Overlooked Urban Travel Pattern. *Traffic Quarterly*, Vol. 32, 1978, pp. 511-529.
15. Hanson, S. The Determinants of Daily Travel-Activity Patterns: Relative Location and Sociodemographic Factors. *Urban Geography*, Vol. 3, 1982, pp. 179-202.
16. Hanson, S., and M. Schwab. Accessibility and Intraurban Travel. *Environment and Planning A*, Vol. 19, 1987, pp. 735-748.
17. Williams, P A. A Recursive Model of Intraurban Trip-Making. *Environment and Planning A*, 1988, Vol. 20, pp. 535-546.
18. Handy, S. L. Regional Versus Local Accessibility: Neo-Traditional Development and Its Implications for Non-Work Travel. Prepared for 1992 Annual Meeting, American Collegiate Schools of Planning, 1992.
19. Handy, S. L. Regional Versus Local Accessibility: Implications for Nonwork Travel. In *Transportation Research Record 1400*, TRB, National Research Council, Washington, D.C., 1993, pp. 58-66.
20. Richardson, A. J., and W. Young. A Measure of Linked-Trip Accessibility. *Transportation Planning and Technology*, Vol. 7, 1982, pp. 73-82.
21. Strathman, J. G., K. J. Dueker, and J. S. Davis. Effects of Travel Conditions and Household Structure on Trip Chaining. Presented at 72nd Annual Meeting of the Transportation Research Board, Washington, D.C., 1993.
22. Wheeler, J. O. Trip Purposes and Urban Activity Linkages. *Annals of the Association of American Geographers*, Vol. 62, 1972, pp. 641-654.
23. Hanson, S. The Importance of the Multi-Purpose Journey to Work in Urban Travel Behavior. *Transportation*, Vol. 9, 1980, pp. 229-248.
24. O'Kelly, M. E. A Model of the Demand for Retail Facilities, Incorporating Multistop, Multipurpose Trips. *Geographical Analysis*, Vol. 13, 1981, pp. 134-148.
25. Golob, T. F. A Nonlinear Canonical Correlation Analysis of Weekly Trip Chaining Behavior. *Transportation Research A*, Vol. 20A, 1986.
26. Goulias, K. G., R. M. Pendyala, and R. Kitamura. Practical Method for the Estimation of Trip Generation and Trip Chaining. In *Transportation Research Record 1285*, TRB, National Research Council, Washington, D.C., 1990, pp. 47-56.
27. Prevedouros, P. D. Trip Generation: Different Rates for Different Densities. Presented at 71st Annual Meeting of the Transportation Research Board, Washington, D.C., 1992.
28. Lockwood, P. B., and M. J. Demetsky. Nonwork Travel—An Evaluation of Daily Behavior. Presented at 73rd Annual Meeting of the Transportation Research Board, Washington, D.C., 1994.
29. Kim, H., S. Soot, and A. Sen. Shopping Trip Chains: Current Patterns and Changes Since 1970. In *Transportation Research Record 1443*, TRB, National Research Council, Washington, D.C., 1994, pp. 38-44.

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