

Non-Motorized Transportation

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Introduction

The contribution of non-motorized modes to personal transportation has, in some respects, remained an enigma over the past years. Little empirical data exists exploring the effects, for example, of higher population densities, and personal or family demographics on the rate of non-motorized trips. Additionally, there is little broad based inferential data that is suitable for drawing general conclusions about who non-motorized trip-makers are and the types of activities these trips are used to accomplish. There are many compelling motives for gathering basic data about non-motorized travel, not the least of which are the recent passage of federal legislation and the increasing conviction that certain types of community structure will reduce vehicle travel.

For example, the long-term effectiveness of mixed use neighborhoods for reducing vehicle travel hinges on fundamental assertions regarding non-motorized travel. Assertions that, for the most part, have not been empirically validated. It is difficult, if not impossible, to predict the relationships between travel patterns and the underlying neighborhood structure without a better understanding of non-motorized travel. Additionally, recent federal legislation, such as ISTEA, requires the preparation of multi-modal transportation plans; plans that require assessment and integration of non-motorized modes.

The purpose of this paper is to present the results of an evaluation of travel characteristics associated with households and individuals making non-motorized trips. The data were collected as part of the National Personal Transportation Study (NPTS). The size and representation of the NPTS dataset facilitates not only comparisons between households making no non-motorized trips (i.e., bike or walk trips) and households making one or more non-motorized trips but is also sufficiently large to allow detailed examination of bike and walk trips alone.

The report is organized into three sections. The first section highlights recent research exploring travel characteristics of non-motorized trip-makers. The limitations of the previous research are also reviewed in this discussion. Using the NPTS data, the second section presents a comparison between households making one or more non-motorized trips and households making only motorized trips during an average day. Finally, the last section presents an in-depth evaluation of the characteristics of the NPTS bike and walk trips.

Literature Review

Much of the more recent research in non-motorized transportation has focused in the areas of safety and design standards and, more topically, policy implementation. Studies on the safety related aspects of biking and walking, ranging from education to accident analysis, may be found throughout the literature (for example, see Smith and Walsh (1) and Stutts, et al (2)). Policy papers have tended to focus more on discussion of future funding opportunities, implementation of ISTEA requirements and, general planning issues (for example, see Broeg et al (3), Replogle (4), and Hope (5)).

Noticeable is the absence of a large body of literature related to the characteristics of the walker or biker and/or the geographic or regional attributes associated with non-motorized trip making. In part this is due to the difficulty in surveying the non-motorized population. Limited numbers of bike and walk trips make small scale surveys difficult. Consequently, survey designs often limit the applicability of the results. As will be seen in the following discussions, the majority of bicycle data, and consequently research findings, often occur in localities that differ substantially from most other urban areas.

In the following sections the state of research associated with non-motorized transportation will be explored. In particular, past research identifying household and person characteristics for trips made by walk and bicycle modes will be summarized and reviewed.

Bicycling and Walking

Previous research on bicycling and walking in the U.S. can be divided into four basic topic areas. These include planning and policy aspects, demand, facilities design, and education and safety. Although these boundaries are artificial to a certain extent, they are useful organizers nonetheless. The major focus of this study are the demographic and geographical characteristics of those individuals electing to travel by non-motorized modes. This information is most often found in the demand related literature. The discussion begins with a summary of findings on trip-maker demographic characteristics and culminates with geographical attributes.

Trip Demographics

Perhaps the most studied demographic characteristics associated with non-motorized travel are those of sex, age, and income. In the following discussion, a review of study findings with respect to each of these major demographic characteristics is presented for both bicycle and walk modes. As will be noted, it is clear from this evaluation that the demographics of those making non-motorized trips vary by mode, i.e., cycling or walking and by trip purpose.

Sex. Recent work by Goldsmith (6) indicates that cyclists are predominantly men. These findings are also consistent with recent count data taken on citywide commuter routes in Phoenix, Arizona (7) in which men accounted for approximately 75 percent of the observed bicyclists. Similarly, a recent Harris Poll found that 60 percent of all cyclists were male (8). Data on the proportions of men and women walk trips is less known. Echoing sentiments expressed by Goldsmith (6), there is little concrete data investigating the characteristics of walkers, particularly those utilizing walking for employment purposes. Recent data gathered in several Seattle neighborhoods suggest that the proportions of men and women walking are approximately equal for most trip purposes (9).

Age. Not unexpectedly, age has also been found to vary between modes. Based on cycling patterns gathered from the Harris Poll (8) and the cities of Seattle and Boulder, Goldsmith (6) found that propensity to cycle declines as age increases. It is clear from the data that the majority of cyclists are also under the

Age Group	Age Group		
	Seattle, WA	Davis, CA	Boulder, CO
16-25	12	52	43
26-35	30	27	22
36-45	30	9	13
46-55	13	5	10
56-65	6	0	6
65 and Older	7	0	7

age of 45. As Table 1 suggests there is a pattern of younger cyclists in university cities, such as Boulder and Davis, when compared to a more diverse market such as Seattle. However, it is important to note that all three areas would generally be considered as highly bicycle supportive.

Income and Employment. Other demographic characteristics, such as income and employment have also been

shown to correlate well with cycling trips. In a study of downtown bicycle worktrips by Lott et al (10), it was found that commuting cyclists were more heavily represented in employment categories of sales, clerical, service, and laborer than those in professional or technical positions. Ashley and Banister (11) found that higher social classes in England tended to result in fewer bicycle trips. Equally revealing are

results from the Harris Poll also indicating diminishing ridership with increasing income (8). Income and employment effects on walking are less well known. In fact, very little recent empirical data exists and that which is available suggests that walk trips decline as income increases (9).

Trip Characteristics

Turning to trip characteristics, the research focus centers on developing estimates of certain trip attributes or characteristics. These attributes primarily include trip distance and trip purpose.

Trip Distance. Review of previous research suggests that cycling distances often vary by geographic region and trip purpose; maximum distances rarely exceed five to six miles. Deakin (12) drawing on earlier research in the San Francisco Bay Area indicates that the average bicycle distance is one to two miles while bike commuters travel on average five to six miles. Recent survey data drawn in Boulder, Colorado (13) indicates a mean bicycle trip distance slightly longer than two miles. Data from Davis, California indicates cycling work trip distances of less than three miles for downtown employees (10).

In contrast, there is limited data on the maximum walking distances for trip-making purposes. Sparse survey data from a variety of locations indicates that walking distances generally do not exceed two miles for commuting purposes (6). In the Boulder, Colorado survey, the average travel time for a walk work trip was slightly more than 12 minutes while the average bike trip took approximately 14 minutes; distances were noted as one mile and 2.7 miles, respectively.

Trip Purpose. The proportion of trips by trip purposes tends to be similar between modes, with non-motorized recreational trip making consistently higher than trip making for employment or shopping purposes. A recent survey in Portland, Oregon (14) indicated that well over 95 percent of the trips made by active bicyclists are for recreational purposes. This finding is similar to that noted in the Harris Poll in which approximately 82 percent of the respondents used a bicycle in the past month for recreational purposes (8). These results do not differ substantially from earlier observations by Floyd (15), in which he concluded commuting to school and recreational trips account for the majority of cyclists trips in the U.S. Similarly the majority of walk trips also tend to be for recreational purposes. The Harris Poll (8) notes that over 70 percent of its respondents undertook a walk trip for exercise or recreation in the previous year.

Trip making for commuting purposes continues to be relatively small for either bike or walk modes. In the city of Seattle, commuting by bicycle and walking constitutes less than 8 percent of the total commuting volume. The 1980 Census data indicates that approximately 5.6 percent of all workers walked to their place of employment while less than 0.5 percent rode a bicycle (16). Those walking or biking to work in 1990 were appreciably smaller, with 0.4 percent biking and approximately 3.9 percent walking (18). Nationally, very few urban areas, in the 1990 census, reported the percent of those biking to work over 0.8 or those walking to work over 3.5 percent (19).

However, higher percentages of walk or bicycle commute trips can be found in several areas throughout the country. In Boulder, Colorado roughly 14 percent commute by walk with approximately 20 percent in Annapolis, Maryland. Both bicycle and walk commuting levels are higher than national averages in areas with universities. In Gainesville, Florida, approximately 6 percent bike to work and in Eugene, Oregon slightly less than 6 percent commute to work by bike (16).

Limitations of Current Research

As might be expected from the previous section, there are numerous limitations to much of the published research. These include surveys that are small, frequently not random, and usually conducted in localities in which extrapolation to other regions is limited at best. Additionally, there is little recent quantitative investigation into the associations between geographic attributes, such as population densities,

and trip maker characteristics, such as age and household structure, and the effects on non-motorized trip-making. For example, although preliminary work by Goldsmith (6) suggests some positive correlation between increased density and the rate of walking, he also notes the evidence is far from conclusive. In the remainder of this paper many of these relationships will be explored. Bicycle and walk trips rates will be developed for a variety of variables to better identify the attributes of non-motorized trip making.

The National Picture: Results from the NPTS

The NPTS is unique in that it provides a sufficiently large database to allow examination of most of the important trip-making characteristics associated with non-motorized travel modes. In the remaining sections, the results of an analysis of the NPTS dataset, with respect to non-motorized travel, are presented. The major discussions are arranged in two sections. In the first section, the differences between households making no non-motorized trips and households making one or more non-motorized trips are compared. These comparisons include, for example, differences by income and household size categories. Following this discussion is a more detailed presentation focusing exclusively on bicycle and walking characteristics. Comparisons again include distinctions by household and person variables.

A Comparison Between Households Making No Bike or Walk Trips and Households Making One or More Bike or Walk Trips

Approximately 81 percent of the interviewed households made zero bike or walk trips while the remaining 19 percent of the households made one or more non-motorized trips. In this section, we will examine the household differences between the two groups. The discussion centers primarily on comparisons of trip rates between household types. Trip rates are calculated independently for households making no bike or walk trips and households making one or more non-motorized trips. Trip rates represent the total number of trips (regardless of mode) per variable category divided by the total households in that category.

Income. Beginning first with income as shown in Table 2, it is notable that non-motorized households, i.e., those households making one or more bike or walk trips, consistently have higher trip rates than those households making only motorized trips. Households with one or more non-motorized trips make approximately 33 to 50 percent more daily trips than those households with only motorized trips. The

data also suggest that trip rates, for both motorized and non-motorized households, increase in an exponential manner leveling off around \$50,000. At lower income levels, differences in trip rates are smaller between households making only non-motorized trips and households making one or more non-motorized trips than at higher levels of income. Above \$20,000, differences hover around four trips per day, below \$20,000, between two and three trips per day.

	HH's Making No Bike/ Walk Trips	HH's Making 1 or More Bike/Walk Trips	Difference (#)
<\$10,000	5.91	8.75	2.84
\$10,000-\$19,999	6.80	9.06	2.26
\$20,000-\$29,999	7.82	12.08	4.26
\$30,000-\$39,999	8.76	13.08	4.32
\$40,000-\$49,999	9.91	15.01	5.10
\$50,000-\$59,999	9.90	13.90	4.00
\$60,000-\$69,999	10.18	14.14	3.95
>\$70,000	10.40	14.32	3.92

Household Size. As Table 3 demonstrates, the same pattern of higher daily trip rates (20 to 30 percent greater) for those households making one or more bike or walk trips continues when rates are examined using household size as a discriminator. Changes in trip rates are greatest between household sizes of one and two persons, increasing by 50 to 60 percent, and flattening as household size increases.

Table 3: DAILY HOUSEHOLD TRIPS BY HOUSEHOLD SIZE

	HH's Making <i>No Bike/ Walk Trips</i>	HH's Making <i>1 or More Bike/Walk Trips</i>	Difference (#)
1	4.46	5.37	0.91
2	6.88	8.76	1.88
3	8.82	11.54	2.72
4	11.55	13.70	2.15
5 or more	13.31	17.25	3.94

Population Density. Examining Table 4, it can be seen that daily trip rates by population density reveals much the same pattern noted in earlier summaries. Households making one or more bike or walk trips consistently make more daily trips than those households making only motorized trips. As can be seen on Figure 1, daily trip rates for households making only motorized trips generally decrease with increasing density, a well established finding. Alternatively, households making one or more

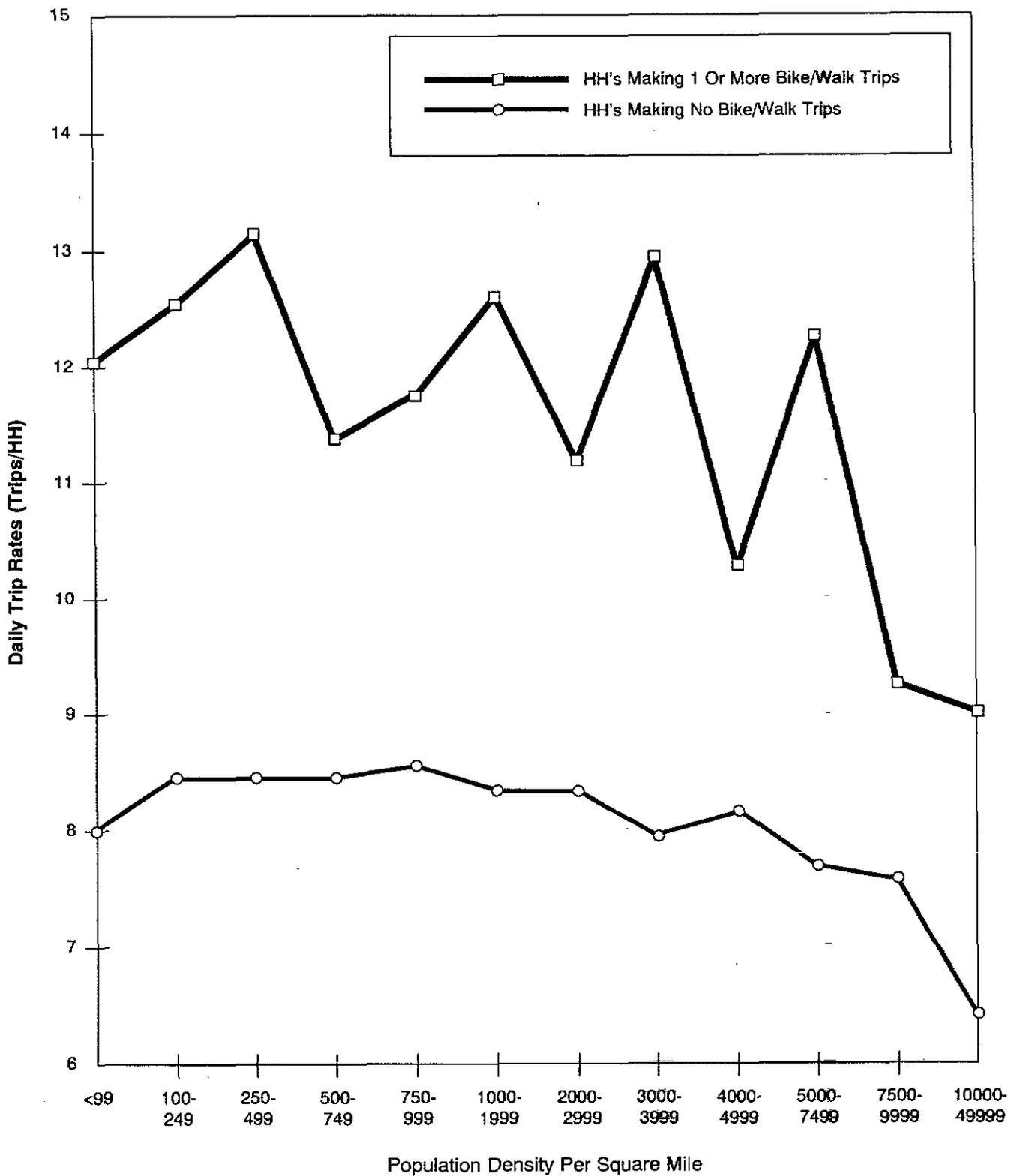
Table 4: DAILY HOUSEHOLD TRIPS BY POP. DENSITY

	HH's Making <i>No Bike/Walk Trips</i>	HH's Making <i>1 or More Bike/Walk Trips</i>
<99	8.03	12.12
100-249	8.43	12.46
250-499	8.44	13.16
500-749	8.41	11.41
750-999	8.57	11.65
1000-1999 (MSA)	8.30	12.63
2000-2999 (MSA)	8.28	11.24
3000-3999 (MSA)	7.86	12.94
4000-4999 (MSA)	8.19	10.32
5000-7499 (MSA)	7.67	12.27
7500-9999 (MSA)	7.56	9.28
10000-49999 (MSA)	6.38	9.04

non-motorized trips tend to make greater numbers of daily trips, with some indication of a slightly decreasing trend in daily trip rates as densities increase. However, some caution should be exercised when evaluating this figure. Although trip rates are expressed for both households making no non-motorized trips and those making at least one non-motorized trip, it should be noted that motorized trips still dominate rates in both categories.

Vehicle Miles of Travel. The comparative analysis between households making only motorized trips and households making one or more non-motorized trips indicates that daily trip rates are not reduced when non-motorized trips are made. In other words, households making one or more non-motorized trips may make them in addition to their motorized trips. This suggests that many of the bike and walk trips may not be a strict replacement of vehicle trips but rather serve as supplemental trips, perhaps augmenting social or recreational tripmaking behavior. A brief examination of vehicle trips rates yield mixed evidence.

Figure 1:
TOTAL DAILY HOUSEHOLD TRIPS by POPULATION DENSITY



Tables 5 and 6 present daily vehicle trip rates for households making one or more non-motorized trips and for households making only motorized trips by income category and household size. The data suggest that at lower income levels some vehicle trip replacement may occur. However, as income increases the differences become less distinct. Table 6 provides slightly more indication of vehicle trip replacement. For household sizes of four or fewer, vehicle trip rates differ by as much as approximately two vehicle trips per day. When household size reaches five or more persons, daily vehicle trip rates become very close.

A second means to assess whether non-motorized trips supplant vehicle trips is to evaluate the differences in daily vehicle miles of travel (VMT) between the household types. In the remaining portions of this discussion, various cross-classifications of VMT for households making only motorized trips and households making one or more non-motorized trips are presented. These data suggest that VMT is less for households making one or more non-motorized trips.

Table 7 suggests that households making one or more non-motorized trips accumulate less daily VMT. The differences are greatest in the higher

middle income categories. This is slightly different from previous research but consistent with findings outlined in the next section which suggest that high middle income households tend to make greater numbers of non-motorized trips for work related purposes. These trips may actually be vehicle replacement trips, however, additional evaluation would be necessary to validate this hypothesis. At high income levels, differences in daily VMT are more pronounced between household types.

Table 5: AVERAGE DAILY HOUSEHOLD VEHICLE TRIPS BY INCOME

	HH's Making No Bike/ Walk Trips	HH's Making 1 or More Bike/Walk Trips	Difference (#)
<\$10,000	4.90	2.84	-2.06
\$10,000-\$19,999	5.56	4.23	-1.33
\$20,000-\$29,999	6.39	6.68	0.29
\$30,000-\$39,999	7.16	7.03	-0.13
\$40,000-\$49,999	8.18	9.77	1.59
\$50,000-\$59,999	8.25	8.39	0.14
\$60,000-\$69,999	8.65	8.73	0.08
>\$70,000	9.15	9.45	0.30

Table 6: AVERAGE DAILY HOUSEHOLD VEHICLE TRIPS BY HOUSEHOLD SIZE

	HH's Making No Bike/ Walk Trips	HH's Making 1 or More Bike/Walk Trips	Difference (#)
1 Person	3.86	1.64	-2.22
2 People	5.71	3.99	-1.72
3 People	7.29	6.36	-0.93
4 People	9.65	7.99	-1.66
5 or more People	10.82	10.22	-0.60

Table 7: AVERAGE DAILY VMT BY INCOME

	HH's Making No Bike/ Walk Trips	HH's Making 1 or More Bike/Walk Trips	Difference (#)
<\$10,000	30.0	30.6	0.6
\$10,000-\$19,999	34.7	31.4	-3.3
\$20,000-\$29,999	45.6	42.8	-2.8
\$30,000-\$39,999	53.6	49.0	-4.6
\$40,000-\$49,999	60.1	53.1	-7.0
\$50,000-\$59,999	61.5	59.6	-1.9
\$60,000-\$69,999	67.3	56.0	-11.3
>\$70,000	71.7	58.2	-13.5

**Table 8: AVERAGE DAILY HOUSEHOLD VMT
BY HOUSEHOLD SIZE**

	HH's Making <i>No Bike/ Walk Trips</i>	HH's Making <i>1 or More Bike/Walk Trips</i>	Difference (#)
1 Person	31.5	29.7	-1.8
2 People	45.5	34.7	-10.8
3 People	58.0	46.3	-11.7
4 People	61.0	51.2	-9.8
5 or more People	59.9	46.5	-13.4

Table 9: AVERAGE DAILY VMT BY LIFE CYCLE

	HH's Making <i>No Bike/Walk Trips</i>	HH's Making <i>1 or More Bike/Walk Trips</i>
Single Adult, No Children	36.9	31.4
Single Adult, Youngest Child 0-5	31.9	20.9
Single Adult, Youngest Child 6-15	35.7	40.9
Single Adult, Youngest Child 16-21	46.4	34.4
Single Adult, Retired, No Children	17.8	20.3
> 2 Adults, No Children	54.8	42.7
> 2 Adults, Youngest Child 0-5	56.2	50.5
> 2 Adults, Youngest Child 6-15	60.7	50.9
> 2 Adults, Youngest Child 16-21	73.2	61.5
> 2 Adults, Retired, No Children	33.9	35.7

Table 10: DAILY HOUSEHOLD VMT BY POP. DENSITY

Persons Per Square Mile	HH's Making <i>No Bike/ Walk Trips</i>	HH's Making <i>1 or More Bike/Walk Trips</i>	Difference (#)
<99	57.1	58.1	1.0
100-249	52.9	50.2	-2.7
250-499	53.5	48.0	-5.5
500-749	53.3	45.9	-7.4
750-999	52.7	33.6	-19.1
1000-1999 (MSA)	46.1	51.8	5.7
2000-2999 (MSA)	43.6	50.7	7.1
3000-3999(MSA)	42.8	45.7	2.9
4000-4999 (MSA)	41.3	35.9	-5.4
5000-7499 (MSA)	42.4	37.6	-4.8
7500-9999 (MSA)	38.8	38.6	-0.2
10000-49999 (MSA)	37.8	24.2	-13.6

Table 8 presents results of cross-classification of VMT by household size. As might be expected, larger households tend to have greater daily VMT's. Comparisons between household types suggests that households making only motorized trips tend to have larger daily VMT's than those households making one or more non-motorized trips.

Turning to an evaluation of households with and without children, there is a clear indication that households with one or more children are more likely to undertake non-motorized travel. These same households also exhibit less daily VMT (Table 9). The implication is that these households are more likely to utilize non-motorized travel for social and recreational trips.

Finally, Table 10 provides a breakdown of VMT by population density. Below 1000 in population density, differences in VMT are fairly dramatic between households making only motorized trips and households making one or more non-motorized trips. However, when densities are between 1000 and 4000 there is an indication that VMT is slightly greater for non-motorized households. However, at densities greater than 4000, VMT for households making one or more non-motorized trips is substantially less than VMT for households making only motorized trips.

Bicycle and Walking Trip-Making Characteristics

The purpose of this section is to present the demographic and geographic characteristics associated with only bicycle or walk trips. In this section, trip rates represent the ratio of daily bike or walk trips to total households or persons. Thus, the trip rates provide some guidance for assessing the number of non-motorized trips that might be expected in different regions. The section begins with an overview of trip maker characteristics for bike and walk trips. The daily bike and walk trip rates are examined with respect to individual characteristics, such as age, sex, and the presence of a drivers license, and household characteristics, such as income, life cycle, and geographic location. Finally, the same type of analysis is undertaken delineating trips by trip purpose.

All Trip Purposes - an Overview of Bike and Walk Trips

The NPTS survey indicates that approximately 1,767 million annual bike person trips (0.7% of total annual person trips) were reported while annual walk trips approached roughly 18,000 million (7.2% of total annual person trips). These results compare to 8.5 percent annual person walk trips and 0.75 percent annual person bike trips reported in the 1983-84 NPTS (17).

As will be seen, the demographics of those making bike and walk trips in the NPTS dataset are consistent with results reported by many of the smaller sample studies described in the literature review. The populations of those making the walk and bike trips vary by sex, family income and composition, and population density. In the following section, the individual and household characteristics associated with those individuals and households making the walk and bike trips are presented.

Sex. Of the total annual nonmotorized person trips, approximately 49 percent of the trips were made by men while 51 percent were made by women. However, the breakdown by the type of mode reveals remarkably different splits by sex. Men made 72 percent of the total annual person bike trips while women made 28 percent. Of those annual person trips by walk, men made approximately 47 percent while women made 53 percent. Viewed alternatively, the daily walk trips by person reveal that men and women have roughly comparable walk trip rates while men have a much

Table 11: DAILY NON-MOTORIZED PERSON TRIPS BY SEX AND MODE

	Bike	Walk
Male	0.04	0.27
Female	0.01	0.29

Table 12: ANNUAL (MILLIONS) AND DAILY PERSON NON-MOTORIZED TRIPS BY DRIVER'S LICENSE¹

	Bike		Walk	
	Annual Trips	Daily Rate	Annual Trips	Daily Rate
Have Driver's License	763 (78.6%)	0.02	9300 (71.2%)	0.19
Do Not Have Driver's License	208 (21.4%)	0.05	3760 (28.8%)	0.85

¹ Includes only those individuals older than age sixteen.

Table 13: DAILY NON-MOTORIZED TRIPS BY AGE

	Bike	Walk
5-15	0.07	0.46
16-19	0.04	0.56
20-29	0.03	0.30
30-39	0.02	0.21
40-49	0.01	0.16
50-59	Ins ¹	0.19
60-64	Ins ¹	0.19
65+	Ins ¹	0.20

¹ Insufficient Data

Table 14: DAILY NON-MOTORIZED HOUSEHOLD TRIPS BY LIFE CYCLE

	Bike	Walk
Single Adult, No Children	0.03	0.53
Single Adult, Youngest Child 0-5	Ins ¹	1.02
Single Adult, Youngest Child 6-15	0.20	1.57
Single Adult, Youngest Child 16-21	Ins ¹	0.64
Single Adult, Retired, No Children	Ins ¹	0.41
> 2 Adults, No Children	0.04	0.54
> 2 Adults, Youngest Child 0-5	0.08	0.62
> 2 Adults, Youngest Child 6-15	0.14	1.01
> 2 Adults, Youngest Child 16-21	0.06	0.52
> 2 Adults, Retired, No Children	0.03	0.31

¹ Insufficient Data

larger daily bike trip rate. As Table 11 suggests, daily trip rates by either sex, and mode, are substantially less than one.

Driver's License. As Table 12 indicates, nearly one-fourth of all annual non-motorized trips were made by those having no drivers license. It is also important to note that this breakdown includes only those individuals greater than age sixteen. Bike and walk trip rates are very different when drivers license is taken into consideration. It is clear that those without a drivers license make two to four times the number of daily bike or walk trips as those with a drivers license.

Age. Previous research suggests that age plays an important role in non-motorized trip behavior. The NPTS data show increased non-motorized trip-making activity for individuals less than age 29. As Table 13 indicates daily trip rates vary between 0.01 and 0.07 for bike trips and 0.16 and 0.56 for walk trips.

Life Cycle. Various household characteristics have also been associated with travel patterns. Beginning with life cycle, bike and walk trip rates are examined in Table 14. The daily trip rates per household vary considerably between life cycle category. As might be anticipated, bike trips are among the lowest for those classified as a retired households with no children. Households with children may make as much as two to three times as many non-motorized trips as households with no children. Interestingly, single adult households with the youngest child between six and fifteen tend to make greater numbers of bike or walk trips than similar two adult households.

Income. Finally, from Table 15, the daily household trip rates by income suggest several interesting aspects of the non-motorized trips. It is clear that the number of daily bike and walk trips per household generally decreases as income increases. Most dramatic is the decrease in walk trip rates between households earning less than \$10,000 and those earning more than \$10,000. The data also suggests that households making less than \$10,000 income make nearly four times as many daily walk trips as those households making more than \$10,000.

	Bike	Walk
<\$10,000	0.08	1.45
\$10,000-\$19,999	0.05	0.62
\$20,000-\$29,999	0.07	0.61
\$30,000-\$39,999	0.09	0.57
>\$40,000	0.06	0.49

Urban Size. As noted in the literature review, the effects of urban size and density on non-motorized trip rates have not been well documented. From the NPTS data it is clear that the largest proportion of annual non-motorized trips occur in urban areas with greater than one million in population (approximately 42 percent for bike and 54 percent for walk). Breaking travel down to daily trip rates by urban size, as in Table 16, suggests that daily household non-motorized trip rates are slightly higher in the larger urban areas when compared to areas under 500,000 in population. As might be expected urban areas with greater than one million population and a subway or rail system have much higher daily walk trip rates than the same size area without rail or subway; the presence of subway and rail systems are also indicative of higher population densities. The data also suggests that there may be a certain size of urban area that is somewhat more amenable to non-motorized travel; rates are generally higher when the urban size is less than 200,000. However, it must also be noted that the preponderance of non-motorized trips for social and recreational purposes may obscure the relationship between urban size and non-motorized tripmaking for commuting purposes.

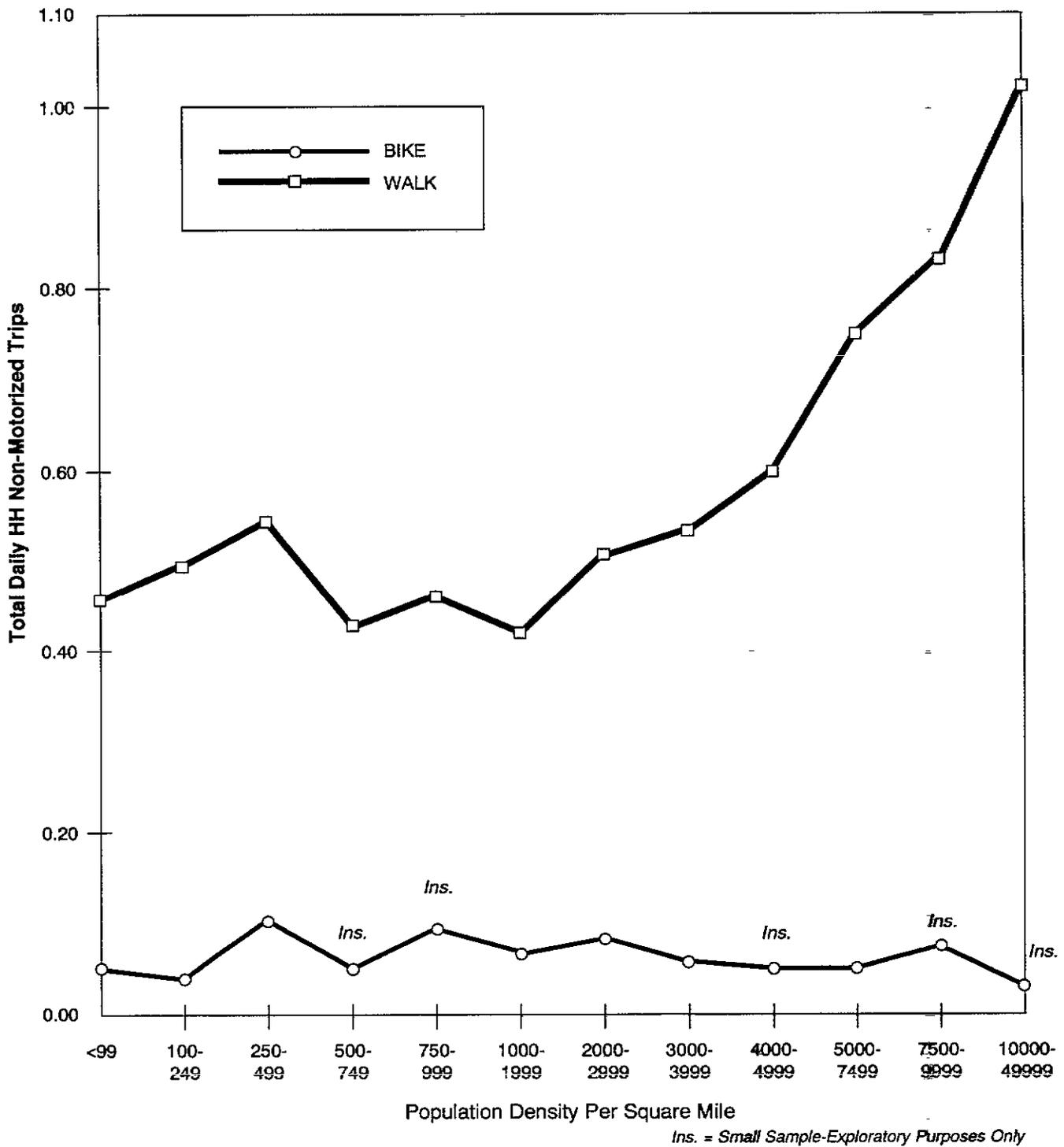
	Bike	Walk
50,000-199,999	0.10	0.58
200,000-499,999	0.06	0.55
500,000-999,999	0.03	0.42
> 1,000,000 no subway/rail	0.07	0.58
> 1,000,000 with subway/rail	0.06	1.07

Finally, the effects of population density on daily non-motorized trip rates can be examined using Figure 2. Contrary to Goldsmith's (6) findings, there appears to be little to no trend between daily bike trips and population density. However, there is also clearly insufficient data, as evidenced by the note shown above certain densities, for definitively assessing possible trends. Walk trip rates show a more defined pattern, with steady increases in total daily walk trips as density increases.

Bike and Walk Trip Characteristics by Trip Purpose

Additional insight into non-motorized trip-making may also be gained by examining trips by trip purpose. As might be expected, the majority of annual non-motorized person trips were made for social and recreational purposes; approximately 55 percent of the annual bike trips and 34 percent of the annual walk trips. This represents a slight increase over both 1983 social-recreational annual bike trips (53%) and walk trips (33%).

Figure 2:
TOTAL DAILY BIKE and WALK TRIPS by POPULATION DENSITY



Alternatively, the proportion of 1990 NPTS work related trips suggest a declining modal share from 1983 estimates (Table 17). Work related trips accounted for roughly 10 percent of the annual bike trips and 12 percent of the annual walk trips. This compares to 1983 estimates of 14 percent for bikes and 14 percent for annual walk trips. Expressing annual trips in terms of daily rates by trip purpose (Table 18) confirms higher trip rates for social recreational purposes. Rates also tend to be higher for family and personal business trips (which include shopping trips).

**Table 17: PERCENT OF ANNUAL TRIPS BY TRIP PURPOSE:
1983 AND 1990 NPTS**

	Bike		Walk	
	1990	1983	1990	1983
Earning a Living	9.9	14.1	12.0	14.3
Family and Personal Business	19.7	19.7	32.4	30.3
Civic, Educational and Religious	14.1	8.8	20.3	20.6
Social and Recreational	55.4	52.6	34.1	32.7

**Table 18: DAILY NON-MOTORIZED HOUSEHOLD TRIPS
BY TRIP PURPOSE**

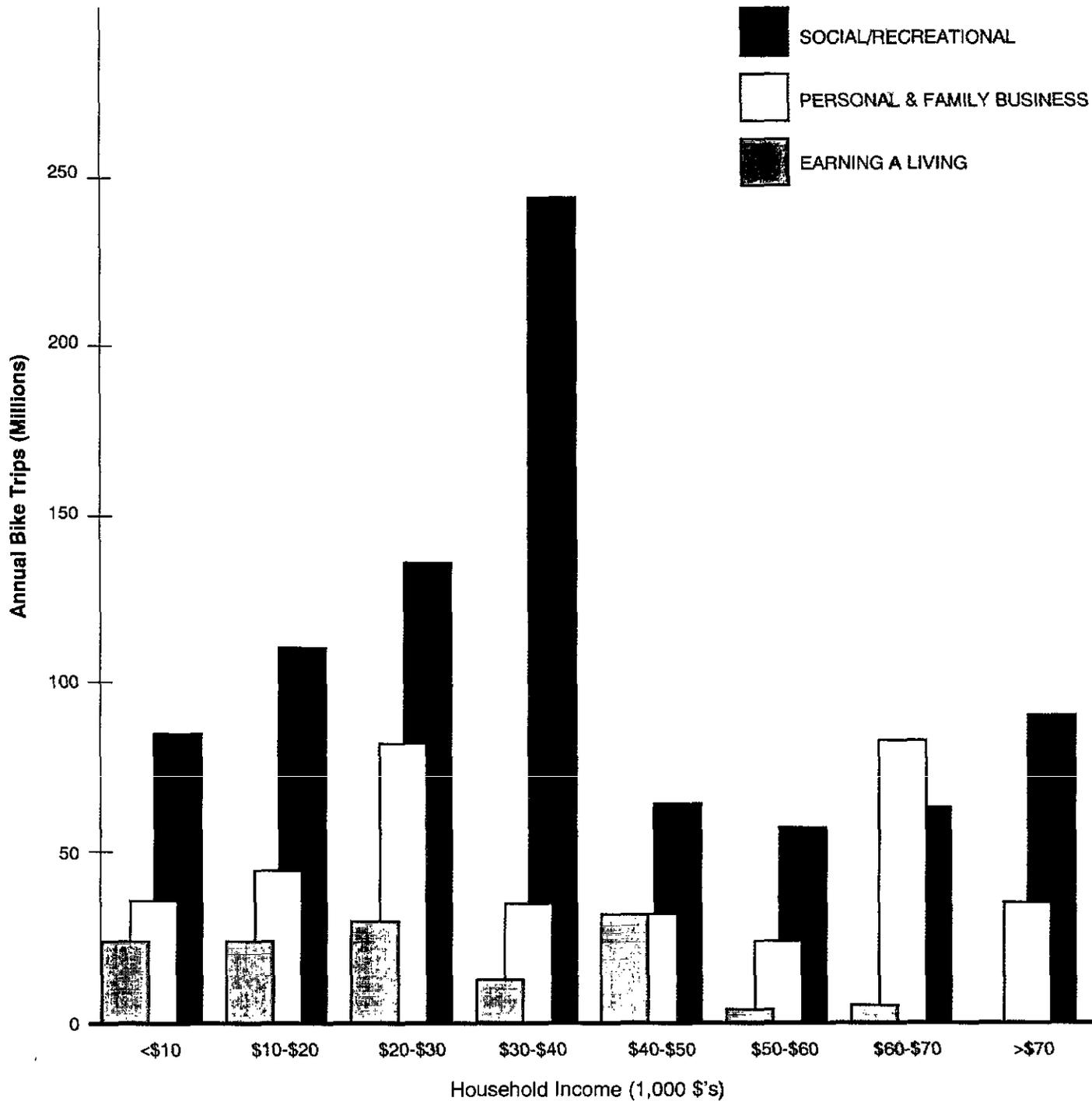
	Bike	Walk
Earning a Living	0.002	0.033
Family and Personal Business	0.004	0.079
Civic, Educational and Religious	0.001	0.022
Social and Recreational	0.008	0.069

The remainder of this section provides trip rates cross classified by the four basic trip purposes in terms of household and individual trip-maker characteristics. The section begins with a discussion of bicycle trips and finishes with a similar discussion of walk trips.

Bicycle Trips. Beginning with basic household characteristics, such as income and life cycle, daily trip rates are discussed in the context of household and individual trip making characteristics. Finally, daily trip rates by geographic characteristics are calculated to help identify trends and patterns in non-motorized travel behavior.

As Figure 3 illustrates, annual trips, by trip purpose and household income, indicate higher numbers of annual social and recreational trips. As was noted in earlier studies, there is an indication of slightly higher numbers of annual trips in certain income categories that is somewhat incongruent with the philosophy of decreasing non-motorized trips with increasing income.

Figure 3:
ANNUAL BIKE TRIPS by TRIP PURPOSE
and HOUSEHOLD INCOME



As Table 19 demonstrates, the pattern of trip making activity varies greatly depending upon income and the type of trip undertaken. It is notable that daily household trip rates increase substantially in the \$20,000 to \$29,999 income category for personal and work related trips. However, any work related trip data must be viewed very cautiously, as sample sizes are generally very small and preclude definitive analysis. Data are presented mainly for exploratory purposes; data may suggest the type of additional research needed to more clearly define trends.

Table 19: DAILY HOUSEHOLD BIKE TRIPS BY INCOME

	Earning a Living	Personal and Family Business	Social and Recreational
<\$10,000	0.001 ¹	0.015	0.035
\$10,000-\$19,999	0.001 ¹	0.012 ¹	0.028
\$20,000-\$29,999	0.007 ¹	0.020 ¹	0.034
\$30,000-\$39,999	0.003 ¹	0.009 ¹	0.065
>\$40,000	0.005 ¹	0.014	0.037

¹ Sample sizes too small for analysis (presented strictly for exploratory purposes).

Daily bike trip rates also vary depending upon purpose and household life cycle (Table 20). Of those individuals making social and recreational trips, daily household bike trip rates vary between 0.011 and 0.092. Trip rates tend to be higher for those households with children. The lack of sufficient data in the single adult households precludes any clear definition of trends between single and two adult households. As with previous analyses, there are not enough data to evaluate rates for work related purposes.

Table 20: DAILY HOUSEHOLD BIKE TRIPS BY LIFE CYCLE AND PURPOSE

	Earning a Living	Personal and Family Business	Social and Recreational
One or More Adults, No Children	0.006	0.008	0.016
One Adult, Youngest Child ≤15	0.005 ¹	0.015 ¹	0.092
One Adult, Youngest Child 16-21	0.016 ¹	0.000 ¹	0.038
One or More Adults, Retired	0.001 ¹	0.008 ¹	0.011
Two or More Adults, Youngest Child ≤15	0.002	0.020	0.063
Two or More Adults, Youngest Child 16-21	0.012 ¹	0.009 ¹	0.033

¹ Sample sizes too small for analysis (presented strictly for exploratory purposes).

Table 21: DAILY PERSON BIKE TRIPS BY AGE AND TRIP PURPOSE

	Earning a Living	Personal and Family Business	Social and Recreational
5-15	0.002 ¹	0.011 ¹	0.046
16-19	0.005 ¹	0.011 ¹	0.017
20-29	0.005	0.008	0.016
30-39	0.003 ¹	0.003 ¹	0.011
40-49	0.002 ¹	0.002 ¹	0.004
50-59	0.000 ¹	0.000 ¹	0.002
60-64	0.000 ¹	0.003 ¹	0.003 ¹
65+	0.001 ¹	0.004 ¹	0.007 ¹

¹ Sample sizes too small for analysis (presented strictly for exploratory purposes).

Not unexpectedly, daily bike trip rates by trip purpose and age suggests that trip rates are highest among younger populations, generally less than 30 years of age. As Table 21 readily identifies, it is difficult to assess trends for work related trips although there is an indication of generally younger bike/walk commuters.

Finally, the average travel distance by bike is approximately two miles. As Figure 4 illustrates, average travel distances are generally higher in areas with densities below 750. However, there is not any clear indication that higher densities result in overall shorter bike trips. Social and recreational trips were longest at 2.2 miles followed by work related and family/personal business trips at 2.1 and 1.6 miles, respectively; the bike trip length, for any purposes, rarely exceeds five miles. Travel times follow much the same pattern with an average travel time for a social/recreational trip at 15.5 minutes, work related trips at 15.3 minutes and family/personal business trips at 11.5 minutes.

Walk Trips. Daily walk trip rates vary depending upon trip purpose. As Table 22 indicates slightly larger trip rates may be found for social and recreational daily walk trips for lower income categories. There is a consistent trend for declining numbers of trips as income increases.

Table 22: DAILY HOUSEHOLD WALK TRIPS BY INCOME AND PURPOSE

	Earning a Living	Personal and Family Business	Social and Recreational
<\$10,000	0.110	0.516	0.464
\$10,000-\$19,999	0.071	0.212	0.213
\$20,000-\$29,999	0.075	0.232	0.177
\$30,000-\$39,999	0.083	0.167	0.179
>\$40,000	0.062	0.142	0.193

Figure 4:
AVERAGE BIKE TRIP LENGTH by POPULATION DENSITY

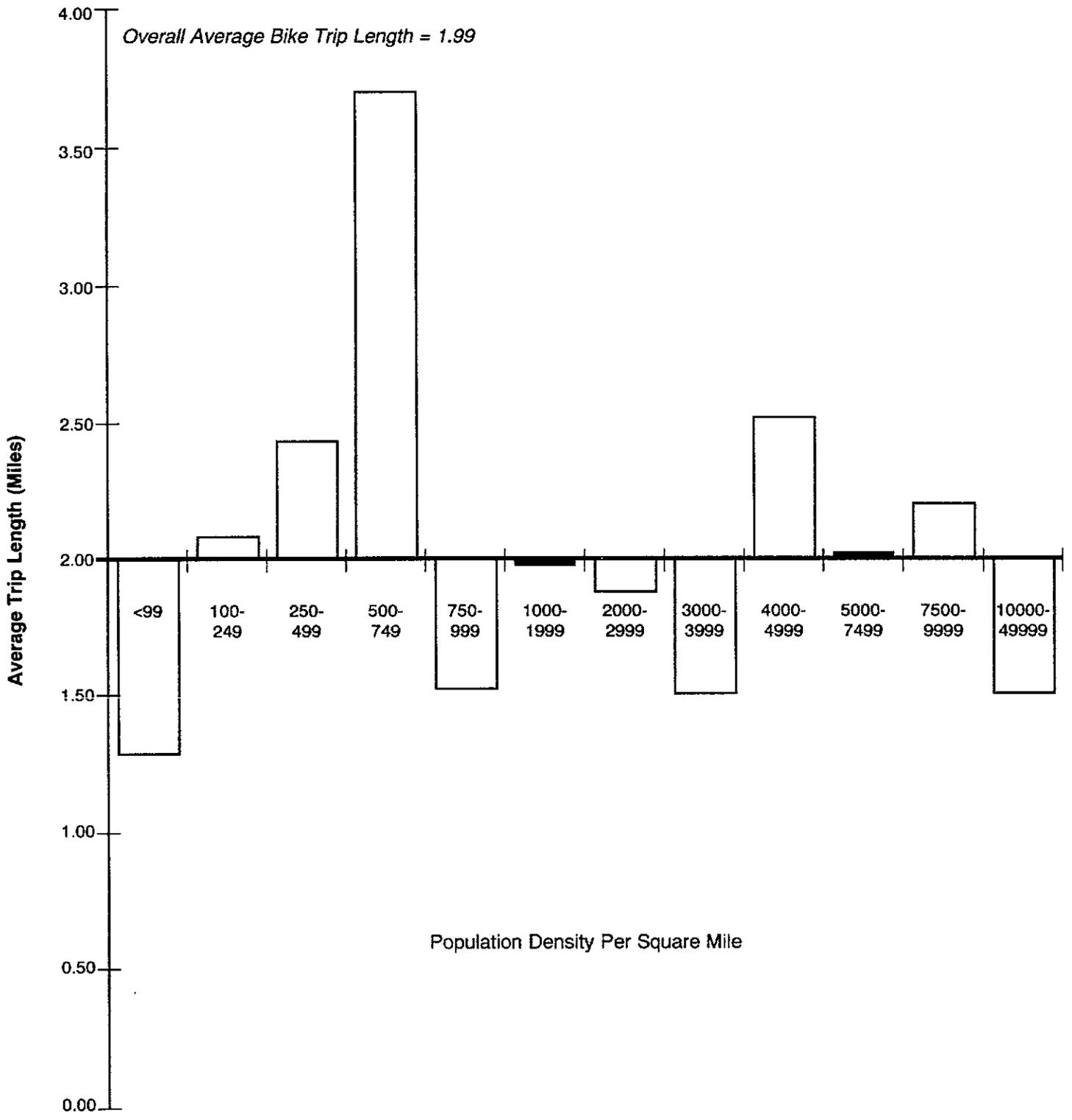


Table 23: DAILY HOUSEHOLD WALK TRIPS BY LIFE CYCLE AND PURPOSE

	Earning a Living	Personal and Family Business	Social and Recreational
One or More Adults, No Children	0.100	0.206	0.161
One Adult, Youngest Child ≤15	0.043	0.409	0.510
One Adult, Youngest Child 16-21	0.066 ¹	0.213 ¹	0.294 ¹
One or More Adults, Retired	0.016	0.153	0.145
Two or More Adults, Youngest Child ≤15	0.073	0.198	0.285
Two or More Adults, Youngest Child 16-21	0.089	0.195	0.166

¹ Sample sizes too small for analysis (presented strictly for exploratory purposes).

As with bike trips, daily walk rates in Table 23 are considerably smaller for single adult households. The presence of older children in two adult households also seems to increase walk rates. As might be expected social and recreational daily trip rates are generally higher regardless of the household life cycle.

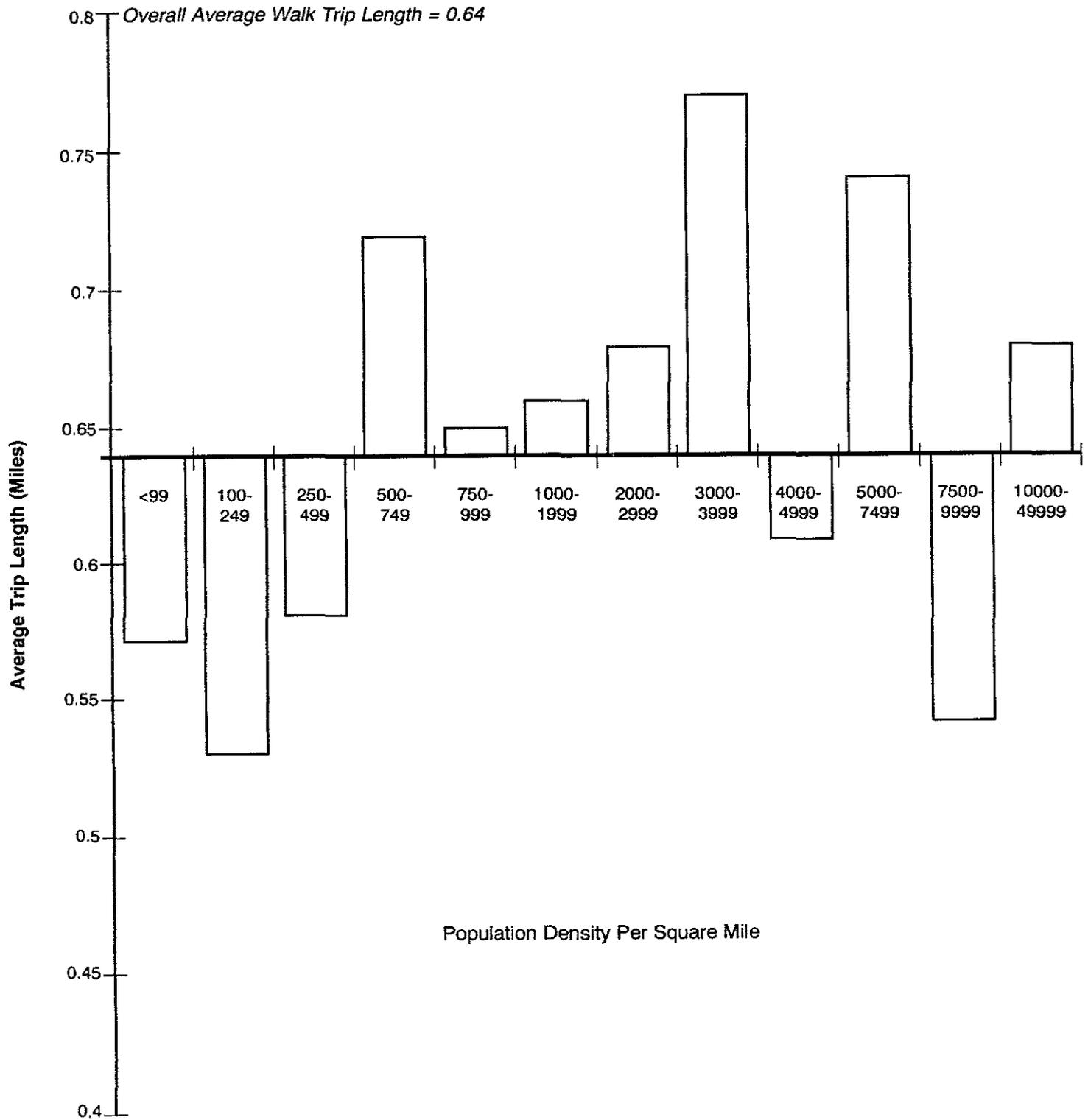
As might be expected, trips rates vary considerably with age (Table 24). Social and recreational trips are made most frequently by younger individuals; rates decrease as age increases for this trip purpose. Trip rates appear to increase as age increases for daily work trips.

Table 24: DAILY PERSON WALK TRIPS BY AGE AND TRIP PURPOSE

	Earning a Living	Personal and Family Business	Social and Recreational
5-15	0.004	0.069	0.165
16-19	0.043	0.147	0.220
20-29	0.054	0.111	0.093
30-39	0.046	0.095	0.063
40-49	0.038	0.065	0.045
50-59	0.038	0.077	0.057
60-64	0.023	0.008	0.076
65+	0.006	0.089	0.083

Finally, the average walk trip travel distance for social and recreational trips were longest at 0.62 miles followed by work related and family/personal business trips at 0.54 and 0.47 miles, respectively; the average daily walk trip length, for all purposes, rarely exceeds 0.6 miles. Figure 5 provides strong evidence that walk trip lengths decrease at higher densities. Travel times follow much the same pattern with an average travel time for a social/recreational trip at 11.5 minutes, work related trips at 9.9 minutes and family/personal business trips at 8.8 minutes.

Figure 5:
AVERAGE WALK TRIP LENGTH by POPULATION DENSITY



Summary

The NPTS data confirm much of the previous research and provide a needed empirical basis for further study. The differences between households making only motorized trips and households making one or more non-motorized trips reveal several interesting aspects of travel behavior. First, it is clear that households making only motorized trips consistently make fewer trips than non-motorized households, regardless of the demographic or geographic cross-classification variables. Alternatively, an examination of VMT between household types suggest that households making any bike or walk trips accumulate less average daily VMT than those households making no non-motorized trips. It is not obvious from the data that non-motorized trips replace motorized trips yet the presence of non-motorized trips seems to indicate a clear propensity for less daily VMT.

The data show some indication that daily trip rates for both types of households (those making only motorized trips and those making one or more non-motorized trips) decline as density increases. However, this decline does not appear to be any faster for the households making one or non-motorized trips than for the households making only motorized trips. The data, throughout the analysis, suggest that there may be optimal densities for encouraging greater non-motorized travel. Additional research in the relationship between density, infrastructure (such as sidewalks and bike lanes), and non-motorized trip rates would be very useful.

Examining bike and walk trip rates independently serves to highlight several potentially important findings. There is a clear indication of increasing walk trip rates as density increases, particularly striking is the rapid increase in rates as densities approach and exceed 2000. Conversely, there is little evidence that bike trip rates increase as densities increase. In part, this is due to a lack of data. Bike populations are clearly elusive and, although the NPTS data provides a remarkably large sample to evaluate, it is often still too small to properly interpret findings.

Finally, there is a clear need for sufficient data for disaggregation by trip purposes. Currently, the NPTS provides enough data for only social-recreational trip disaggregation and interpretation. To fully understand non-motorized trip behavior, at the minimum, there should be sufficient data for disaggregating and interpreting work related and personal business bike and walk trips as well. The NPTS provides an extremely valuable beginning point by clearly identifying and confirming household and person characteristics. These, in turn, should provide the basis for greater evaluation of how infrastructure and density affects non-motorized trip-making.

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