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How Do They Get There? A Spatial Analysis of a 'Sprawl School' in Oregon

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Introduction

For over 50 years, communities across the United States (US) have experienced a shift away from small, neighbourhood schools to large ones located on the urban periphery. Two effects of this type of 'sprawl school siting' are increased traffic congestion during school pick-up and drop-off times and decreased walking and cycling by children accessing school. This study is a spatial exploration of how students get to school at one such sprawling location in Bend, Oregon.

As a vital part of the community, schools can have a profound impact on the social, economic and physical character of a city (Chung *et al*., 2002). While 'sprawl' schools are often built to satisfy shifting regional populations, new schools tend to be built even beyond new development (where land purchase may be less expensive) and, given their distance from local housing, often require major arterials for school access. As a result, children have become highly dependent on adults with cars, especially where school buses do not provide services. And as schools consolidate into larger buildings built far from residential areas, parents find themselves left with no choice but to drive their children to school and extra-curricular activities. One obvious effect of this type of 'sprawl school siting'—building large new facilities on the urban fringe—is increased traffic congestion during school pick-up and drop-off times, in some cases resulting in as much as a 30% increase in cars (United States Environmental Protection Agency Development Community and Environment Division, 2003). Another potential impact can be seen in decreases of physical activity among youth. When school sites are remote, and children do not walk or ride bikes to school, they are deprived of the opportunity to exercise. This, in combination with a variety of other factors (poor diets, television, the popularity of video/computer games) has lead to an increase in the number of overweight and obese children in the US (Schmidt, 2003). For this reason, many new national programmes are emerging to promote walking and biking to school, including the US Department

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of Health and Human Services and the Centers for Disease Control and Prevention (CDC)'s 'Children-Walk-to School' campaign and the 'Safe Routes to School' programmes. It is hoped that these programmes will lead to increased numbers of children who walk or bike to school, yet it may be that the built environment created to support new 'sprawl schools' may make such programmatic interventions difficult to succeed with.

This study is a spatial exploration of how students get to school at one such sprawling location in Bend, Oregon. Through a survey of student mobility, a spatial analysis of student locations, and an analysis of the mobility infrastructure between student homes and their school, this study hopes to provide some insight into the connection between school location, how children get to school, and why. Specifically, there are three basic questions guiding this study:

(1) How do children get to school and what are the reasons behind those choices?
(2) What is the relationship between distance from school and mode used to access school?
(3) What characteristics of the mobility infrastructure may influence student mode choice?

Due to a relatively small sample size, this study is not intended to offer statistically significant evidence of the impacts of an urban fringe school on student mobility to and from that school. Rather, this study is intended to present a case example of the relationship between school location and travel mode, as well as a set of methodological techniques for visualising and analysing the transportation impacts of school siting decisions.

School Siting Context

Due to many factors, including the high cost of land, lack of available land and the desire (perceived and real) for large sport fields, America's schools are increasingly being built on the periphery of communities (Beaumont *et al*., 2002; Passmore, 2002; United States Environmental Protection Agency Development Community and Environment Division, 2003). Many districts follow siting guidelines that used to be suggested by the Council of Educational Facility Planners International (CEFPI) (these guidelines were rescinded by the CEFPI in the fall of 2004 but were used during the time of this study). These guidelines suggest a 10-acre minimum plus one additional acre for each 100 elementary students, a 20-acre minimum plus one additional acre for each 100 junior-/middle-school students, and a 30-acre minimum plus one acre for every 100 high-school students (Weihs, 2003).

In trying to follow these guidelines, school districts often move to urban fringe locations because either they cannot afford the expensive land in the city or there simply are not areas of land large enough within existing urban areas on which to build schools to the guidelines. Other factors responsible for large sites are the need for athletics facilities, staging areas for buses, parking, buffer zones and security features. Because of these size requirements the cost of building schools within settled urban areas becomes exorbitantly expensive and many school administrators seek cheaper, undeveloped land on the urban fringe.

Access to School

One obvious side effect of building schools at the urban fringe, where housing densities tend to be low and street connectivity poor, is the reduction in mobility choice for students (and teachers) to access school (Beaumont *et al.*, 2002). In 1969, close to 90% of students who lived within a mile of school walked or biked to school (*Nationwide Household Travel Survey*, Federal Highway Administration, 2003). In 2000 only 31% walked or biked to school, and according to the National Institutes of Health only 13.5% of today's school children walk or bike to school (Federal Highway Administration, 2003; United States Environmental Protection Agency Development Community and Environment Division, 2003). Schools built on the urban edge are normally built in less dense and less connected land-use patterns, leading to the decrease of children walking and biking to school. In contrast, schools located in neighbourhoods or other central locations have greater numbers of students who walk or bike to school (Gurwitt, 2004).

Walking routes that are perceived as unsafe because of high traffic volumes or lack of sidewalks, for example, have some effect on whether or not children walk or bike to school (Passmore, 2002; McMillan, 2003, 2005; United States Environmental Protection Agency Development Community and Environment Division, 2003). Street width, the absence or presence of trees, and other urban-form-related issues all have impacts on children's travel mode to and from school (Handy *et al.*, 2002; Pikora *et al.*, 2002; Lee & Moudon, 2004; Timperio *et al.*, 2004). If schools are located at long distances from the homes of many of their students, walking and bicycling will be minimised. One North Carolina study found that older schools (defined as ones built before 1973) had a much larger percentage of children walking to them than those built later, because of their more centralised location within established neighbourhood environments (Salvesen & Hervey, 2003).

Transportation and Urban Form

The urban form at a neighbourhood scale is an important element that allows residents to choose a non-automotive transportation option, if such alternatives are available. In terms of getting to school, some research has shown that urban form has a modest effect on transportation mode choices when looking at travel time to school and the distance children live from school (McMillan, 2003). Other researchers have found that people who live in pedestrian-oriented environments were more likely to go by foot to the market (Bernick & Cervero, 1997). Handy (Handy & University of California Transportation Center, 1995) found that residents that live in 'traditional neighbourhoods' have also been found to make two to four more walk/bicycle trips per week to neighbourhood stores than those living in nearby, automobile-oriented environments. And recently, Krizek (2003) found that people who live in areas with good 'neighbourhood accessibility'—areas with good street connectivity—are more likely to walk and use transit than those who live in more traditional auto-oriented environments. A good walkable urban form, therefore, can be a key contributor to local mobility (Handy & University of California (System) Transportation Center, 1995; Krizek, 2002, 2003).

The existing street network often provides a key indicator of the walkability of local environments, especially in more urbanised areas where off-street paths may be less likely to exist. Streets form the foundation and framework upon which cities are shaped, community interaction takes place and neighbourhood life exists (Southworth & Ben-Joseph, 1997). Southworth & Ben-Joseph (1997) argue that the significant contemporary urban issues of today—congestion, pollution and community isolation—are inextricably linked to road patterns. Straight streets, small block lengths and good street connectivity are some of the indicators that one can use to identify and quantify the street-network-based urban form at a neighbourhood scale (Calthorpe & Poticha, 1993; Ewing & Florida Department of Community Affairs, 1997).

A number of geographical information systems (GIS) approaches have been used to measure walkability and connectivity. Some examples of these measures include: block size (Cervero & Kockelman, 1997; Hess, 1997), intersection density (Handy, 1996; Cervero & Kockelman, 1997), route directness (Randall & Baetz, 2001), land-use barriers (Fang Zhao *et al*., 2003) and commercial density, intensity and choice (Handy *et al*., 2000). Schlossberg *et al*. (2004) and Schlossberg & Brown (2004), utilising ideas from Jacobs (1995), Southworth & Ben-Joseph (1997) and others, classified streets into pedestrian-friendly and pedestrian-hostile categories and conducted GIS-based spatial analysis on the impact of type of road on the likely zone of walkability surrounding transit stops. In addition, they looked at intersection type and density to measure the pedestrian connectivity of the local environment. They concluded that the presence of auto-dominant (pedestrian-hostile) roads causes significant impedances to pedestrian access to transit stops. Such results and methods can easily be adapted to the school environment where, like a transit stop, the urban form around local destinations impacts the travel modes available to local residents.

Sky View Middle School and the Oregon Context

While Oregon does not have specific regulations regarding acreage requirements, school districts are bound to follow state and local land-use requirements. Land use is regulated to preserve rural and natural areas through the promotion of Oregon's 19 Statewide Planning Goals. Oregon's goals, among other things, require that all cities estimate future growth and need for land and designate an 'urban growth boundary' (UGB) where future development must take place (Oregon Department of Land Conservation and Development, 2000). All public entities must provide comprehensive and public facility plans; however, there is no provision for localities to put buildable land aside for schools (Oregon Department of Land Conservation and Development, 1998).

Sky View Middle School, the focus of this study, is located in the foothills in Oregon's Cascade Mountains adjacent to the Deschutes River and home to a popular ski destination. Although Bend does receive snow in the winter, its location in the high desert on the east of the Cascades results in a significantly greater amount of sunny days than in the more famous wet weather often thought of in the Pacific Northwest. Sky View Middle School, constructed in 2000, reflects the sprawl school phenomena. Sky View is a large school built just inside the urban growth boundary adjacent to Lava Ridge elementary school, which was built in 1994. Figure 1 shows the Bend and Sky View area, showing just how close to the urban fringe Sky View was built. Sky View houses approximately 800 students and has a large parking lot on two sides of the school and is surrounded by a chain link fence. Sky View shares athletic fields with its elementary school neighbour.

Methods

Three main research methods were employed to understand the travel modes of Sky View Middle School children: (1) a mail survey sent to the parents of every middle school student; (2) an analysis of survey responses in a spatial context with

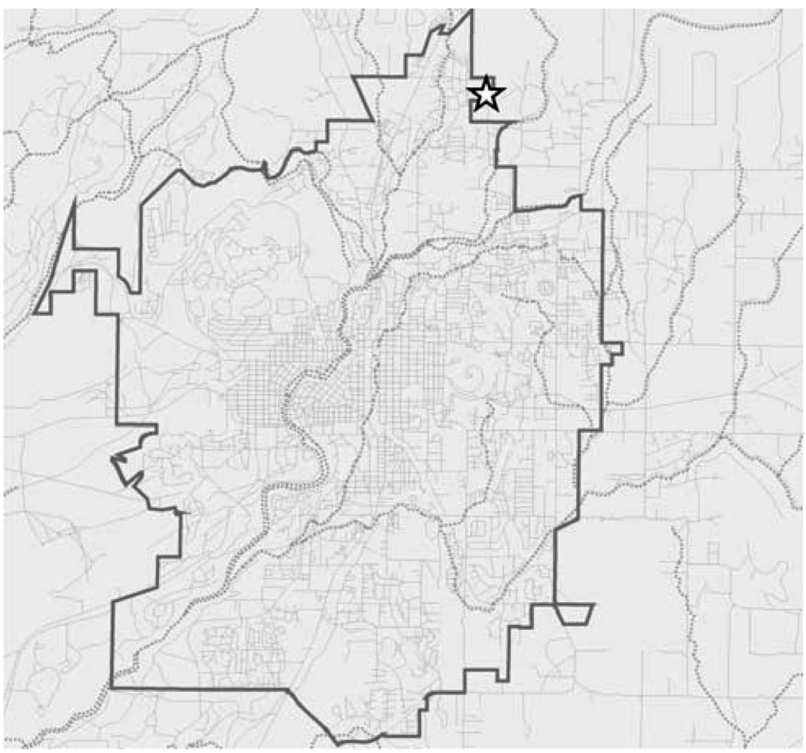


FIGURE 1. Bend UGB and Sky View location.
This map shows the UGB around the city of Bend, OR. The historical development of Bend is located in the centre of the image. Sky View Middle School is represented by the star in the northeast section and is located right on the urban fringe.

GIS; and (3) a comparative analysis between the local mobility infrastructure and the student mobility choice.

Survey

A mail survey was sent to each middle school household and directed to the parents of the student. The four-page survey addressed three main questions: (1) What mode does the child use to get to and from school and how many times per week is that mode used?; (2) For children who are driven to school, why is that the choice?; and (3) What activities may allow more children to walk or bike to school? For those children who do walk or bike to school at least occasionally, the survey asked them to trace their route on a street map provided with the survey. In total, 550 surveys were sent and 108 were returned, representing a 20% return rate; 104 of the surveys had addresses that could be geocoded and 18 maps were completed by respondents, although some were completed by people whose children do not walk or bike to school.

Survey Spatial Analysis

In addition to a frequency and correlation analysis of the surveys, each of the responses was geocoded with GIS for a spatial analysis. Three basic calculations were derived from this spatial approach. First, a Euclidean distance between the child's home and school was calculated, thereby allowing an analysis correlating distance to school with travel mode to school. Second, a Manhattan or network distance was calculated between home and school, representing actual travel distances along the street network (see Figure 2). This network distance makes it possible to measure the connectivity of the area around the school by comparing straight-line and network distances. The third spatial component to the analysis was to select survey respondents within 1.50 miles of the school for a

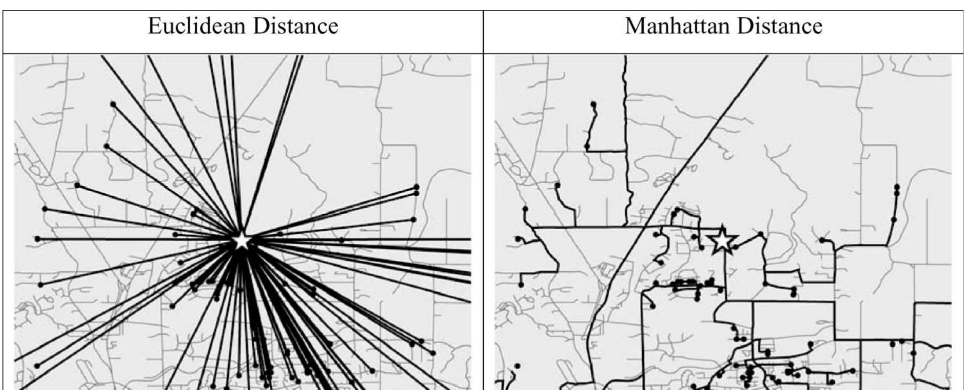


FIGURE 2. Distance calculations, Sky View students within 2 miles of school.

more in-depth analysis. The 1.50-mile threshold was used because this is the distance which the school bus system uses to determine who is eligible to use the bus; those living beyond 1.50 miles can access the school bus. Focusing on students living within 1.50 miles (Euclidean) of the school also presents an interesting subset of students to look at because the mobility behaviours of children (and/or their parents) are completely determined by family decision making, and 1.50 miles is within biking distance for most students. The key question here is to understand why some children, who theoretically live close enough to school, do not walk or bike; thus a comparison between bikers and non-bikers and walkers and non-walkers at varying distances within this 1.50-mile area becomes possible.

Data/Results

In terms of distance, of the 104 survey responses with validated addresses, the average Euclidean distance from home to school was 2.27 miles, with a minimum distance of 0.16 miles and a maximum distance of 11.20 miles. Along the street network, the average distance from home to school was 3.18 miles, with the minimum distance of 0.21 and a maximum of 14.15 miles. Thirty-two (29.6%) respondents lived within 1.50 miles of the school, with the average Euclidean distance from home to school of 0.73 miles and an average network distance of 1.09 miles (Table 1).

None of the students who lives further than 1.50 miles from school walks to or from school and 3% of those students bike to and from school at least once per week (a slightly higher percentage of students bike with less frequency). For those students who live within 1.50 miles of school, 19% walk and 25% bike to school at least once per week. Percentages for walking (and biking, surprisingly) increase on the home trip, presumably meaning that some children are dropped off at

TABLE 1. Walking and biking statistics

	All respondents ($n = 104$)		Respondents beyond 1.50 miles of school ($n = 72$)		Respondents within 1.50 miles of school ($n = 32$)	
Average Euclidean distance (miles)	2.27		2.95		0.73	
Average Manhattan distance (miles)	3.18		4.11		1.09	
	Walk	Bike	Walk	Bike	Walk	Bike
At least occasionally (% to school)	8.7	17.3	0.0	6.9	28.1	40.6
At least occasionally (% from school)	12.5	18.3	0.0	5.6	40.6	46.9
At least once per week (% to school)	5.7	4.6	0.0	2.8	18.9	25.0
At least once per week (% from school)	4.8	10.6	0.0	2.8	34.5	28.2

school in the morning by parents going to work or running other errands, and then walk home. For those who live closer to school, 35% walk home and 28% bike home at least once per week. As expected, those students who live in closer proximity to school have a much higher likelihood of travelling by foot or bike. The numbers are higher on the way home, when presumably there is less likelihood of a parent to accommodate the trip home because school ends in the middle of a typical working day.

Looking at all respondents, both walking and biking are statistically significant and inversely related to both Euclidean and Network distances; that is, as expected, the further a child is from school, the less likely he/she is to walk or bike. Close proximity to school clearly enhances the capacity and the numbers of students who can exercise an independent mobility option (i.e. walking or biking) to get to or from school.

The survey also asked parents what other modes their children use to get to and from school. Respondents could choose more than one option and specify with what regularity they used that transportation choice (e.g. occasionally, once per week, twice per week, etc.). Table 2 lists the top choices for getting to and from school separated into the two spatial categories: those who live within and those who live beyond the 1.50-mile bus service distance. Only those modes that respondents use at least three times per week are shown.

For students living beyond 1.50 miles of school, the most frequent modes are all motorised forms of transportation: driving alone with a parent, carpool, or a school bus. In terms of those respondents who live beyond 1.50 miles of school, the bus is the primary mode to go to school (40.3%) and to go home (52.8%); driving alone with a parent is the second most popular travel mode for both going to school (30.6%) and going home (23.6%); and carpooling to and from school is also common, with 29.1% of students carpooling to school and 23.6% carpooling home.

For those students who live within 1.50 miles of school, the primary way to go to school is alone with a parent in a car (40.6%), followed by biking (21.9%) and carpooling (21.9%). Transportation behaviour on the way home is quite a bit different, with carpooling the most frequent mode (28.1%), followed by walking (25.0%), biking (25.0%) and driving alone with a parent (18.1%). It is interesting to

TABLE 2. Primary modes of school access—use at least three times per week

	Students beyond 1.50 miles of school (%)		Students within 1.50 miles of school (%)	
	To school	From school	To school	From school
Bus	40.3	52.8	—	—
Alone in car with parent	30.6	23.6	40.6	18.8
Carpool	29.1	23.6	21.9	28.1
Walk	—	—	6.3	25.0
Bike	—	—	21.9	25.0

note that one-quarter of students walk home with some regularity, even though only 6% of students walk to school. Again, this implies that parents often drop their children off at school on the way to work, but allow the students to walk home.

It is quite encouraging that of those students who live within 1.50 miles of school, 28% walk or bike to school and 50% walk or bike home from school at least three days a week. However, we were curious as to why more students do not walk or bike to/from school, especially given that the physical distance between home and school is quite small. To address this issue, survey respondents were asked: ''If you usually drive your child(ren) to and from school, please tell us the reasons''. A series of 23 reasons were listed that could be synthesised into five main categories: *Urban Form* (e.g. dangerous traffic conditions and lack of complete sidewalks), *Convenience* (e.g. school bus is unavailable and drop off on way to work), *Personal Safety* (e.g. afraid of strangers and afraid of bullies on bus), *Physical Comfort* (e.g. bad weather and too far to walk or bike) and *Personal Requirements* (e.g. backpack too heavy and before-/after-school activities). The primary reasons for not allowing children to walk or bike to or from school can be seen in Table 3. Of all the categories, Convenience is the most common reason why children are not allowed to bike or walk to school (65.6%) and Physical Comfort is the least likely (37.5%). The most common individual reason for not walking or biking is the weight of children's backpacks. Three Urban Form variables (dangerous traffic conditions, lack of complete sidewalks, high-speed vehicles) are among the eight variables that at least 10% of respondents selected. Clearly, Urban Form is not the only determinant as to why children (or their parents) choose to walk or bike to school, yet it is one of the frequently stated factors.

The final survey question asked respondents who usually drove their child(ren) to school to select options that, if in place or made available, would change their habits, thus allowing their child to walk and/or bike to school. Eleven potential

TABLE 3. Summary categories and some primary reasons for not walking or biking (students within 1.50 miles of school)

Reason	Response (%)
School requirements	56.3
Backpack too heavy	28.1
Projects or musical instruments	18.8
Physical comfort	37.5
Bad weather	28.1
Convenience	65.6
Drop off on way to work	21.9
Urban form	46.9
Dangerous traffic conditions	18.8
Lack of complete sidewalks	15.6
High-speed vehicles	12.5
Personal safety	40.6
Afraid of strangers	18.8

Note: Respondents could choose more than one reason; therefore percentages do not add up to 100%.

responses were listed, which were then grouped into four general approaches: *Escort* (e.g. accompanied by other children, bike bus), *Infrastructure* (e.g. sidewalks, safety crossings, speed enforcement), *Never* and *Other* reasons.

The most interesting result from this question was that only 6% of parents who live within 1.50 miles of school would never allow their child to walk or bike to school (Table 4). That means, from our sample, that almost every family that lives within a physically accessible distance to school would be open to having their children walk or bike to school. To have their children walk or bike to school, parents generally preferred an escort approach (53%), although improving the infrastructure was also important (44%). In the escort approach, children walk or bike to school with other children with the assumption that there is greater safety when children travel in a group. Parents were not necessarily demanding that the group have an adult chaperone; in fact, parents showed a greater preference to have a group of children travel without a chaperone (28%), than having an adult either walk or bike with the group of children (25%).

In terms of the mobility infrastructure, 16% of parents desired enhanced safety crossings at key intersections (the second most common response), 13% desired better enforcement of speed limits on motorists and 9% thought that that the sidewalk network needed better development.

The Mobility Infrastructure: A Spatial Examination

In addition to understanding how children get to school, we wanted to examine the street network surrounding Sky View Middle School to see how consistent the school's placement is with walkability. Figure 3 applies Schlossberg and Brown's work on transit-oriented development (Schlossberg *et al*., 2004; Schlossberg & Brown, 2004) to schools and includes eight maps that visually represent different aspects of the street network within 1.50 miles of the school. Descriptions of the maps follow the entire series.

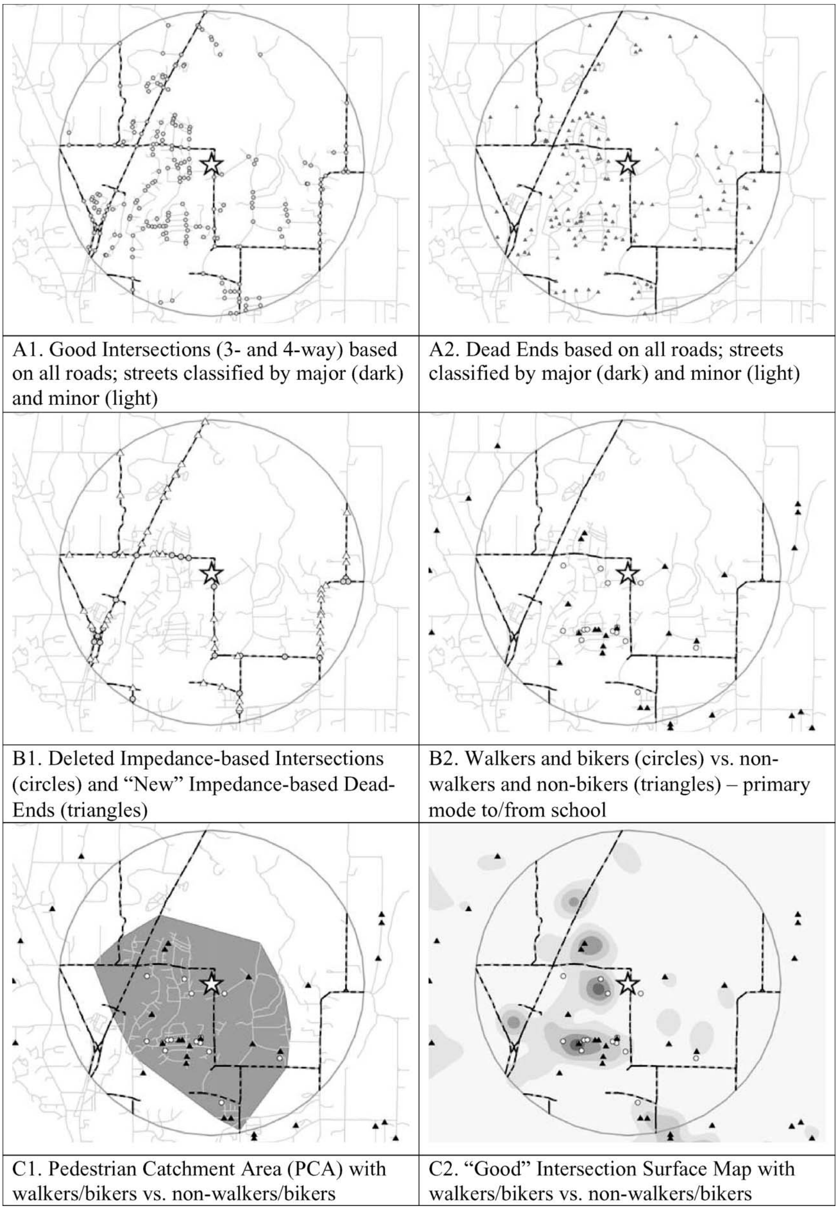
Intersection analysis (A1 and A2). These two maps visually show the location of 'good' intersections (three- and four-way) and dead ends. Each of these designations provides some insight into the connectivity of the area surrounding

TABLE 4. Prerequisites for walking or biking

Approach	Response (%)[1]	Weighted response (%)[2]
Escort	53.1	17.7
Infrastructure	43.8	10.9
Other	9.4	2.3
Never	6.3	1.6

Notes: [1]Respondents could choose more than one reason; therefore percentages do not add up to 100%.

[2]The weighted response is calculated by dividing each total approach category by the number of variables that contribute to that category, thereby eliminating any double-counting bias.



A1. Good Intersections (3- and 4-way) based on all roads; streets classified by major (dark) and minor (light)

A2. Dead Ends based on all roads; streets classified by major (dark) and minor (light)

B1. Deleted Impedance-based Intersections (circles) and "New" Impedance-based Dead-Ends (triangles)

B2. Walkers and bikers (circles) vs. non-walkers and non-bikers (triangles) – primary mode to/from school

C1. Pedestrian Catchment Area (PCA) with walkers/bikers vs. non-walkers/bikers

C2. "Good" Intersection Surface Map with walkers/bikers vs. non-walkers/bikers

FIGURE 3. Sky View Area mobility infrastructure—visual analysis.

the school. Locations with intersections that are greater than four-way are ones with a large and complicated convergence of streets, making it difficult to cross as a pedestrian or cyclist. Dead ends also provide an impediment to connectivity, which is exaggerated for walkers and cyclists. Streets with dead ends do not necessarily need to be barriers for pedestrians or cyclists if paths exist to exit the dead end (in a cul-de-sac, for example). Such cut-throughs are not common in the Sky View area, meaning that dead ends truly are mobility barriers. What is surprising in these maps is the quantity and dispersion of dead ends throughout the 1.50-mile area, indicating that there is a high amount of mobility impediment in the area.

These maps also show two additional phenomena: (1) the general layout of the street network surrounding the school; and (2) the presence and spatial location of high-volume, auto-oriented streets. In terms of all the streets, it is clear that there is not a high-density street network in close proximity to the school; in fact, there are large swaths of land that are absent of roads altogether, thereby minimising the inherent path opportunity for walkers or cyclists. When looking at the maps, it appears that there is a considerable amount of auto-oriented streets and their spatial placement completely divides the space around the school. Finally, these maps make the most problematic aspect of this school visually obvious: that the only two roads that lead to Sky View Middle School are designated as high-volume, high-speed segments. It is no wonder that: (a) parents may prefer to drive given that the street infrastructure explicitly favours high speeds; and (b) for parents to allow their children to walk or bike to school, they would prefer their children to travel in groups and to have a more pedestrian-oriented mobility infrastructure.

Impedance-based intersections and dead ends (B1). This map is the result of combining the intersection analysis with the street classification. In this analysis, by removing the heavily auto-oriented streets, we can see where ‘new’ dead ends appear and where some intersections should be ‘eliminated’ from the analysis. A deleted intersection would occur where a minor road crosses an arterial road. Although from a driver’s perspective that intersection would indeed be a real point along the journey, for a pedestrian or cyclist (at least a youth cyclist) the arterial does not present a realistic mobility option, thus eliminating the crossing as a place where one could change direction—an intersection. Likewise, imagine a minor road ending at an arterial in a three-way T-intersection. From the pedestrian perspective, this may be considered a dead end, because walking along the arterial is not a desired option. In reading this map, each deleted intersection and each added dead end lowers the pedestrian friendliness of the environment.

Student choice visual analysis (B2). This map combines the general street network with the survey data, identifying students who walk or bike to or from school at least three times a week (circles) compared to those who do not (triangles). With this map, one can note the location of the student respondents, the mobility infrastructure available to them, and whether there are any clear visual patterns that explain mobility behaviour in one part of the school area versus another area.

Connectivity analysis (C1 and C2). These maps illustrate connectivity as well. Map C1 shows the distance one could reach by travelling 1.50 miles from school along the street network compared to the 1.50-mile distance one could reach by travelling in a straight line from the school location. The greater the shaded area, the better the coverage the street network provides. A truncated shaded area, as in this case, shows relatively poor street coverage. A second analysis, called an Impeded Pedestrian Catchment Area (IPCA) (Schlossberg *et al*., 2004; Schlossberg & Brown, 2004), re-calculates the distance travelled from the school, but using only minor roads. In this case, since it is impossible to access the school on anything other than a major road, the shading is non-existent, meaning there is no way to access the school using more pedestrian-friendly roads. In Map C2, the good intersections have been turned into a surface density map. Darker areas represent places with good connectivity. In this map, there are three decent pockets of connectivity to the west of the school, but good street connectivity in general is lacking throughout the entire 1.50-mile zone. Both maps have the students represented, differentiated by whether their primary mode to or from school is walking/biking (circles) or a motorised mode (triangles).

Spatial Interpretation

There are three take-home points from the visual representation of urban form and mobility choices. First, the relationship between the school location, the location of the surrounding neighbourhood and the limited potential for walking and biking, given that location, is very clear. The zone around the school likely to be most convenient to pedestrians (or cyclists) is limited, given the school location on the UGB; this location effectively eliminates short-distance trips to school from the east or northeast because housing in those areas are severely restricted. Second, the non-bussing zone around Sky View Middle School is quite heavily populated with major auto-dominant roads, carving up the space near the school and creating potential barriers (physical, safety or perceived safety) to students (or their parents) who might be inclined to walk or bike to school. The school itself, in addition to being located on the UGB, is located at the intersection of two major roads, demonstrating a clear preference for automobile access and efficiency. Third, when looking at where the walking/biking students live compared to students who do not walk/bike often within this 1.50-mile zone, it is clear that the two groups are somewhat intermingled. That is, children who walk/bike to school live in very close proximity to children who do not, indicating perhaps that it is not clear to parents or their children that there are safe routes to school. In these mixed areas, perhaps ideas of a walking or biking school bus (or walkpool/bikepool), where groups of children walk or bike to school as a group, might help children or parents who may be hesitant to use that mode given the urban infrastructure barriers.

Table 5 provides some quantitative interpretations of the maps above, giving yet another set of indicators to the appropriateness of the mobility infrastructure to walking and biking to school. (As a reference for two of the figures in Table 5, the intersection density within half a mile of the Gresham Transit Center in Portland, OR (a relatively low-density area), is 145 intersections per square mile (Schlossberg *et al*., 2004), whereas that for the area surrounding Sky View is much lower at 32 intersections per square mile.) For the Pedestrian Catchment Area (PCA), a score of 0.50 or above indicates that the area has decent walkable coverage; in the Sky View case, the score of 0.38 accurately reflects the poor walking environment surrounding the school.

TABLE 5. Sky View Area mobility infrastructure—quantitative analysis

Roads (miles)	
Major roads	12.81
Minor roads	35.21
Minor to major road ratio	2.75
Intersection density (per square mile)	
Good intersections	31.504
Good intersection—minor roads only	21.92
Dead ends	18.67
Dead ends—minor roads only	25.04
Intersection to dead end ratio	1.70
Intersection to dead end ratio (minor roads only)	0.86
Pedestrian Catchment Area (PCA)	0.38
Impeded Pedestrian Catchment Area (IPCA)	0.00

Conclusion

Concerns about trends in school siting and accessibility are growing; schools located on the periphery of communities where there is low-density housing and limited connectivity place added transportation burdens on city infrastructure and require cities, school districts and families to rely on bussing or car transport for students. Planners and advocates for smart growth express concern that these ‘sprawl schools’ can exacerbate broader urban challenges, such as inefficient land-use patterns and social inequality (Passmore, 2002).

The mode students use in travelling to school is impacted by site locations. Not only does total distance from school impact the mode children use; urban form, convenience and personal requirements impact mode choice. In this study, 41% of children who live within 1.50 miles are driven to school alone by a parent, while only 6% walk. Parents of these children cited ‘convenience’ as the primary reason why they drive their children to school. Convenience may also explain the differences in travel modes on the trip home from school for those living within 1.50 miles of school. On the way home, when it is often more inconvenient for parents to pick children up, 25% of children walk home and another 25% bike home at least three times per week—despite the poor infrastructure for these modes.

Despite the preference for convenience, almost all parents living within 1.50 miles of school that were surveyed would be willing to have their children walk or bike to school, dependent on one or two main criteria. The primary way they would feel comfortable having their children walk or bike would be if they travelled to school in a group. Such escorting does not necessarily need to involve a parent, although chaperone-led groups of cyclists or walkers were supported. The other prerequisite for allowing their children to walk or bike to school is an improvement in the mobility infrastructure relating to these two modes of travel. Parents desired a safer infrastructure that better caters to the needs of pedestrians or young cyclists.

Looking at the mobility infrastructure, the series of GIS-based visual and quantitative analyses show that the street network clearly provides an impediment to non-auto modes of travel. Sky View Middle School can only be accessed by travelling along streets designated as major, auto-dominant roads. No minor roads are available to access the school, thereby forcing students to compete with high-speed, heavy-car-volume streets. Beyond this classification of street type, the mobility infrastructure surrounding the school is also less than ideal from a pedestrian point of view. Within the UGB, the street network is characterised by poor connectivity—more so if one considers auto-dominant roads removed from the potential pool of walking paths. And since the school is located literally on the urban fringe, right on the UGB, there is by definition little community access on one side of the school because development is mostly restricted outside of the UGB.

Clearly, there are several reasons why children do not walk or bike to school beyond the physical infrastructure and urban form. However, when schools such as Sky View Middle School choose to locate at the urban fringe and on arterial highways, the capacity for children to walk or bike to school is severely restricted. In other areas of land-use and transportation planning, big-box, urban-fringe development is being questioned and Smart Growth initiatives are emerging to counterbalance the sprawling development trend of the last 60 years. From a transportation perspective, it is probably time for the trend in school siting decisions to be equally questioned.

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