

## Journey-to-Work Patterns in the Age of Sprawl: Evidence from Two Mid-Size Southern Metropolitan Areas

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### **Abstract:**

Among others, one commonly identified negative consequence of urban sprawl is an increase in the length of the journey to work. However, there has been more discussion of this than serious scrutiny, hence the relationship between urban sprawl and commuting patterns, especially at the intraurban level, remains unclear. Using the 2000 Census Transportation Planning Package (CTPP) data for two Southeastern metropolitan areas, this research investigates the extent to which workers living in sprawl areas commute farther to work than those living in higher density areas. The analysis of variance confirms that workers commuting from sprawl areas to urban areas experience a longer commute in terms of time as well as mileage, though this varies when workplace and home locations are taken into account. However, multivariate statistical results suggest that there are limits to the utility of sprawl as a predictor of travel behavior compared to workers' socioeconomic characteristics, as other factors appear to be equally or more important.

**Keywords:** Alabama | commuting | GIS | urban sprawl

### **Article:**

Urban sprawl is increasingly acknowledged as a phenomenon with widespread negative impacts on society (Torrens 2006). Among others, one particular negative consequence commonly identified is sprawl's effect on travel time and traffic congestion in urban areas (Downs 1998; Galster et al. 2001). However, there has been more discussion of this than serious scrutiny (Ewing, Pendall, and Chen 2003; Crane and Chatman 2004), and the relationship between urban sprawl and commuting patterns, especially at the intraurban level, remains unclear. The purpose of this research is to investigate the impact of urban sprawl on commuting at a local scale. We assess the extent to which people living in sprawl areas have commuting patterns different from those living in higher density areas, and whether sprawl is a useful concept with which to investigate commuting. We also examine to what extent the locations of sprawling jobs are

lengthening commuting times and distances for residents of higher density neighborhoods, and what this might suggest for future commuting patterns.

We have conceptualized the term “sprawl” as a process of rapid population growth occurring in areas characterized by low densities, outside of traditional urban or built-up areas. It is the seemingly contradictory nature of rapid growth in sparsely settled areas that characterizes the urban form known as sprawl. This type of growth must also be located outside established urban areas, and preferably not contiguous with it, to be distinguished as sprawl rather than outward urban growth (U.S. Department of Housing and Urban Development 1999). In traditional urban geography terms, sprawl can be distinguished from monocentric or polycentric urban forms both by very low densities in peripheral areas (a leveling of density gradients) and by the absence of a continuous density surface from center to edge (Ewing 1994). Sprawl instead shows as seemingly randomly placed population clusters outside the continuous built-up area. Commuting patterns in such a city will not necessarily reflect traditional inward commuting, with length increasing as density decreases. Instead, in a sprawling environment the commute length may reflect the dispersal of jobs as well as homes, producing commuting experiences that may not correspond to standard models.

The ways in which the concept of sprawl has been addressed in previous work, and how this relates to our approach is discussed in the next section. Expectations about the effects of sprawl on commuting are also addressed. Our methodology for quantifying sprawl is then described, along with data and study areas. Next, we conduct an analysis of commuting patterns between sprawling and urban areas to evaluate relationships between sprawl and commuting. The final section discusses the results and the importance of sprawl to the journey to work.

## **Background and Rationale**

What is Sprawl?

One of the most comprehensive reviews of the literature (Galster et al. 2001) distinguishes several conceptualizations of sprawl. It is sometimes identified by an example or stereotype, such as Los Angeles or Atlanta. Sprawl is also often viewed as any form of urban development that does not meet the aesthetic approval of a critic. Analyses of urban structure may see urban sprawl to be the negative outcome of some process (such as a lack of proper city planning), or as the cause of other negative outcomes (such as increased traffic, congestion, and social isolation). Sprawl may be seen as an urban spatial pattern or as a process of urban growth. To this list it may also be added that sprawl has sometimes simply become a term that refers to any recent urban growth (as in Chapman and Lund 2004; Crane and Chatman 2004; Gutfreund 2004; Wolch, Pastor, and Dreier 2004).

Despite this range of approaches, the majority of research has clearly conceptualized sprawl as a spatial pattern, particularly one with low population densities (Malpezzi 1999; Galster et al. 2001; Hasse and Lathrop 2003a; Lopez and Hynes 2003; Ewing, Pendall, and Chen 2004; Wolman et al. 2005). However, density is clearly not sufficient to map sprawl, as this could encompass rural areas with scattered homes, or even parts of Detroit where housing abandonment has led to low densities (Ryznar and Wagner 2001). Other elements of urban form

have therefore been included in sprawl definitions. Some approaches include a low level of compactness, a lack of mixed land uses, low proximity of different land uses to each other, low levels of contiguity in urban development, lower levels of jobs-housing balance, and street network patterns (Galster et al. 2001; Ewing, Pendall, and Chen 2004; Tsai 2005; Wolman et al. 2005). These various elements may be combined with density to create elaborate sprawl measures. Wolman et al. (2005) used five dimensions to measure sprawl, Galster et al. (2001) used eight, and Ewing, Pendall, and Chen (2004) created a sprawl index with twenty-two variables; these often require specialized data and considerable processing to be implemented (Lopez and Hynes 2003). However, the usefulness of this type of analysis can be seen in the case of detailed comparisons between metropolitan areas.

Few researchers have conceptualized sprawl as a growth process. Most work that has taken change into consideration has made use of remotely sensed land use/land cover data to identify new urban growth and/or the loss of forest or farmland, which is considered sprawl (Hasse and Lathrop 2003a, 2003b; McDonald and Rudel 2005; Zeng, Sui, and Li 2005). Defining sprawl using population change is less common. One such example defines sprawl as a combination of a larger percentage of metropolitan statistical area (MSA) population and a higher percentage of population growth between 1990 and 2000 located outside the Census-defined urbanized areas (El Nasser and Overberg 2001). However, as with density, rapid growth is not sufficient by itself to define sprawl, as cities can exhibit high rates of outward growth without sprawl (Gober and Burns 2002). Both approaches should be used.

The spatial scale and locations within which sprawl has been conceptualized vary considerably. Some view sprawl as a phenomenon found throughout metropolitan areas (Malpezzi 1999; Lopez and Hynes 2003; Tsai 2005). Others have identified it as taking place only within urbanized areas (Galster et al. 2001; Wolman et al. 2005), and still others refer to sprawl as located entirely outside urbanized areas (El Nasser and Overberg 2001). Sprawl may also be assessed at the level of local governments such as townships (Hasse and Lathrop 2003a, 2003b; McDonald and Rudel 2005). Similar indicators of urban form have also been evaluated at the level of zones such as tracts, block groups, or neighborhoods (Hartgen 2003a, 2003b; Rajamani et al. 2003; Song and Knaap 2003, 2004; Song 2005). Much less has been done to define and map urban sprawl within metropolitan areas, though rapid growth has been used to map sprawl at the block group or block level (Sultana and Chaney 2003; Weber and Maret 2003).

A significant limitation of most sprawl work is that it provides only summary index values and does not actually provide any indicator or threshold of whether sprawl is present. Sprawl is the term assigned to one end of a density and compactness continuum, with the other end referred to by such terms as smart growth, traditional urbanization, or even monocentric cities. This means that sprawl cannot be identified as a type of urban form, but is instead an urban ranking (like congestion, quality of life, or cost of living). What is needed is an ability to actually map out sprawling areas within a metropolitan area. This in turn requires the use of a threshold value to actually identify areas within an MSA as urban or sprawl.

Our research makes use of a threshold value based on both low density and rapid population growth to identify sprawl, and it maps sprawl outside the urbanized area of a city. We are therefore conceptualizing sprawl as both a pattern and process in peripheral areas. High growth

rates are likely when densities are low, and low densities will not last long if growth rates are high. This relationship is the essential nature of sprawl as a dynamic urban process and pattern.

### Sprawl and Commuting

Discussions of sprawl are quick to argue that it has negative consequences for travel (Anderson, Kanaroglou, and Miller 1996; Johnson 2001; Gillham 2002). Lower densities and less compact or noncontiguous urban areas mean that homes, workplaces, shopping, and other destinations are farther apart. Longer distances and dispersed destinations will strongly favor the use of automobiles over public transportation, carpooling, or walking. These expectations can be referred to as the standard view of sprawl and commuting: increased time, congestion, pollution, and so forth, all with negative outcomes for communities, family life, and personal health. Although commuting now constitutes only about 25 percent of daily trips, it is a vital activity for households (Hanson and Pratt 1988; Horner 2004), and any negative effects of sprawl should be apparent on this activity. It is commonly accepted that longer commutes are undesirable as they are a burden and reduce time available for other activities (Koslowsky, Aizer, and Krausz 1996; A. E. Green, Hogarth, and Shackleton 1999; Clark, Huang, and Withers 2003; Clark and Wang 2005).

Despite increases in population and traffic (and presumably sprawl), average metropolitan commuting times have remained relatively constant over the past few decades (Gordon, Kumar, and Richardson 1989a, 1989b; Gordon, Richardson, and Jun 1991; Levinson and Kumar 1994; Levinson 1997). Following this argument, Crane and Chatman (2004) found that suburbanization of jobs (which they call sprawl) is associated with shorter commuting distances, but that overall commuting for cities, as they grow outward, is lengthening. Indeed, the average commuting time in the United States increased from 22.4 to 25.5 minutes between 1990 and 2000 (U.S. Census Bureau 2004), although there has been a slight decrease since then (from 25.5 minutes to 25.01 minutes in 2005; CNN 2006). These findings have been interpreted to confirm the breakdown of traditional urban forms, with employment locations increasingly dispersed throughout the city. Individual commuters now have increased opportunities to relocate closer to workplaces in order to maintain constant commuting times, or even to decrease their commute durations. This has been called “rational” relocating, as it assumes that households are acting to increase their economic well being, as well as possessing perfect information about job and housing opportunities (Levinson 1998). Sprawling cities therefore offer the possibility of urban growth without increases in commuting burdens on households. There is also evidence that people may derive pleasure from the experience of commuting, and will not necessarily perceive a long commute as a burden (Ory et al. 2004). These issues present a very different possibility for sprawl and its influence on commuting. This research will assume that commuting is a burden, but one that households may be adapting to.

The commuting impacts of urban sprawl have seldom been examined, and within this research the findings are mixed. Ewing, Pendall, and Chen (2004) found no relationship between commuting time and sprawl (represented as a low density noncompact spatial pattern), but did find that other travel behavior is associated with cities with higher levels of sprawl, such as increased automobile use and more miles traveled per day. Although the authors conclude that arguments that sprawl will reduce travel times are therefore false, the fact that journey-to-work

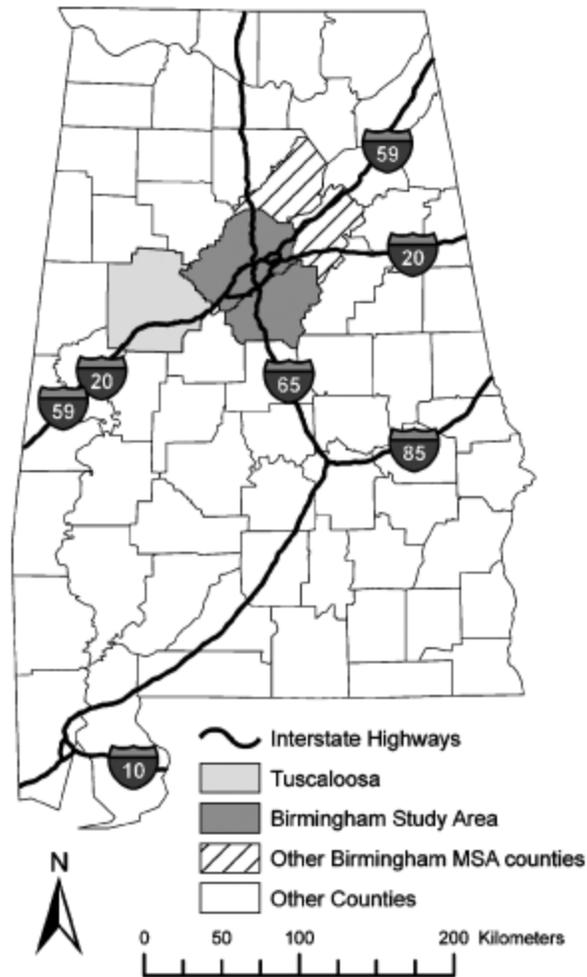
times are not significantly greater does not contradict the expectation that workers will relocate to preserve their commuting times. This finding is the opposite of many commuting studies that did not examine sprawl but used low residential densities and other aspects of neighborhood design within cities (e.g., Handy 1996; Boarnet and Crane 2001; Ewing and Cervero 2001). These typically found associations between longer commutes and greater rates of auto use.

Population growth has also been examined as a sprawl-related influence on commuting. Sultana and Chaney (2003) confirmed that commuting times are higher in areas with rapid growth. Sarzynski et al. (2006) used a metropolitan sprawl index constructed from seven land use types and compared this to congestion variables for fifty metropolitan areas. This research found that faster growing cities have longer commute times, suggesting that relocation is not occurring, or at least that in areas of rapid growth it has not yet been established. Other relationships between sprawl and travel were also apparent, as denser areas have higher rates of daily traffic per freeway lane, and greater centrality of housing was associated with increasing average hours of delay. These suggest that sprawl could actually improve travel conditions.

Urban sprawl and its relationships with commuting have only rarely been examined within metropolitan areas (Sultana and Chaney 2003). Hence, it is not clear what relationships will be apparent at this scale. The standard expectation that sprawl is associated with longer commutes may not remain apparent (or may even favor sprawl) if residents are in fact relocating to sprawling areas to maintain commuting times. This research examines commuting differences between urban and sprawl areas within metropolitan areas to identify which of these outcomes is apparent. It also investigates the potential importance of relocation by disaggregating commute trips according to both residential and workplace locations. Finally, given the importance of individual and household characteristics on travel behavior, this research examines whether sprawl adds to our understanding of commuting when the key explanatory variables are taken into account. A large body of theoretical and empirical research (e.g., Handy 1996; Sultana 2005a; Limtanakool, Dijst, and Schwanen 2006) has shown that a number of variables (e.g., race, income, mode of transportation, location, population and household density, employment density, home-ownership, and time leaving home for work) significantly influence work-trip length and other travel behaviors. These may have a greater degree of influence on commuting than sprawl, and so are also incorporated as key explanatory variables.

### **Study Area, Data, and Methodology**

Many analyses of sprawl are based on large metropolitan areas in the United States (e.g., Galster et al. 2001; Sarzynski et al. 2006). However urban sprawl is also a growing problem in smaller metropolitan areas, which have been neglected by researchers (Weber and Maret 2003). Birmingham and Tuscaloosa, Alabama, two midsize southeastern metropolitan areas, were therefore selected for this study (Figure 1). The population growth of both of these metropolitan areas is lower than the national average of 13.1 percent, and both are more dependent on automobiles than the national average, with only 0.5 percent of weekday trips by bus in Tuscaloosa and 0.8 percent in Birmingham, compared to a national average of 4.7 percent (U.S. Census Bureau 2003).



**Figure 1.** Location of Birmingham and Tuscaloosa study areas. MSA=metropolitan statistical area.

In 2000, the Birmingham metropolitan area contained 921,106 people within four counties (U.S. Census Bureau 2003). Since the commuting data used here are available for only two Birmingham counties, Jefferson and Shelby, these will be used to represent the metro area. The Birmingham metro area has historically been decentralized due to the location of mines and industrial development within Jones Valley (White 1981), but population patterns still reveal high densities in the metro area within this valley (Figure 2). Suburbanization and highway-oriented growth has resulted in major suburban population clusters to the south of Birmingham, especially along I-65.

The Tuscaloosa metropolitan area (Figure 3) constitutes one county with a population of 164,876 (U.S. Census Bureau 2003). The city of Tuscaloosa and the suburb of Northport contain the majority of the population, with higher densities found along major highways radiating out from the city.

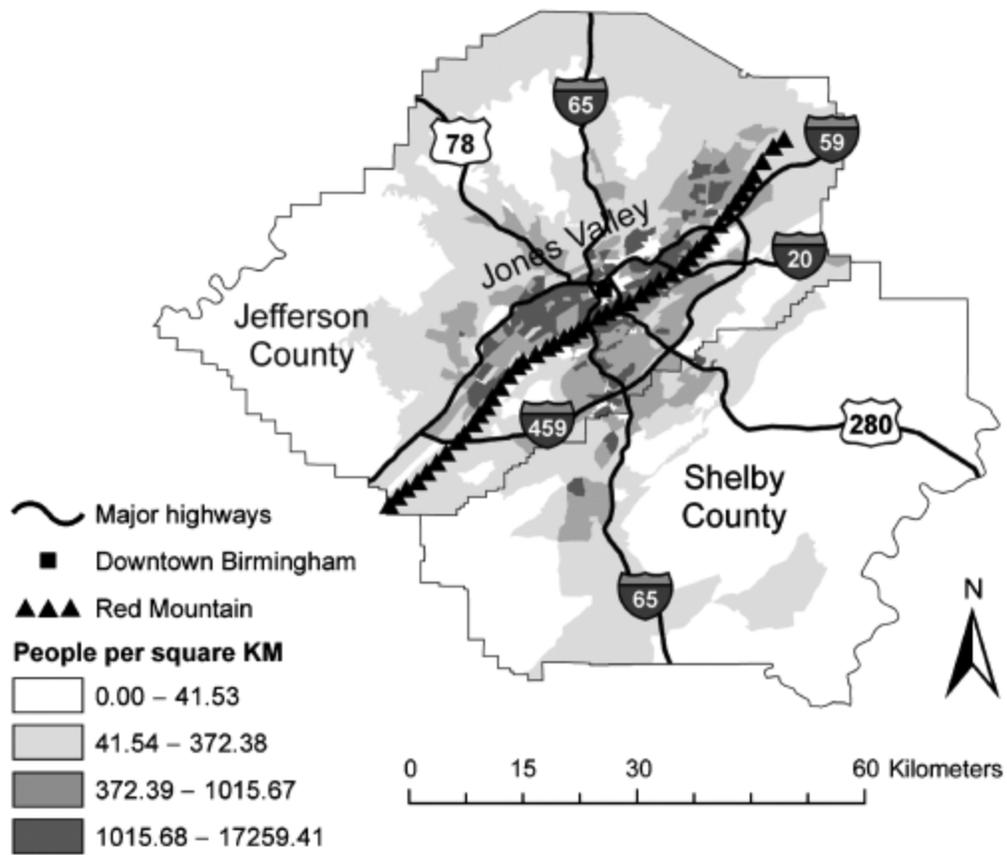


Figure 2. Population densities in Birmingham.

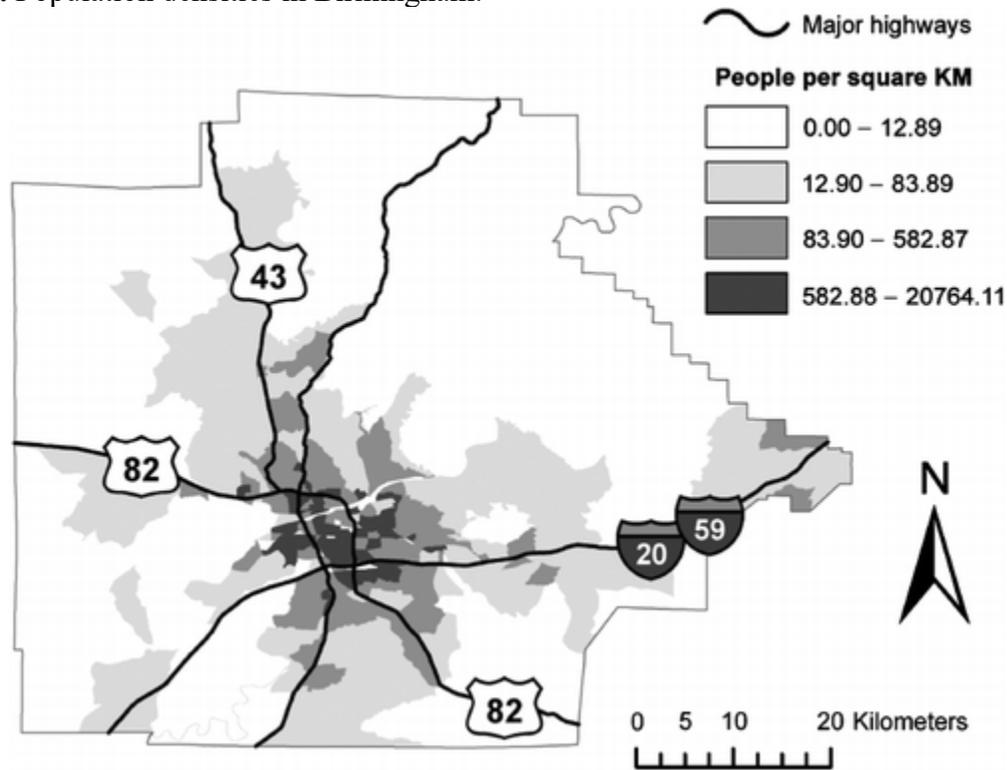


Figure 3. Population densities in Tuscaloosa.

The Census Transportation Planning Package (CTPP) data set is a collection of 2000 Census data designed for transportation planning. In addition to a wide range of population data, it contains commuting times, vehicle usage, times of day commuters left for work, and home and workplace locations, all cross-tabulated with a wide range of socioeconomic data, and divided into three parts. Part 1 provides data by place of residence, Part 2 provides similar data by job locations, and Part 3 provides trip interchange (origin-destination) data and one-way mean travel time by mode for each origin-destination pair. All data are aggregated to standard census and planning zones. The smallest of these are Traffic Analysis Zones (TAZs), which are smaller than block groups and are designed to enclose areas of homogenous trip generation and attraction. Data from Parts 1 and 3 are used in this research.

As discussed above, sprawl is identified in our analysis as an urban growth process with both high population growth rates and low population densities within metropolitan areas but outside of established urban areas. The average percentage change in population between 1990 and 2000 for each MSA was used as the minimum for identification as sprawl (Weber and Maret 2003). Population data for TAZs were obtained from the 1990 and 2000 CTPPs. Since many TAZs do not maintain the same boundaries between those two years, 1990 data could not be directly transferred to the 2000 zones. Thus, the 1990 Part 1 population was interpolated to a raster grid (with 100 m cells) using ArcView geographic information systems (GIS), and the resulting values were then transferred to the 2000 zones. Because of the small size and changing TAZ boundaries it is possible that population change in some areas was over- or underestimated. However, the use of fine resolution for interpolation minimizes the possibility of errors in the identification of sprawl areas. Using a maximum population density for 2000 also minimizes the potential for erroneous sprawl, as the smaller low-density 2000 TAZs will have small populations that are unlikely to show large increases from 1990.

As operationalized for the Birmingham and Tuscaloosa metropolitan areas, our definition of residential sprawl is those areas with a population growth of at least 7.25 percent for Birmingham, and 9.6 percent for Tuscaloosa (the average population growth percentages for each MSA). Similarly, as sprawling areas have low density, the 2000 MSA average population density is used as a threshold value. This criterion selects areas that have fewer than 160.83 people/km<sup>2</sup> for Birmingham, and fewer than 47.11 people/km<sup>2</sup> for Tuscaloosa. Finally, as sprawl takes place in peripheral areas, only areas outside of the Census-defined 2000 urbanized area boundary are used. The remainder of the metropolitan area was treated as rural, and was not included in the analysis.

Using Part 1 data, our analysis identified as sprawling areas a total of fifty-nine TAZs in Tuscaloosa with 17,175 people (10.42 percent of the total MSA population), and sixty-two zones in Birmingham, containing a population of 99,620 (12.37 percent). Sprawl in the Birmingham area encircles the urbanized area, as well as a large portion of Shelby County (Figure 4). Areas along major highways (I-65 and US 280) are included, but so are many areas that do not necessarily possess high accessibility to the city. The southwest is becoming developed as a residential area, whereas the suburbanization of northern Shelby County has been well underway for decades. Sprawl in Tuscaloosa is noticeably separated from the urbanized area boundary, and is found in all directions, though most of the major highways are covered within sprawling areas

(Figure 5). As with other Southeastern cities, there appear to be few physical or political limits to urban growth in these metropolitan areas (El Nasser and Overberg 2001). How these sprawl patterns relate to journey-to-work travel patterns is examined in the next sections.

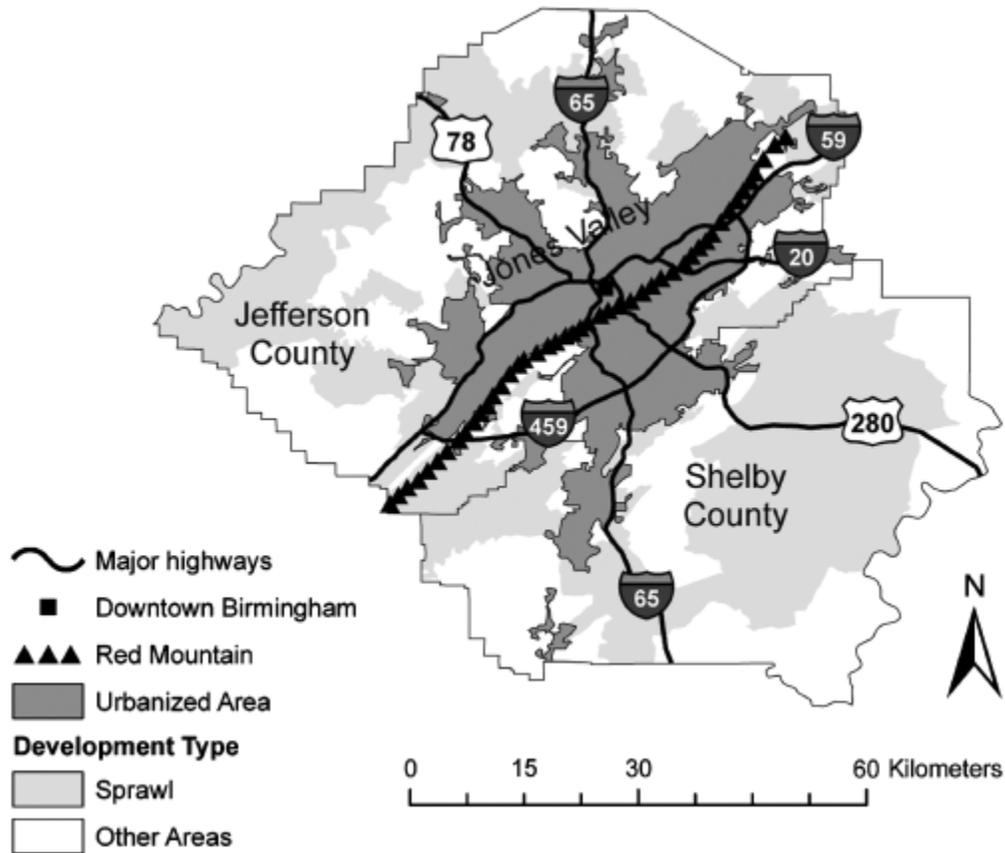


Figure 4. Sprawl in Birmingham.

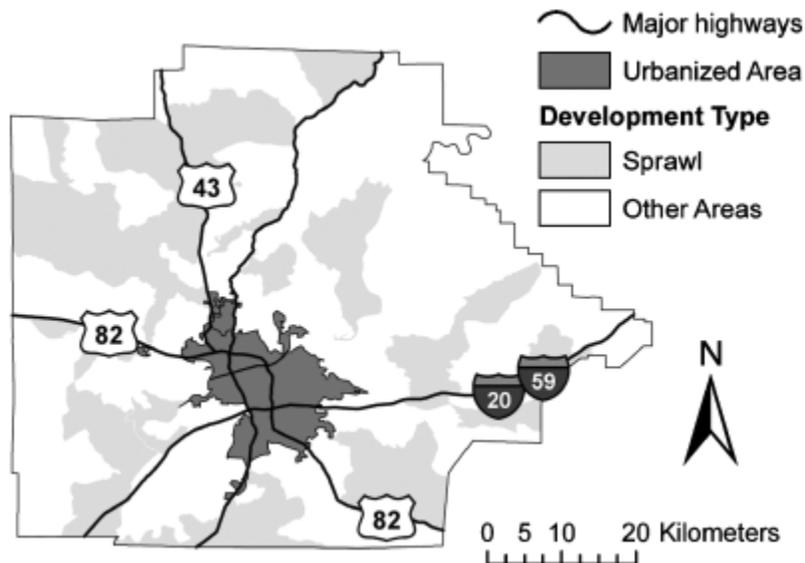


Figure 5. Sprawl in Tuscaloosa.

## Results

### Sprawl and Journey-to-Work Patterns in Birmingham and Tuscaloosa

Part 1 of the CTPP was used to extract variables (Table 1) such as average commute time, average commuting times by mode choices (e.g., those driving alone in cars, riding public transit, and biking or walking), as well as socioeconomic variables that have been shown to be important for explaining commuting behavior (Handy 1996; Sultana 2005a; Limtanakool, Dijst, and Schwanen 2006). Most journey-to-work research has used time as the measure for separation between home and work, since travel time can be directly obtained from commuting data. However, it has been suggested that distance (in miles) should also be considered, as commute time will likely vary depending on locations, street network, speed, and time of day (Wang 2000). Although travel times may be strongly influenced by sprawl, mileage should provide a more consistent measure of commute length. We therefore added this variable to our research. Commute mileage was measured within GIS using the origins and destinations of commuting flows from Part 3 data. The network distance from the origin TAZ to the destination TAZ was measured for each pair of TAZs that had commuting flows. To do this, the distance between a pair of zones was multiplied by the number of commuters between that pair of zones, classified by trip origin and destination (urban or sprawl), and was added to the total for the appropriate category. These values are also summed by trip origin and by trip destination for use with Part 1 data.

**Table 1.** Variables used from Part 1 CTPP data

Commute distance and time
Average length in miles (for flows from Part 3)
Average duration in minutes
Average duration in minutes for those driving alone
Average duration in minutes for bus riders
Average duration in minutes for bikers and walkers
Transportation method
Percentage of workers who commute alone in a car
Percentage of workers who commute by bus
Percentage of workers who commute by bike or walking
Commuter characteristics
Percentage of households that own their own home
Percentage of residents who are white
Average household income for workers in households
Percentage of workers below the poverty level
Percentage of workers below the poverty level who drive alone
Percentage of workers below the poverty level who ride the bus
Percent of workers below the poverty level who bike or walk
Percentage of workers who leave between 7:30 and 9:30 a.m.
Average vehicles per worker in households
Density
People per km <sup>2</sup>
Housing units per km <sup>2</sup>
Households per km <sup>2</sup>
Employed residents per km <sup>2</sup>

Note: Data are from Part 1 of the 2000 Census Transportation Planning Package (CTPP).

Using one-way analysis of variance (ANOVA), a comparison was made between sprawling and nonsprawling (urban) areas to see whether sprawl makes any difference to mean commute lengths (in terms of mileage and times), or mode choices, or whether these areas vary in socioeconomic aspects. This tests whether there is a difference between two sample groups, but also examines the variability of the sample values (within group variation). Based on these two estimates of variability we can determine whether the group means differ. Our arguments are simple, as we will not notice any differences in commutes between the two places if sprawl does not increase the commutes for the residents. Our data were carefully examined to see whether ANOVA was an appropriate statistical test. One-way ANOVA can be run when the Levene test is found to be insignificant, which means population variances for both groups are equal—one of the fundamental assumptions for ANOVA.

The comparison of sprawling and urban areas confirms the prevailing view about sprawl, as average miles, commute time, and drive time are significantly longer for people living in sprawling areas compared to those living in denser urban areas in both MSAs (Table 2). Similarly, sprawl residents are more likely to drive alone and less likely to use public transit. In contrast, biking and walking time are greater for residents of urban areas in Tuscaloosa, which itself is very surprising. However, this may be because of very small numbers of people choosing these modes in Alabama, especially in sprawling areas. Neither is there any significant difference in the number of people who leave for work during the morning peak.

**Table 2.** Commuting differences by place of residence

Variable	Birmingham			Tuscaloosa		
	Urban N=646	Sprawl N=62	sig	Urban N=204	Sprawl N=59	sig
Distance and time						
Average miles	6.31	16.02	0.000	4.36	16.06	0.000
Average time	17.71	29.04	0.000	16.16	29.73	0.000
Average drive time	16.90	28.47	0.000	15.97	28.90	0.000
Average bus time	10.99	6.49	0.197	1.24	2.97	0.209
Average bike/walk time	5.41	3.10	0.237	3.18	0.53	0.017
Density						
Population density (km <sup>2</sup> )	947.56	66.83	0.000	922.81	20.25	0.000
Worker density (km <sup>2</sup> )	360.30	32.69	0.000	391.84	8.60	0.000
Household density (km <sup>2</sup> )	392.52	24.46	0.000	363.71	7.69	0.000
Housing density (km <sup>2</sup> )	477.53	26.17	0.000	405.61	7.97	0.000
Commuter characteristics						
Percentage of workers who are white	42.40	91.11	0.000	53.54	87.58	0.000
Percentage of workers who own their home	47.59	87.02	0.000	52.88	87.91	0.000
Average household income (\$)	38909.63	66725.24	0.000	39133.65	50026.61	0.003
Average vehicles per household	1.25	2.19	0.000	1.51	2.16	0.000
Transportation method						
Percentage of workers who drive alone	61.39	88.34	0.000	74.95	76.40	0.729
Percentage of workers using transit	1.13	0.13	0.023	0.15	0.46	0.091
Percentage workers who bike/walk	1.99	0.75	0.201	2.57	1.96	0.612
Percentage of workers who leave during morning rush hour	27.14	28.28	0.668	28.53	25.55	0.324
Percent below poverty	6.35	2.49	0.572	10.48	3.52	0.001
Percent drivers below poverty	3.70	1.71	0.018	7.94	3.00	0.003
Percent bus riders below poverty	0.32	0.05	0.165	0.02	0.00	0.419
Percent bikers/walkers below poverty	0.58	0.05	0.359	0.42	0.00	0.083

Note: Shading indicates no significant commuting differences at  $p = .05$  or better.

## Sprawl and Relationships between Workplace and Residence Locations

The geographic locations of both the home and workplace have a strong influence on commute duration (Hanson and Pratt 1988; Crane 2000; Johnston-Anumonwo 2000; Sultana 2005b). It can be expected that trips from a sprawl home to a sprawl workplace would have greater times and mileage than those within urban areas. Using data from Part 3 of the CTPP (along with commuting mileage calculated from it) it is possible to examine how both residential and workplace locations influence commuting patterns (Tables 3 and Table 4). The four quadrants of the tables show each combination of residence and workplace location (urban or residential sprawl), and the commuting values in each were tested with ANOVA for differences between them (Figure 6). As there are 22,710 jobs in sprawl areas for Birmingham, Table 3 clearly shows an undercount for commuting to sprawl areas. This can be explained by the suppression of small flows in the CTPP due to privacy. It should be noted that workers who commute into the metropolitan area from adjacent counties are not shown, nor are those who leave urban and sprawl areas for other counties. No information is available at the TAZ level for these flows across county lines. Excluding these trips removes commutes that would likely be of longer duration than those entirely within the MSA.

**Table 3.** Journey-to-work flows in Birmingham

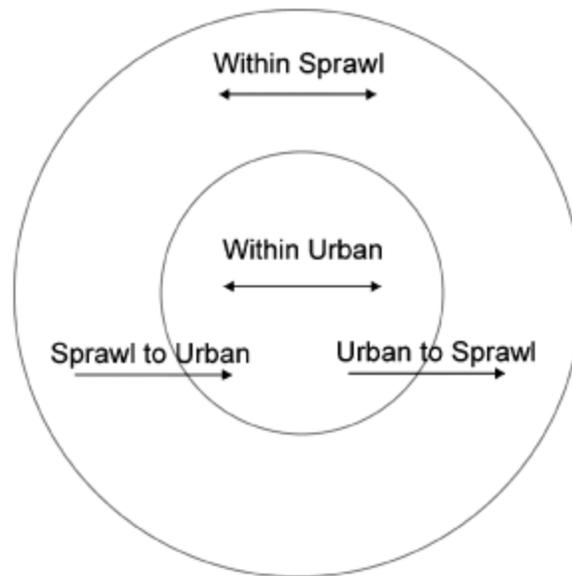
		Place of employment																					
		Urban							Sprawl														
Place of residence	Significance	Significance																					
		N	Miles	Time	Drive time	Bus time	Bike/walk time	Significance	N	Miles	Time	Drive time	Bus time	Bike/walk time	Significance								
Urban		21426	9.00	23.18	19.57	0.76	0.065	0.29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	911	17.72	26.72	23.09	0.74	0.47	
Sprawl	Bike/walk time					0.47	0.374	0.32	0.005	0.770	0.721	0.274	0.013										
	Significance	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.005	0.770	0.721	0.274	0.013										
	Bike/walk time					0.20	0.000	1.17															
	Bus time					0.08	0.069	0.35															
	Drive time					30.52	0.000	22.61															
	Time					33.72	0.000	25.28															
	Miles					20.28	0.000	16.19															
	N	3244																					
		Commute to urban							Commute to sprawl														
		24670	10.48	24.56	21.01	0.67	0.44	0.55	0.30	22.96	26.33	17.30	1253										

Note: Shading indicates no significant commuting differences at  $p = .05$  or better.

**Table 4.** Journey-to-work flows in Tuscaloosa

		Place of employment																				
		Urban							Sprawl													
Place of residence	Significance	Significance																				
		N	Miles	Time	Drive time	Bus time	Bike/walk time	Significance	N	Miles	Time	Drive time	Bus time	Bike/walk time	Significance							
Urban		2933	4.18	14.99	12.88	0.10	0.699	20.12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3011	15.77	23.34	13.07	0.10	0.60	
Sprawl	Bike/walk time					0.61	0.159	—	0.012	—	0.000	0.000	0.000									
	Significance	0.000	0.000	0.000	0.819	0.474	0.012	—	0.000	0.000	0.000	0.000	0.000									
	Bike/walk time					0.47	0.993	0.47	—	—	—	—										
	Bus time					0.12	0.709	—	—	—	—											
	Drive time					24.51	0.000	10.96														
	Time					28.59	0.000	15.79														
	Miles					16.82	0.000	7.10														
	N	481																				
		Commute to urban							Commute to sprawl													
		3414	5.96	16.91	14.52	0.10	0.59	0.20	0.00	16.26	20.15	12.11	135									

Note: Shading indicates no significant commuting differences at  $p = .05$  or better.



**Figure 6.** Commuting flows between urban and sprawl areas.

In both MSAs, similar commuting patterns are apparent. The shortest commute lengths and times are found for those who commute within urban areas (the dotted ellipse in the upper left quadrant); the longest are found for people who commute from sprawl areas to urban areas (the ellipse in the lower left quadrant). Workers who commute from urban to sprawl and within sprawling areas have intermediate travel time and mileage values. This is significant given that sprawl encompasses many widely separated areas in these cities. Cross commuting from one development type to the other produces the greatest commuting lengths, not altogether surprising given that sprawl areas are defined as being peripheral.

The row averages appear on the right-hand side of the table and show averages for all workers by their place of residence. Similarly, column averages are on the bottom and show commuting patterns by place of employment. The averages by place of residence show that commuters from urban areas have shorter commutes than those from sprawling areas. However, in each case higher values from cross commuting workers raise the average. The averages by place of work show that commuters to urban areas tend to have shorter commutes than those who travel to sprawl jobs. The shorter commutes of those commuting entirely within urban areas are clearly offsetting the long journeys of cross-commuters from sprawl areas. As urban jobs shift to sprawl areas, average commutes could rise for urban workers but decrease for sprawl workers. A change in residence from urban to sprawl would also appear to greatly increase the average commutes of urban workers.

#### Multivariate Analysis of Sprawl and Relationships with Commuting

The ANOVA result clearly reveals differences in commuting between sprawl and urban areas, but it does not consider the effects of other independent variables at the same time. Stepwise multiple regressions were therefore carried out to identify to what extent commuting distance and times are related to sprawl when other key factors such as household socioeconomic characteristics and time leaving home (to show the rush hour effect on commuting) are controlled for in the analysis. The commute distance and travel times are used as dependent

variables (Table 1). In addition, a dummy variable representing whether a zone was identified as sprawl was included (where 1 indicates the place of residence is in a sprawl area). To ensure that our models are free from multicollinearity, a test was run to verify that independent variables are not correlated. The stepwise selection procedure was used to add and remove variables in the models to solicit only those variables that are statistically significant for explaining variation.

**Table 5.** Commuting regression models by place of residence

Variable	Birmingham				Tuscaloosa			
	Miles	Time	Auto time	Transit time	Miles	Time	Auto time	Transit time
<i>N</i>	558	558	553	150	243	243	241	11
Adjusted <i>R</i> <sup>2</sup>	0.753	0.683	0.666	0.39	0.781	0.463	0.344	0.937
Constant	0.345	0.745	0.741	1.6	0.88	6.315	5.654	0.136
Sprawl dummy	0.337	0.086	0.1	<i>0.069</i>	0.738	0.497	0.413	
Transportation method								
Percentage of workers who drive alone	0.453	0.583	0.6	0.234	0.14	0.275	0.257	
Percentage of workers using transit		0.252	<i>0.062</i>	0.666				0.904
Percentage of workers who bike or walk					<i>-0.077</i>			
Commuter characteristics								
Percentage of workers who own their home	0.271	0.287	0.295			0.175	0.158	
Percentage of workers who are white	0.16		<i>-0.079</i>	-0.301	<i>0.093</i>			
Average household income (\$)	-0.157	-0.153	-0.166					
Percentage of workers below poverty	0.212	0.365	<i>0.061</i>		<i>0.123</i>			
Percent drivers who are below poverty	-0.093	-0.231			-0.168			
Percent of transit users below poverty		-0.133		-0.264				0.175
Percent of bike/walkers below poverty		-0.157						0.066
Percentage leaving during morning rush hour	-0.128	<i>-0.066</i>			-0.097			
Average vehicles per household	0.102	<i>0.091</i>	0.11		0.127			
Density								
Population density (km <sup>2</sup> )								
Housing density (km <sup>2</sup> )		0.272						<i>-0.039</i>
Household density (km <sup>2</sup> )	<i>-0.049</i>	-0.226						
Worker density (km <sup>2</sup> )				0.127				

Note: All values are standardized coefficients. Italics indicate variable significant at .05; all other variables are significant at .001.

The results (Table 5) clearly show that living in sprawling areas increases commuting distance and times for residents in both metropolitan areas, with the exception of travel time by bus in Tuscaloosa. That this is so even when other variables are present in the model provides strong confirmation of the argument that residential sprawl lengthens commutes, whether measured in miles or minutes, and by car or bus. However, a number of other variables are clearly important in explaining commutes. A higher percentage of workers driving alone to work is also associated with longer trips to work for every measure of commuting distance, again except for transit time in Tuscaloosa. Workers who live in areas where more people drive alone, are white, own more cars, and with incomes below the poverty line are also likely to travel longer mileages to work in both metropolitan areas. Except for those with incomes below the poverty line (which suggests the possibility of spatial mismatch as jobs move to peripheral areas), these results all fit common expectations about the characteristics of people who live in sprawl. In Birmingham higher average incomes are related to shorter commutes, which is inconsistent with many previous commuting studies although consistent with findings for nearby Atlanta (Sultana 2005a). A

similar set of variables accounts for travel time in Birmingham, though in Tuscaloosa the presence of sprawl, the percentage driving alone, and the percentage of commuters owning their own home are the only significant explanatory variables that remain after stepwise selection. The effect of density on commuting (in addition to the sprawl dummy) is quite limited, and lower levels of housing density and workers per km<sup>2</sup> are actually associated with lower travel times in Birmingham. It is also interesting that none of these variables appear at all for driving time, which indicates that for this measure of commute length sprawl captures all significant effects of urban density.

The similarity between travel times and mileage models is important, as these represent quite distinct ways of measuring commuting trips. Although the definition of sprawl used here does not take street networks into account, there is no evidence that morning commuting traffic will overload major streets. Contrary to other findings (Texas Transportation Institute 2002; Sultana 2005a), we find that morning rush hour commuters travel fewer miles, and also fewer minutes, in Birmingham. It is interesting that a larger white population increases mileage in both cities, which is consistent with findings from the neighboring metro area of Atlanta (Sultana 2002), but reduces driving and transit times in Birmingham. As the white population is overwhelmingly suburban in this metropolitan area, this indicates that suburban commuters travel greater distances, but on faster roads. A central city-suburb distinction can therefore still remain important despite the presence of widespread sprawl.

The several noteworthy differences between Birmingham and Tuscaloosa can be explained by the limited use of public transportation in Tuscaloosa and the smaller size of the MSA. The standardized coefficients for the percentage drive-alone variable are actually much larger than that for sprawl in Birmingham, whereas the opposite is true in Tuscaloosa. This indicates that sprawl is a more important explanatory variable in the smaller metropolitan area. Mode choice and other socioeconomic variables are equally or considerably more important than sprawl in Birmingham. A smaller metropolitan area, such as Tuscaloosa, may simply not have the size to warrant or enable the suburbanization of jobs to sprawling areas that has taken place in Birmingham. The larger MSAs may have more opportunity to sprawl, but their sprawl may actually have less impact on commuting patterns than in smaller MSAs.

## **Conclusions**

This research shows that clear differences exist in commuting patterns between urban and sprawling areas, and that these confirm the standard expectation that commutes will be longer and more automobile-dominated in sprawling areas. However, the ability to examine flows of commuters using Part 3 of the CTPP allows us to highlight which groups of workers have the longest journeys to work. Perhaps surprisingly, it is not workers who live and work in sprawl, but those who commute into urban areas from outlying zones. The lower values of within-sprawl commuting are increased by the high sprawl-to-urban commuting values. This shows that sprawl does not simply (or necessarily) lengthen commutes.

Although there are important considerations regarding causation, time-lags, and residential self-selection (Handy, Cao, and Mokhtarian 2005; Sarzynski et al. 2006), this research is consistent with the idea that households may relocate closer to the workplace (if their workplace is

relocated to sprawl areas), or vice versa, to maintain or improve commuting conditions. However, there are limits to this possibility, as our findings also suggest that average commuting times can be expected to greatly increase if sprawl residents continue to journey to urban jobs. To the extent that jobs move to sprawling areas, commuting times may go down due to an increase in shorter within-sprawl commuting, even if within-sprawl commuting is not quite as short as within-urban commuting. Increasing sprawl could therefore lead to an equalization of commuting times, assuming that only either the home or the workplace of individuals changes (but not both). Similar possibilities have been observed at the metropolitan level (Crane and Chatman 2004), though with the same problem of identifying trends from a cross-sectional analysis.

There are limits to the utility of sprawl as a predictor of travel behavior, as is shown in the multivariate statistical analysis section. Sprawl clearly does not account for all socioeconomic variations that explain commuting (or even the effect of density on commuting). Sprawl in Birmingham would appear to be less useful as a predictor of commute length than many socioeconomic variables. This is not surprising, as individual and household characteristics have been found to be fundamental to travel behavior (Handy 1996, 2005; Ewing and Cervero 2001; Mokhtarian and Salomon 2001; Srinivasan and Ferreira 2002). Despite the residential self-selection and homogeneity that are often suggested as typical in sprawl, the presence of sprawl does not remove the importance of socioeconomic variations in these areas, though it appears to do so to a greater degree in Tuscaloosa than Birmingham.

The methodology used here is based on discrete zones, and so is subject to the modifiable areal unit problem, or MAUP (M. Green and Flowerdew 1996; Openshaw 1996). The results are not independent of the size and shape of the zones used to map sprawl and aggregate travel behavior. The use of raster cells for defining sprawl could be a solution (Galster et al. 2001), but the MAUP would remain a problem when using commuting data from the CTPP. The possibility of errors due to interpolation will also remain in such an approach. Instead, the question of the most appropriate scales and areas of analysis for sprawl should be examined, as it has been for other travel behavior topics (Horner and Murray 2002; Sultana 2002; Hasse and Lathrop 2003a).

The presence of barriers to development must also be taken into account. Parkland, water, or other undevelopable land could exaggerate the measurement of sprawl by lowering densities or requiring noncontiguous development (Wolman et al. 2005). Finally, the definition of sprawl used here is based only on density and growth rates. As with other work, the continuity or clustering of land development, characteristics of local street patterns, and the presence of mixed land uses could also be combined with a threshold value for identifying sprawl. This would require making use of data beyond that found in the CTPP. Remote sensing and aerial photography is useful in mapping land use change associated with sprawl (Hasse and Lathrop 2003a), and this approach could potentially be linked to commuting data.

The issues examined here are important because it has been customary to focus only on the costs of sprawl, not the benefits (Downs 1999; Malpezzi 1999). It can be argued that the costs of increased commuting (congestion, air pollution, and so forth) may in fact actually be less than the benefits for households. For example, there is evidence that sprawl is helping to increase the supply of affordable housing and to narrow the homeownership gap between whites and blacks

(Kahn 2001). Commuting distances may be less a concern than housing or other locational considerations (Mokhtarian and Salomon 2001). If this is the case, sprawl may strike some as ugly but it may have benefits, at least for those with the opportunity to relocate. Whether or not the patterns of sprawl identified here are actually related to negative outcomes for the commuters and households involved should be explored in the future.

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