TAKING THE PULSE OF ACTIVE TRANSPORTATION

MEASURING THE BUILT ENVIRONMENT FOR HEALTHY COMMUNITIES

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1 INTRODUCTION AND BACKGROUND

A growing body of research reveals significant links between built form, travel patterns and public health. In particular, people living in car-dependent communities with barriers to active transportation (i.e. walking, cycling, and other non-motorized modes) appear to get much less physical activity and are at increased risk of being obese and suffering from inactivity-related illnesses than their counterparts in more walkable communities (e.g. Brownson et al. 2001; Ewing et al. 2003; Frank et al. 2003; Frumkin 2002; Moudon et al. 1997; Powell et al. 2003; Ross 2000; Saelens et al. 2003; Shriver 1997).

For a more complete understanding of the built environment-physical activity-health connection in Nova Scotia, researchers, community groups, and policy-makers require access to reliable and locally specific data. In particular, researchers need to develop and test more effective ways to measure the built environment – the physical human-made structures and infrastructure that we use and inhabit every day – with special consideration to those elements that exert the strongest influence on physical activity.

The Province of Nova Scotia recently launched "Community Counts," an online database that provides public access to comprehensive socio-economic and health data for Nova Scotian communities.[1] The project aims to help decision makers come to informed decisions by providing them with detailed information on a range of household, social, income, health, labour, production, demographic, education, resource, and natural environment indicators. Currently, very few built environment indicators exist in Community Counts. This study aims to contribute to the development of such indicators for inclusion in the database.

A comprehensive examination of all aspects of the built environment as they affect the wide range of human activities would require a massive undertaking. As such, this study focuses on factors that most strongly influence the decision to walk or bicycle for transportation purposes. It then presents the evaluation of 121 potential indicators intended to measure active transportation related factors such as the existence of safe and convenient walking or cycling routes that directly connect to a variety of nearby community destinations. The study concludes with recommendations to include 15 active transportation related built environment indicators in Nova Scotia's Community Counts database.

For additional background information on physical activity, health, active transportation, the built environment, and indicators see Appendices B, C, and D.

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[1] The Community Counts database is accessible online at: www.gov.ns.ca/finance/communitycounts

1.1 Goals & Objectives

The **primary goal** of this study was to research and propose built environment indicators for Community Counts that best serve the needs of decision-makers, community residents, and researchers in Nova Scotia interested in the links between health, built form, and active transportation behaviour.

Five specific objectives guided the pursuit of this goal:

1. Review the state of knowledge about what aspects of the built environment encourage and discourage active transportation.

2. Review the indicators that have already been developed to measure active transportation related factors in the built environment and asses them according to the Nova Scotian context.

3. Propose active transportation indicators for Nova Scotia that would be most helpful to include in the Province's evolving Community Counts database.

4. Collect and compare data for these indicators from a sample of 4 Nova Scotian communities (Hopewell, Glace Bay, Spryfield, Halifax Citadel) in order to test the indicators and data collection techniques in the field.
5. Illustrate how the data might be applied in future research to refine our understanding of the connections between active transportation, obesity, and morbidity and the mechanisms that drive these connections in Nova Scotia;

6. Demonstrate through a public workshop how the data might be collected and used by local residents and community groups to help them make informed decisions and strengthen their advocacy position with decision-makers.

1.2 Background

The connections between physical activity and the built environment currently receive a great deal of public and media attention largely due to the striking connections made in 2003 between obesity and urban sprawl.

This connection was first confirmed in the landmark study where Reid Ewing et al. (2003) developed a "sprawl index" and used it to rank 448 U.S. counties and 83 metropolitan areas in an effort to determine the relationship between urban sprawl, physical activity, obesity, and morbidity. They found that there were "small but significant" associations with minutes walked and hypertension. More importantly, residents of sprawling counties were likely to walk less, weigh more, and have greater prevalence of hypertension than residents in compact counties.

Sprawl is a particular type of built form that has dominated North America over the past half-century. As high rates of car ownership and easy highway access allow more people to move further apart from each other and further away from their jobs, retail, and daily activities into uniformly spread out suburbs or sparsely populated rural areas, walking, cycling, and public transit become less viable means of transportation. This type of built form thus leads to a marked increase in automobile use (Ewing and Cervero 2001), a further decline in walking and cycling (Saelens et al. 2003; Sallis et al. 1998; Shriver 1997) and an overall decline in physical activity and community health more generally (Ewing et al. 2003).

The share of the population that Statistics Canada considers rural is nearly twice as high in Nova Scotia (36.7%) as it is for the rest of Canada (20.6%) (Peuter and Sorensen 2005). The built form of Nova Scotia's extensive rural areas makes it particularly difficult to promote walking and cycling for utilitarian travel – distances are simply too great. This challenge will only increase over the next 30 years as HRM proposes to direct 25% of their predicted 100,000 new residents to rural areas and 50% to equally automobile-dependent suburban areas (HRM 2005).

Although non-motorized modes account for few overall commute trips, a national survey (Go for Green/Environics 1998) found that 58% of Canadians walk and 26% of Canadians cycle for transportation at least sometimes. As shown in Tables 7-2 to 7-5 below, Atlantic Canadians are the least likely regional group to ever use walking (44%) or cycling (14%) for transportation although they are the most likely to agree that they would like to walk for transportation more often (88%). More than half (54%) of Atlantic Canadians would like to cycle more often as a mode of transportation. Clearly, then, there is a significant latent demand for active transportation in Canada and especially in Atlantic Canada.

1.3 Context for Current Study

Given this unmet demand for walking and cycling and the enormous health and community benefits associated with meeting this demand, Nova Scotia's Office of Health Promotion has prepared the "Nova Scotia Pathways for People Framework for Action" (2005) as a key document to guide active transportation policy and programming in the Province. The draft document calls for actions that fall under six categories: public education; policy and legislation; research and knowledge exchange; resource commitment; supportive social environments; and, of most interest to the current study, supportive physical environments -- defined as providing "physical environments where choosing active transportation is easy, safe, practical, and efficient" (2005: 9). One of the key principles of the framework is that "community design should support active transportation" (2005: 12).

In order to support implementation of the proposed active transportation framework, this study seeks to determine what built environment characteristics make choosing active transportation easy, safe, practical, and efficient and then proposes indicators to track these characteristics. *Section 2*, below, presents an overview of findings from the empirical literature. *Section 3* evaluates and discusses potential indicators for Community Counts based on findings from the literature and an assessment of the Nova Scotia context. *Section 4* offers conclusions and recommendations. For more details on this study's method, see Appendices A and B.

2 LITERATURE REVIEW
THE BUILT ENVIRONMENT & ACTIVE TRANSPORTATION

Academic and popular interest in the built environment-physical activity-health connection has surged in recent years. This new energy has led to partnerships between public health and planning professionals and has established a new interdisciplinary field in its own right which, while still in its infancy, has at its core a belief that the design of the built environment plays a key role in shaping its residents' physical activity levels and health outcomes. The validity of this belief, however, is still the subject of much debate as the literature review below reveals.

In order to recommend the most appropriate active transportation-related built environment indicators for inclusion in Community Counts, this study first reviews the literature examining built form impacts on walking, cycling, and other non-motorized transportation modes. While a broad range of research was considered in this review, thirty empirical studies were particularly useful as their research designs enabled them to make conclusions about statistically significant relationships.

As a recent report by the Ontario College of Family Physicians' (2005) discovered, very few Canadian studies have been conducted to date. The literature review that follows, then, draws primarily from American sources with special attention to instances where Canadian studies are available.

Research so far consists entirely of correlational or cross-sectional studies (which examine a sample at one point in time). Unlike longitudinal studies (which follow a sample through time), correlational studies cannot establish cause-effect relationships. Instead the literature described below can only establish statistically significant relationships between variables and suggest avenues for further examination.

Studies come from two main disciplinary backgrounds – transportation planning and health promotion. Studies from the travel behaviour literature tend to focus on walking and cycling for utilitarian trips. Studies from the physical activity literature have traditionally considered walking and cycling for recreation although have more recently begun to consider utilitarian physical activity as well (e.g.; Sallis et al. 1997, 1998; Ross 2000; Craig et al. 2002; Giles-Corti and Donovan 2002).

The built environment impacts active transportation differently than leisure time physical activity. For instance, while design, aesthetics, sociability and personal safety influence the choice to walk or cycle around the block for exercise (e.g. Hovell et al. 1989) these factors exert little influence on the decision to walk or cycle to work or for errands (Humpel et al. 2002). Given this study's focus on active transportation, the literature review below focuses on those studies that consider walking and cycling for utilitarian purposes and does not explore in any detail the extensive literature on walking and cycling for leisure-time exercise.

Nearly all studies concur that two fundamental elements of the built environment – "density" and "land use mix" – are positively correlated to walking or cycling for utilitarian trips (e.g. the greater the density and mix of uses, the greater the number of non-motorized trips). Both "density" and "land-use mix" are ultimately connected to "access" (distance and convenience to destinations) which is overwhelmingly cited as the primary barrier to active transportation. Traffic safety appears to influence cyclists more so than pedestrians, while design and aesthetics do not exert a statistically significant influence on non-motorized transport nor, for the most part, does fear of crime.

It is difficult to identify the particular contributions of specific built form elements since they tend to be interrelated. For instance, a low density neighbourhood also tends to have fewer different land uses and fewer sidewalks while a higher density neighbourhood tends to have more sidewalks and a wider variety of land uses – a phenomenon Saelens et al. (2003) refer to as "spatial multicollinearity." Because of spatial multicollinearity, some researchers use indices to represent multiple complementary features at once. For example, Krizek (2000) developed a "Less Auto-Dependent Urban Form" (LADUF) rating composed of land use mix (number of employees of selected types), density (housing units and persons per sq. mi), and connectivity (average block area). He found that the percentage of all trips made by walking, cycling, and transit in high LADUF neighbourhoods was 29% compared with 14% in medium LADUF neighbourhoods and 6% in low LADUF neighbourhoods.

Despite the research design challenges, most studies attempt to separate out the independent effects of neighbourhood characteristics on active transportation. The following sections explore each of the relevant characteristics in more detail.

2.1 Distance and Time

The National Active Transportation Survey (Go for Green/Environics 1998) found that a vast majority of Nova Scotians (88%) and Canadians (82%) would ideally like to walk as a mode of transportation more often but a number of barriers prevent them from realizing this desire. Canadians overwhelmingly cite "distance" (47%) as the primary barrier followed by "time" (19%), which is ultimately a function of distance (e.g. far away destinations require more travel time). For nearby destinations walking and cycling travel times are relatively competitive with automobile travel times when factors such as parking are considered. As destinations get further away, however, the travel time difference between motorized and non-motorized modes grows exponentially. This time gap is more pronounced for pedestrians who travel at approximately 5 km/h at a moderate pace than it is for cyclists who can travel at approximately 15 km/h at a moderate pace (FHWA 1994).

There is, of course, an upper limit to the time that individuals are willing to invest in different travel modes. Through a mail-out survey, Hawthorne (1989) found that Ontarians are willing to walk a little over twenty minutes for trips to work and about the same time for errands. At an average walking pace of 5 km/h, this time translates into a trip distance of approximately 1.66 km.

A survey by the Municipality of Metropolitan Seattle (1991) found similar thresholds, with 40% of residents reporting a maximum suitable walking distance for errands of one mile (1.6 km) or less and 70% reporting two miles (3.2 km) or less.

The Go for Green/Environics survey (1998) found that 70% of Canadians would be willing to bike to work if there were dedicated bicycle lanes that could get them there in under 30 minutes which translates into a distance of roughly 7.5 km. The same survey reported that among the 58% of Canadians who walk at least some of the time as a mode of transportation, the average one-way trip distance is 3.2 km. In many European countries, however, active transportation trip distances are much greater indicating that differences in the social and built environments can have an impact on willingness to travel further by non-motorized modes (Pucher and Lefevre 1996).

Table 2-1 – Attitudes Toward Walking as a Mode of Transportation – 'Agree' (%)
(Go for Green/Environics 1998: 6).

	Canada	Atl	Que	Ont	Man	Sask	Alta	BC
Never Have Time to Walk	31	35	27	38	27	29	32	32

After Ontarians, Atlantic Canadians are the second-most most likely regional group to agree (35%) that they don't have the time to walk (see Table 4-1). Bringing more destinations closer to where people live would reduce both "distance" and "time" and would thus reduce the primary barrier to active transportation identified by 66% of Canadians.

Several empirical studies reveal strong negative correlations between distance and the choice to use non-motorized modes for any trips (Cervero and Duncan 2003) and for school trips in particular (EPA 2003). The number of walking trips to commercial areas is negatively correlated with both street network distance to the nearest commercial area (Handy and Clifton 2001) and straight-line distance (McCormack et al. 2001).

2.1.1 Distance Costs and Induced Travel

There is some dispute over the conclusion that shorter trip distances yield higher levels of walking and cycling. Crane (1996a, 1996b, 2000) argues that shortening distances may not increase active transportation and may, in some cases, actually lead to an increase in car trips. He argues that the decision to make a trip is based on a rough cost-benefit analysis where the individual considers factors like the time it takes to travel, the amount of congestion and stress she is likely to encounter, and the dollar cost of one mode relative to the others. Increasing the proximity of destinations may reduce the cost of travel by car more significantly than it reduces the cost of travel by foot or bicycle and thus increase car trips. Crane (2000) suggests that neighbourhoods with high street connectivity generate both more pedestrian as well as more automobile-based trips since the well-connected and higher efficiency street system imposes fewer time or distance costs on both modes of travel.

Crane's observations add another layer of complexity to the "distance" variable suggesting a need to lower distance costs for active transportation modes while maintaining or increasing distance costs for motorized modes (e.g. pedestrian-and-bicycle-only connections). Ultimately, though, reducing trip distance is an absolute requirement to facilitate increased active transportation levels. Building at higher densities is one strategy to shrink distances between destinations.

2.2 Density

Typically, higher densities of people mean higher densities of destinations. More destinations lead to a higher likelihood that one's destination of choice – or at least a satisfactory destination – will by within walking or cycling distance (Frank and Pivo 1994). Because destination density is more awkward to measure given the huge variety of possible destinations, researchers make extensive use of readily available population, household and employment density data as a reasonable proxy measure (Dunphy and Fisher 1994).

While some empirical analyses (e.g. EPA 2003; Krizek 2003) found no statistically significant relationship between density and the decision to walk or cycle, many more studies uncovered a strong positive correlation. Several studies found that as residential and retail density increased at both trip origin and destination the percentage of both work and shopping trips made by foot increased. (Frank and Pivo 1994; Greenwald and Boarnet 2001). In an analysis of the American Housing Survey, Cervero (1996) found that an individual's choice to walk or bike was positively correlated with the presence of mid-rise and high-rise multifamily housing within 300 ft. and negatively correlated with single-family housing within 300 ft. Results of a travel diary survey in Oregon show bicycle trips accounting for 2% of all trips in low density neighbourhoods (0-2 households/acre), rising to 10.4% of all trips in denser neighbourhoods (5+ households/acre) (Parsons Brinckerhoff Quade and Douglas Inc. 1993). A travel diary survey in San Francisco showed non-motorized modes taking a greater modal share of all trips as neighbourhood density increased (Kitamura et al. 1997).

There may be a critical threshold before density has any impact on active transportation. Doubling the household density in a sparsely populated rural county of Nova Scotia, for instance, would likely have little impact on walking and cycling behaviour. Once higher densities are achieved, however, the number of active transportation trips quickly rise (Dunphy and Fisher 1994; Frank and Pivo 1995). Frank et al. (2003) suggest that synergistic effects start to occur at 13 residents per acre – transit becomes more viable, driving becomes more expensive, and there are more destinations within walking and cycling distance.

Although density is a well-established correlate of walking and cycling, in many cases density may serve as a proxy indicator for level of transit service or demographic characteristics or ease of car use (Boarnet 2001; Dunphy and Fisher 1996; Frank and Pivo 1994; Schimek 1996). Ultimately, density may not have a significant independent effect

2.3 Land Use Mix

Land use mix can be understood as the degree to which different types of land uses are located within close proximity to one another. Land use mix is closely related to distance since a higher degree of mixing increases proximity between different uses and enhances the viability of active transportation. Mix can be measured at different scales from the building to the land parcel to the neighbourhood to the region. The neighbourhood scale provides the setting for most walking and cycling trips and is hence the scale of interest to this study.

There are several different ways to conceive of land use mix:

Proximity. Refers to distance between a given location and different activities. Proximity is often measured in the literature as distance from an individual's home to some specified non-residential land use, such as a commercial area.

Intensity. Refers to the volume of different uses and can be counted numerically as total number of different land use types and total number of facilities within each different land use type.

Distribution. Refers to the way different uses are spread across space. The literature suggests several ways to measure land use distribution including the three described below:

- **Balance Index**

  This index represents the degree to which two different land uses exist in balance with each other in a community. When the two uses are distributed evenly, the index is 1. If there is only one use in the community, the index is 0. This index is often used by planners to show the jobs-housing balance (Song and Rodriguez 2005).

- **Entropy Index**

  The entropy index measures the degree of similarity in land use mix between a given area and its larger regional context. A community with a land use mix mirroring that of the larger region would receive a score of "1". A community with totally different land uses or in very different proportions from the region would receive a lower entropy score. A number of studies have employed the entropy index to measure land use mix (Cervero 1989; Frank and Pivo 1994; Kockelman 1996)

- **Dissimilarity Index**

  The entropy index measures the presence or absence of land uses relative to the region but does not consider the type or intensity of mixing. A dissimilarity index is thus a useful complement (Kockelman 1996; Cervero and Kockelman 1997). This technique first divides the study area into a grid of one hectare squares and then assigns a predominant land use to each one. The index measures the dissimilarity of each square based on the predominant uses in its neighbouring squares. The average of all the scores represents the land use mix of the area.

Most studies that included land use mix, concluded that a variety of uses at both the origin and destination is positively correlated with walking and cycling (Hanson and Schwab 1987; Frank and Pivo 1994; Cervero and Duncan 2003). Analysis of a one-day travel diary survey in the San Francisco Bay Area found that the number of sales and service jobs within a 30 minute walk of trip origins and destinations as well as the heterogeneity of land use was correlated with adults' choice to walk or bicycle (Kockelman 1997). Craig et al. (2002) found that the number and variety of destinations significantly contributed to their pedestrian environment score which was positively correlated to walking to work. An in-person survey of adults in Perth, Australia found that having shops within walking distance of home is positively correlated with walking for transportation (Giles-Corti and Donovan 2002). There is some indication that perceived variety of stores may be just as important as actual variety of stores in the choice to walk to commercial areas (Handy and Clifton 2001).

A study using data from a comprehensive regional travel survey of metropolitan Seattle (Frank, Dumbaguh, and Leary 2002) found that the choice to walk for non-work travel is correlated to the number of different types of retail and commercial land uses near an individual's home and less a function of the actual amount of floor area devoted to nonresidential uses. In particular, the numbers of certain types of land uses within a ¼ mile (400 m) of home is correlated to walking for non-work travel. The number of *retail establishments*, *restaurants,* and *office buildings* near home showed the strongest correlations followed closely by the number of *schools* and *grocery stores*.

Drawing on the results of the Seattle study, Frank et al. (2003) suggest that the best indicator of land use mix should focus less on amount of commercial floor area in the community and instead on the absolute numbers of different commercial land uses within the community.

2.4 Transportation System/Infrastructure

Transportation systems consist of the sum of physical infrastructure (e.g. streets, sidewalks, transit, trails) that facilitate transportation in a region. Four dimensions characterize the quality of any transportation system: presence, connectivity, continuity, and condition (Frank et al. 2003).

Several studies pointed to the presence of sidewalks as a significant correlate of walking for transportation (e.g. Kitamura et al. 1997; Giles-Corti and Donovan 2002a; Sharpe et al. 2004). The EPA (2003) study on children walking to school found that walk trips were positively correlated with sidewalk coverage, measured as both the percentage of streets with sidewalks and average sidewalk width. Sharpe et al. (2004) indicate that sidewalk condition may also be significant.

The more intersections in the network, the more direct a route is likely to be from any one destination to any other. A grid street system presents more route choices and more direct route options than a curvilinear street system. Street connectivity and sidewalk continuity were significant in two separate travel diary surveys from Portland, Oregon (Parsons Brinckerhoff Quade and Douglas Inc. 1993; Greenwald and Boarnet 2001). The former study (1993) also found that steep inclines were especially negatively correlated to cycling as did Ashley (1989) and Cervero and Duncan (2003).

2.5 Safety

Physical activity and travel surveys often report "safety" as a barrier to walking and cycling although the nature of the perceived danger is not always well defined. In general, there are two principle types of safety concerns for pedestrians and cyclists: personal safety (e.g. crime) and traffic safety (e.g. motor vehicle traffic speeds, number of crosswalks). Each type is related to different features of the built environment and impacts differently on active transportation behaviour.

2.5.1 Personal Safety

Studies that focused on particular population sub-groups such as children and youth (Molnar et al. 2004), visible minorities (King et al. 2000), and the elderly (Booth et al. 2000)., found the strongest correlations between actual and/or perceived personal safety and levels of outdoor physical activity. Crime and fear of crime are likely more significant barriers to physical activity for women, and non-white women in particular (Evenson et al. 2002; King et al. 2000; Wilbur et al. 2002). While several studies associate personal safety and crime with lower levels of recreational physical activity, there is less evidence that personal safety has a significant impact on utilitarian walking and cycling.

2.5.2 Traffic Safety

Understandably, traffic safety is a concern for pedestrians and cyclists given their relative exposure to fast-moving vehicles. The Go for Green/Environics survey (1998) found that 53% of respondents see traffic safety as a barrier (especially to cycling). Atlantic Canadians are the most likely to agree (64%) that cycling is dangerous.

Table 2-2 - Attitudes Towards Cycling as a Mode of Transportation 'Agree'
(Go for Green/Environics 1998: 12)

	Canada	Atl	Que	Ont	Man	Sask	Alta	BC
Cycling is Dangerous	53	64	49	57	52	40	45	59

Traffic collision statistics in the United States show that pedestrians and cyclists suffer rates of traffic fatalities per 100 million trips that are two to three times higher than car drivers (Pucher and Dijkstra 2003). Traffic safety is clearly a legitimate concern.

Zeeger (1993) points to several potential factors that could contribute both to these high fatality rates and to the perception of risk including: an inadequate network of sidewalks and bicycle paths, dangerous intersections and crosswalks and poor lighting. Short traffic signal timing, wide streets, and inadequate median "refuges" increase risk especially to slower moving senior citizens (Dorfman 1997). Studies indicate an inverse relationship between pedestrian safety and high traffic speeds (Jacobsen et al. 2000) and the number of miles of arterial streets in a community (Levine et al. 1995).

2.6 Design and Aesthetics

Some theorists propose that site and streetscape design and aesthetics have a significant influence on pedestrian travel (Pedestrian Federation of America 1995; Southworth 1997). A household survey in Ontario (Hawthorne 1989) found that aesthetically appealing landscaping, trees, parks, and open space as well as pedestrian amenities such as the availability of shade on hot days; the presence of benches and places to rest, and perceived safety from crime may be factors in determining levels of participation in active transportation.

Table 2-3 – Attitudes Toward Walking as a Mode of Transportation – 'Agree' (%)
(Go for Green/Environics 1998: 6).

	Canada	Atl	Que	BC	Man	Ont	Alta	Sask
No Pleasant Places to Walk Near My Home	15	20	21	15	14	15	10	10

Empirical research, however, does not show any significant relationship between design and active transportation. Cervero and Duncan (2003) concluded that design features of the pedestrian and cyclist environment at both trip origins and destinations had no impact on the decision to use non-motorized modes. Craig et al. found that visual interest and aesthetics were the only neighbourhood characteristics that did not contribute significantly to their "environment score" which was otherwise strongly correlated with walk to work trips.

Ultimately, few studies have been conducted on this subject perhaps because of the difficulty involved in measuring the many qualitative and subjective factors that make up urban design.

2.7 Differences Between Modes

Although walking and cycling are often grouped together, they involve different infrastructure and user characteristics and hence different factors influence the decision process (FHWA 1999). Those traveling by skateboard, roller-skates, manual wheelchair or push scooter also each have their own needs and characteristics. For example, in many places cyclists are not allowed on sidewalks and pedestrians and skateboarders are not allowed on roadways. Pedestrian trips tend to be shorter and slower than bicycle trips and a large percentage are actually trips to access other modes such as transit. Since most able-bodied people already know how to walk, the decision to ride a bicycle for transportation involves a "greater conceptual leap" (FHWA 1999: ch.2) than the decision to walk for transportation.

These differences might make cyclists more concerned about facilities for safety and pedestrians more concerned about streetscape design details. Given their smaller wheel diameters and weaker braking capabilities, roller-skaters and skateboarders might be more concerned about pavement condition and steep grades. Most studies tend to group all non-motorized modes together in one category – especially if they are drawing on travel survey data that did not separate the different modes. This grouping may hide some significant features unique to one mode and hence should be avoided whenever possible.

2.8 Non-Built Environment Influences

Ultimately, non-built environment factors tested in many of the studies – such as personal attitudes, vehicle ownership, climate, policies that restrict auto use, and overall attractiveness of other modes – may exert a stronger influence on active transportation than any elements of the built form discussed above. A supportive built environment is not necessarily sufficient to induce higher levels of walking and cycling. However, even in studies finding attitudinal and lifestyle factors as the most significant influence on active transportation (Kitamura et al. 1997; Bagley and Mokhtarian 2002; Giles-Corti and Donovan 2002), the built environment still plays a facilitating, although indirect, role.

The problem of "self-selection bias" means it is difficult to determine whether people are more likely to walk to work because of a supportive built environment or because of personal lifestyle preferences that favour walking and hence also favoured living in a walkable neighbourhood (Craig et al. 2002). Lifestyle and attitudinal factors have generally not been considered in the travel behaviour literature.

In the fist major study to account for attitudinal factors, Bagley and Mokhtarian (2002) found that a devoted car-driver transplanted from the suburbs to a walkable urban neighbourhood will increase their levels of walking, but only moderately. Meanwhile, a suburbanite walking enthusiast transplanted to the same more walkable urban neighbourhood will significantly increase their levels of walking.

This finding makes intuitive sense. Pedestrian unfriendly single-use residential suburbs make walking to many destinations impossible, even for walking enthusiasts, by virtue of the long distances involved. Building more walkable communities with many well-connected nearby destinations allows those individuals predisposed to walking and cycling to use these modes more frequently but a supportive built form may not alone entice avid car-drivers out of their cars. For most people, then, the built environment plays a facilitating role, either encouraging or discouraging active transportation behaviour in concert with a host of other mediating variables.

3 FINDINGS & DISCUSSION

3.1 The Indicators

From a review of the literature, this study identified 144 potential active transportation related built environment indicators. Potential indicators were passed through a series of 4 filters before proceeding to the indicator evaluation process. Indicators were removed from consideration if:

- there was a **lack of empirical evidence** showing its correlation to active transportation;
- they were incapable of offering **relative comparisons** between communities;
- they were unable to be measured with **objectively collected** data;
- they were oriented to the **individual** rather than a community-wide measure.

For more detail on each of these filters and to view the list of indicators that were screened out, see Appendix F.

After passing potential indicators through these filters, the 121 remaining candidates were evaluated on a 3 point scale for each of the following 8 criteria. In each case, a score of 1 represents disagreement with the statement below the criterion, a score of 2 represents partial agreement, and a score of 3 represents full agreement:

1. *Representative* - The indicator is representative of a broad range of built environment elements that relate to active transportation or can act as a proxy for several other indicators.
2. *Data Availability* - Data for the indicator is readily available for Nova Scotia.
3. *Data Reliability* - Data for the indicator is collected in Nova Scotia in ways that ensure a high degree of reliability.
4. *Ease of Data Collection* - Collecting data for the indicator is relatively easy and not unduly time-consuming, labour-intensive, or expensive
5. *Frequency* - This indicator is updated as frequently as required to maintain valid data.
6. *Useful for Decision-making and Program Administration* - The indicator is effective at measuring policy-performance and evaluating programming outcomes.
7. *Attractive to Public* - The indicator is understandable, credible, expressive and has resonance with the media and the wider public.
8. *Useful for Researchers* - The indicator is easily adapted into research studies examining connections between physical activity and the built environment.

Appendix G presents the result of this assessment in the form of an evaluation matrix. Several indicators scored consistently well across all categories. Section 3.2 below discusses the recommended indicators in more detail including their potential application, available data sources and any notable data limitations.

3.2 Population & Household Density

Recommended Indicators

- The number of residents per square kilometer of inhabited area (ecumene).
- The number of households per square kilometer of inhabited area (ecumene).

Application

Density is a fundamental dimension of land use and is strongly correlated to walking and cycling in the literature. The higher the density, the more likely residents are to use active transportation.

Issues

Density indicators require that a boundary be delineated. Most density figures in use today rely on existing, and often arbitrary, boundaries of census tracts or municipal borders. Calculations of density within some existing political borders tends to give an inaccurate picture of actual settlement patterns. The gross density figure may incorporate vast tracts of backcountry, as it does for many Nova Scotia census tracts, yet make it appear as though population were uniformly spread over the entire area.

Net density (density on inhabited land) provides a more accurate spatial picture of actual land use and is a more useful indicator of potential walking and cycling behaviour. Net density is calculated by using GIS to draw a line around the outermost civic address points (minimum bounding polygon) at a chosen geographic scale (e.g. community). Geographers refer to the resulting shape as the "ecumene." The length and width dimensions of the ecumene can also be measured to provide a sense of settlement configuration pattern (e.g. long strip vs. compact centre).

Data Source

Community Counts already uses civic address points from the Nova Scotia Civic Address File (NSCAF) extensively. To create the ecumenes, Community Counts would need to manually draw the ecumene boundary around the outermost civic address points in each community. Protocols for buffer widths etc. would need to be developed in order to ensure consistency across each community. See Appendix X for examples of ecumene boundaries in the four test communities.

Present Data Limitations

While population ecumenes have not yet been generated for Nova Scotia, there are no significant barriers to doing so. All of the required data currently exists at Community Counts.

3.3 Retail Jobs Density

Recommended Indicators

- The number of retail jobs per square kilometer of ecumene area.

Application

Population, employment, and retail densities together provide a simple portrait of land use balance. Employment density provides a picture of the extent to which the community is a commercial and employment center and hence the destination for commute trips. However, retail employment density is a good proxy for extent and intensity of retail shopping in the community which is strongly correlated to increased levels of active transportation.

Issues

As above, net density is a preferable measure to gross density.

Data Source

The Census provides employment figures, including retail employment, to the Census Subdivision level.

Present Data Limitations

Census Sub-Divisions, which often incorporate several communities, are too large in scale to be useful for analysis of walking and cycling which are local phenomena. Ideally Statistics Canada would release smaller-scale employment figures. CSD level data may be used as an interim measure.

3.4 Land Use Mix – Proximity

Recommended Indicators

- The percentage of residential dwellings within 2.5 km (walking distance) and 8 km (cycling distance) of the following building uses: retail sales, food and beverage, business/office, neighbourhood schools and grocery stores.

Application

These indicators are reasonable proxies for distance to destinations – the primary barrier to active transportation. Knowing how many dwellings are within walking and cycling distance to different destinations provides a snap-shot of current potential demand for active transportation.

Issues

The Go for Green/Environics survey (1998) found that 2.5 km and 8 km were the maximum reasonable distances people were willing to travel on foot and on bicycle respectively. As these figures represent average upper thresholds, many people may not be willing to travel this far under human power. Ideally, then, several concentric buffers would encircle each destination at 0.5 km intervals, capturing the percentage of the population within 0.5 km, 1 km….7.5 km and 8 km of the given land use.

Data Source

The building use field in the Nova Scotia Civic Address File (NSCAF) was populated with field survey data collected by Provincial consultants between 2000 and 2002. The data is still reasonably current and many municipal units are making an effort to keep their information up to date. Building use is coded according to the three-level Nova Scotia Standard Land Use Classification System (see Appendix H for more details). This classification system permits a remarkable degree of specificity at the tertiary level, even distinguishing between different types of grocery stores (e.g. farm market, food, liquor, pharmacy, specialty). As a result, Community Counts is able to integrate highly detailed and relatively reliable building use data in a GIS for the purposes of calculating the land-use mix indicators recommended above.

Present Data Limitations

Halifax Regional Municipality maintains its own civic addressing file (HRMCAF), separate from the centrally housed NSCAF used by every other municipal unit in the Province. HRM has not yet conducted a survey of building use and so this field remains blank in the database. Civic addressing officials at HRM are concerned that once surveyed, they would have no mechanism in place to keep the data current and as a result they are reluctant to expend the vast amount of time and resources required to complete the initial inventory. Nevertheless, HRMCAF officials believe funding may be available to survey building uses within the next 3-5 years (Helm 2005). Until this time, land use mix indicators on Community Counts will not be able to show results for HRM.

Every other municipal unit is responsible for keeping their own civic address data up to date by remotely connecting to the NSCAF website hosted by Service Nova Scotia & Municipal Relations. In order to determine whether building use data was being kept current by the responsible municipalities, this study conducted an informal e-mail survey of the 23 planning departments and commissions in Nova Scotia. From the 16 responses, nine planning departments reported that they were making efforts to keep NSCAF building use data up to date primarily through occasional visual surveys. Seven planning departments reported that they currently have no intention or capacity to keep their building use data up to date. These survey results suggest that as time goes on the building uses entered in 2001 by the original contractors will become increasingly less accurate.

3.5 Land Use Mix – Intensity

Recommended Indicators

- Number of different types of commercial land uses in an area

Application

This simple indicator measures the variety of commercial land uses in an area – a feature that has been identified as the most significant built environment influence on walking for non-work travel (Frank, Dumbaguh, and Leary 2002).

Issues

The distinction between different "types" of commercial uses must be clarified for this indicator to have any meaning. Employing the same types as those set out in the Nova Scotia Standard Land Use Classification System would be the most convenient and reasonable option.

Data Source

Building use data in the Nova Scotia Civic Address File (NSCAF) as described above.

Present Data Limitations

As discussed above, HRM currently lacks building use data in their civic address file which limits province-wide comparative analysis potential.

3.6 Land Use Mix – Distribution

Recommended Indicators

- Entropy Index
- Dissimilarity Index

Application

While mathematically complex to the layperson, the entropy index and dissimilarity index are reportedly easily calculated via a GIS (Song and Rodriguez 2005) which is why they have recently become popular indicators of mixed use in the planning literature. These indices provide a useful picture of the relative balance of land uses in a community compared with the region and an assessment of the evenness of spatial distribution of uses across a community. For technical details and formulas for these indices see Krizek 2003.

Issues

These indices do not communicate their message very clearly to the layperson – some technical knowledge is required to interpret the results. Any necessary background information could be provided in an explanatory document on the Community Counts website.

Both of these indices require the division of communities into a series of smaller zones ranging in size from the block level to the transportation analysis zone level. Accomplishing this task for the entire Province will be time-consuming. Assigning predominant land uses to each of these smaller zones will be even more laborious. The literature suggests, however, that these indices are effective measures of land use mix and as land use mix is one of the strongest predictors of non-motorized travel, this study recommends pursuing the development of the entropy index and dissimilarity index.

Data Source
Building use data in the Nova Scotia Civic Address File (NSCAF) as described above.

Present Data Limitations
As discussed above, HRM currently lacks building use data in their civic address file which limits province-wide comparative analysis potential.

3.7 Infrastructure – Presence

Recommended Indicators
- Ratio of sidewalk/path km to street center line kilometers

Application
In much of Nova Scotia, from suburban Halifax to rural Guysborough, streets and roads lack sidewalks or roadside paths of any kind thus discouraging pedestrian and other non-motorized travel. This indicator is able to gauge the balance between pedestrian and motorized infrastructure.

Issues
In many rural areas, sidewalks are too expensive and are not a feasible option. Should roadside trails, snowmobile or ATV paths or paved road shoulders be considered as pedestrian supportive infrastructure in these cases? To what basic standard of non-motorized infrastructure provision should Nova Scotian communities aspire? Further discussion needs to occur before finalizing the terms of this indicator.

Data Source
Detailed local infrastructure data is currently not maintained at a provincial level and would need to come from the individual municipal units.

Present Data Limitations
While HRM maintains an extensive digital sidewalk inventory as do several other Nova Scotian towns, this data is either not available or not yet digitized for many municipalities. Judging from the rapid growth of GIS in Nova Scotia and in general, this study predicts that the majority of municipal units in this Province will be GIS-equipped within the next 5 years. In the interim, this indicator could be displayed on Community Counts for those municipalities with digitized sidewalk data.

3.8 Infrastructure - Connectivity

Recommended Indicators

- Motorized & non-motorized connectivity index

Application

Distance between destinations is the most significant barrier to active transportation. A well-connected system of non-motorized infrastructure (e.g. sidewalks, trails, pedestrian friendly streets) helps to minimize the network travel distance by facilitating more direct routes. The connectivity index is calculated by dividing the total number of street segments (street lengths between intersections) by the total number of street nodes (intersections or dead-ends) (Ewing 1996). A higher index means that travelers have increased route choice, allowing for more direct connections between any two points. A perfect grid network scores a 1.5. Ewing (1996) recommends a score of at least 1.4 to ensure walkability. A reduced connectivity score for motorized traffic enhances the attractiveness of non-motorized modes. It is hence important to compare both figures.

Issues

The connectivity index also does not communicate its message very clearly to the layperson. Users require some technical knowledge which could appropriately be offered on the Community Counts website.

Data Source

The street center line file for Nova Scotia is readily available courtesy of the Nova Scotia Geomatics Center.

Present Data Limitations

Currently, the Nova Scotia street center line file cannot identify nodes and segments. As a result, the illustrative connectivity index for the test community of Spryfield (see Appendix I) was developed and calculated manually. Purchase of appropriate GIS software may enable Community Counts to conduct automated connectivity index calculations.

3.9 Modal Split - Output

Recommended Indicators

- Modal split for each of the following four trip categories:
  - Journey to Work
  - Journey to School
  - Non-Home Based Trips
  - Home-Based Discretionary Trips

- Modal split should count the following nine modes:
  - % car/truck/van to work (driver)
  - % car/truck/van to work (passenger)
  - % public transit to work
  - % walk to work
  - % bicycle to work
  - % motorcycle to work
  - % taxicab to work
  - % 'other non-motorized' to work
  - % 'other motorized' mode to work

Application

Each of the previous recommended indicators measures an "input" - an element of the built environment that impacts active transportation. In order for policy-makers, the public, and researchers to understand the nature of the built form-travel relationship, the "output" side of the equation must also be accurately measured. Reliable and detailed "output" data allow the various stakeholders to evaluate the effectiveness of different built form interventions, monitor travel trends over time and relate them to changes in the built environment, and develop more targeted active transportation programs.

Data Source

In other jurisdictions, this type of detailed travel data is collected through mail-out or phone surveys. Every five years, a University of Toronto group (Data Management Group 2001) coordinates a large scale Greater Toronto Area travel survey to coincide with the Census mail-out period.for the Greater Toronto Area of the travel surveys such as is collected through extensive is through a comprehensive Provincial

Present Data Limitations

Nova Scotia currently relies on Journey to Work data from the Census. However, these trips capture only a fraction of the total trips that most people make. In the United States, commuting to work accounted for only 15% of all trips. Furthermore, non-work trips could differ in significant ways from journey to work trips. To understand the full range of active transportation behaviour, Nova Scotia needs an expanded travel survey. Such an ambitious data collection project may be prohibitively expensive and so alternative delivery mechanisms should be sought.

4 CONCLUSION & RECOMMENDATIONS

The Government of Nova Scotia has recognized the tremendous health potential of active transportation and is the only province in Canada with a provincial-level active transportation program – "Pathways for People." One of the goals of Pathways for People is to create physical environments where choosing active transportation is easy to do. Exactly what that physical environment might look like is still the subject of some debate in the planning, physical activity and travel behaviour literature.

A survey of that literature did reveal, however, some fundamental dimensions of the built environment that most researchers agree are positively correlated to active transportation: 1) population and retail density; 2) land use mix; and 3) the presence of well-connected non-motorized transportation networks

Based on these findings this study proposes a set of 15 built environment and travel indicators for inclusion in Community Counts. The data that will one day hopefully populate these indicators will help guide future urban form interventions and will help measure progress towards walkable, bikeable communities. The data can be used by citizens to learn more about their own communities and advocate for the changes they want to see. Finally, these indicators will be useful for future research. To date, there have been no longitudinal studies conducted on the links between the built environment and active transportation, owing primarily to a lack of continuously updated, objectively collected built environment databases against which to measure a population through time. Implementation of the indicators recommended in this study will enable researchers to use Nova Scotia as a living laboratory for ground-breaking physical activity and travel research.

1. This study recommends that the following 15 indicators be adopted as core measures of the built environment on the Community Counts website:

    - The number of residents per square kilometer of inhabited area (ecumene).
    - The number of households per square kilometer of inhabited area (ecumene).
    - The number of retail jobs per square kilometer of ecumene area.

    - The percentage of residential dwellings within 2.5 km (walking distance) of the following building uses: retail sales, food and beverage, business/office, neighbourhood schools and grocery stores.
    - The percentage of residential dwellings within 8 km (cycling distance) of the following building uses: retail sales, food and beverage, business/office, neighbourhood schools and grocery stores.
    - Number of different types of commercial land uses in an area
    - Entropy Index
    - Dissimilarity Index

    - Ratio of sidewalk/path km to street center line kilometers
    - Motorized connectivity index
    - Non-motorized connectivity index

- Journey to work – modal split
- Journey to school – modal split
- Non-home based trips – modal split
- Home-based discretionary trips – modal split

This study also recommends the following:

2. The "Pathways for People" Framework for Action should be adopted as Provincial Policy. The proposed indicators in this study should form the basis for regular evaluation of progress towards realizing the "supportive physical environment" goals set out in the Framework.

3. A system of regular municipal land use reporting to Service Nova Scotia & Muncipal Relations should be implemented. The land use reports should include any updates on new and old non-motorized networks (sidewalks, trails etc.) so that accurate connectivity data can be maintained in Community Counts.

4. The Province of Nova Scotia should negotiate with Statistics Canada to gain access to smaller scale employment data, at levels below the census subdivision.

5. A more extensive Province or Maritime-wide travel and household activity survey should be conducted every five years in conjunction with the Census. This survey should collect information about journey to school trips, non-home based trips, and discretionary home-based trips as well as socio-economic information.

5 APPENDICES

5.1 Appendix A – Study Question, Purpose, Objectives

5.1.1 Study Question

What built environment indicators will be most useful to community residents, researchers and decision-makers in Nova Scotia interested in the links between health, built form, and active transportation behaviour and, as such, should be included in the "Community Counts" database?

5.1.2 Study Purpose

This study recommends for inclusion in Community Counts a set of indicators measuring those elements of the built environment that most influence active transportation. These indicators will serve the interests of diverse stakeholders in Nova Scotia including: policy-makers, community organizations, and academic researchers.

(a) Indicators to Facilitate Decision-Making and Program Management

In order to make informed and evidence-based choices, decision makers at all levels (community group leaders, civil servants, politicians) need access to the right indicators populated with reliable data. Effective indicators help decision-makers and managers evaluate active transportation programs, policies, and built form interventions. Indicators also help to measure progress against stated targets and goals and against other jurisdictions.

For instance, through the "Pathways for People" initiative, the Office of Health Promotion has shown leadership in striving to create a climate in which active transportation opportunities are valued and supported across Nova Scotia. Incorporating the proposed built environment and active transportation indicators into Community Counts will provide an objective assessment of how well active transportation is, in fact, being supported in each of Nova Scotia's 278 communities.

(b) Indicators to Engage and Empower Communities

Good indicators can help convey complex built environment and land use information in an attractive way that helps to engage the wider public in the promotion of active transportation. Providing people with access to relevant information about the built form of their communities is an empowering process that equips residents to participate in the political process and better advocate their positions to decision-makers.

(c) Indicators to Enable Future Scientific Research

To date, the active transportation-built environment literature consists mostly of survey-based cross-sectional studies that examine active transportation and built environment samples at one point in time. Standardized built environment indicators are not commonplace and so researchers must collect their own, often inferior, datasets through surveys or field visits.

Providing reliable and regularly updated data in Community Counts enables researchers to employ built environment indicators in future Nova Scotia-based research without having to first laboriously develop their own datasets. Keeping track of built environment changes over time also facilitates more effective longitudinal research which is necessary to establish causal connections between the built environment and active transportation.

5.1.3 Study Objectives

This study seeks to:

1. Review the state of knowledge about the aspects of community design and transportation systems that encourage and discourage physical activity and active transportation;

2. Review the different indicators that have been developed to measure active transportation related factors in the built environment and asses them according to Nova Scotian context.

3. Propose active transportation indicators for Nova Scotia to include in the Province's Community Counts database;

4. Collect and compare data for these indicators from a sample of 4 Nova Scotian communities:
    - Pictou County (rural municipality)
    - Glace Bay (small town/urban agglomeration)
    - Spryfield (suburban)
    - Halifax Citadel (urban)

    in order to test the indicators and data collection techniques in the field, and to provide near-complete data sets to the four case study communities.

5. Based on the data gathered in these four case study communities:

    - Illustrate how to apply the data in future research to refine our understanding of the connections between active transportation, obesity, and morbidity and the mechanisms that drive these connections in Nova Scotia;

5.2 Appendix B – Method

5.2.1 Indicator Identification

Using traditional print and electronic resources available to users of Nova Scotia university libraries, a literature review was conducted using search terms such as "Urban Sprawl AND Health", "Built Environment AND Health", and "Active Transportation AND Health." From this literature review, which included diverse sources focused on a wider range of issues, the current state of research and knowledge about built environment impacts on active transportation was summarized. Using the same method, an additional literature review on "indicators" using search terms such as "Sustainability Indicators", "Travel Behaviour Indicators", "Sustainable Transportation Indicators," and "Built Environment Indicators" was conducted. From this literature review, which will drew from a range of disciplines and sources, a list of potential indicators for measuring active transportation related components of the built environment was prepared.

5.2.2 Literature Review

65 potential indicators were identified that have been used in studies examining the relationship between the built environment and active transportation or related studies. Some of the indicators were cited regularly in the literature, while some appeared less frequently. Some of the indicators showed strong positive or negative correlations with active transportation while some demonstrated little correlation. At this stage, however, potential indicators were culled from the literature indiscriminately and assembled in a spreadsheet to facilitate evaluation.

5.2.3 Indicator Evaluation

As Boarnet (2004) noted, there are several challenges to the exercise of indicator development such as making effective use of data from different sources and fields that have often been developed to address different questions. Another key challenge is to develop indicators that are general enough to be useful to the wide range of users of Community Counts and specific enough to capture relevant and useful data to answer particular questions. It is thus important to clearly explain the rationale behind the different criteria being used to evaluate indicators.

MacLaren (1996) points out that there is an extensive discussion around selection criteria in the social, environmental, and sustainability indicators literature. Contributing to this discussion, Miller (2004) recommends a purposeful approach to formulating indicators that emphasizes the importance of considering the roles that they will be expected to play. The roles expected of the indicators being developed in this study are described above in the *Study Goals* section and include: contributing to future scientific research; helping to inform decision making and program administration; and empowering communities by helping people become better informed about their own conditions and thus enabling them to more effectively advocate their position to decision-makers.

In light of these expected roles, this study first screened potential indicators through four filters before evaluating the remaining candidates more thoroughly. The filters removed indicators that had no strong correlation to active transportation in the literature, relied on dualistic categories, could not be objectively measured, and whose orientation was to the individual rather than the community.

The remaining indicators were evaluated on a 3 point scale (low, medium, high agreement) for each of the following eight criteria:

1. Representative;
2. Data availability;
3. Data reliability;
4. Ease of data collection;
5. Frequency of data collection;
6. Usefulness for policy and decision-making;
7. Attractiveness to public; and
8. Usefulness to researchers.

From this evaluation the study proposed a set of active transportation indicators as well as potential data sources and collection methods. As it turned out, much of the required data was already available through existing sources such as the Census, the Nova Scotia Civic Address File, and the Street Centerline File.

5.2.4 Indicator Testing

It is important to assess the feasibility and reliability of the proposed data collection methods. Are the indicators able to measure what they were intended to measure? Are proposed proxy measures effective substitutes for desired indicators for which no data is available? The study conducted field tests by collecting as much of the necessary data as possible for each of the proposed indicators in four sample communities.

Four communities in Nova Scotia were selected as case studies/indicator testing sites. In order to maximize the likelihood that data availability problems or questions about an indicator's effectiveness would be revealed, the indicators were tested in one rural community (Hopewell - Pictou County), one small town (Glace Bay), one suburban community (Spryfield), and one urban community (Halifax Citadel). These sites were selected upon the advice of Dennis Pilkey, Director of Community Counts, in order to take advantage of existing indicator or GIS projects underway in some of the communities and in order to represent a range of values on key characteristics of the built environment.

Maps and aerial photographs and census data was gathered for each of these communities in order to make data entries for as many of the indicators as possible via remote means. Following the experience of data collection, the study reviewed the proposed indicators once more against the original selection criteria to allow for new insights. The initial evaluation was deemed valid and a final set of built environment-active transportation indicators was proposed.

5.3 Appendix C – Background: Physical Activity

Physical inactivity has long been recognized as a significant determinant of ill health contributing to increased levels of heart disease, stroke, hypertension, type 2 diabetes, colon cancer, breast cancer, osteoporosis, obesity, depression, anxiety, and stress. Obesity dramatically increases the risk of type 2 diabetes which is itself a major risk factor for amputations, blindness, kidney failure, and heart disease. In a recent type 2 diabetes trial, weight loss and physical activity were more effective in controlling the disease than medication (Jackson and Kochtitzky 2001). In addition, for treatment of mild cases of anxiety and depression, physical activity is as effective as the most commonly prescribed medications (Jackson and Kochtitzky 2001; additional.

Recent studies have demonstrated that even small amounts of moderate physical activity confer significant health benefits. As a result of these findings the Public Health Agency of Canada has shifted its health promotion focus away from high-intensity activities towards more regular moderate-intensity activities such as brisk walking or bicycling. Canada's physical activity guidelines (PHAC 2005) now recommend accumulating 60 minutes or more per day of moderate-intensity physical activity in minimum bouts of at least 10 minutes. Currently, approximately two-thirds of the Canadian adult population do not meet these recommendations (Craig et al 1999). Similarly high levels of physical inactivity are found in other countries with similar socio-demographic profiles and development patterns such as the United States, the United Kingdom and Australia (US Department of Health and Human Services 1996; National Audit Office 2001; National Advisory Committee on Health and Disability 1998).

Within Canada, Nova Scotia is home to the second highest levels of physical inactivity in the country after Saskatchewan. A 1997 national survey of Canadians' physical activity patterns (Craig et al 1999) showed that 72% of residents in this province are too inactive to reap the health benefits of physical activity. Not surprisingly, Nova Scotia has one of the highest rates of obesity in the country (Colman 2000).

5.3.1 Ecological Approach to Understanding Physical Activity Behaviour

Until recently, research has focused on identifying individual determinants of physical activity. This approach has been criticized because it places undue emphasis on the individual and fails to consider the social and physical environment within which health behaviour takes place (Milio 1986; McLeroy et al. 1988; Tesh 1988; Minkler 1989; Stevenson & Burke 1992; Stokols 1992). There is little point, for instance, in encouraging people to walk, jog, or bicycle when there are no safe or adequate places to pursue these activities.

As a result of these earlier critiques, a new generation of physical activity research (Barnes and Schoenborn 2003; Bauman et al. 2002; Buchner and Miles 2002; Corti et al. 1996; Giles-Corti and Donovan 2002; King et al. 2002; Lewis et al. 2002; Maia et al. 2002; Miller et al. 2002; Nankervis 1999; Powell 2002; Rutten et al. 2001; Sallis et al. 1989; Sallis et al. 1997; Sallis et al. 1998; Sharpe et al. 2004; Stahl et al. 2001) has taken an ecological approach in identifying the broad range of elements that may enable or inhibit individuals in meeting recommended physical activity levels. These elements are many and complex but can be usefully understood in terms of three broad categories: i) social factors, ii) physical environment factors, and iii) individual factors.

Social factors may include societal values, public policies and market forces. Physical environment factors may include natural features such as topography, climate and terrain as well as elements of the built environment such as land use patterns, transportation infrastructure, and design features. Individual factors may include demographics, culture, health status, genetic traits, time constraints, lifestyle preferences, and personal values, beliefs, and motivation.

Each of these factors interacts with the others in multiple and complex ways and should therefore not be considered in isolation. Nevertheless, some researchers suggest that changes to the physical environment hold the most promise for increasing community physical activity levels. While a supportive physical environment may not be *sufficient* to increase community physical activity levels, the literature suggests it may be a *necessary* or *facilitating* condition. For instance, reducing the distance between an individual's home and work does not guarantee that this person will commute by foot. They may have too many heavy things to carry, they might need their car for work, or they may simply not like walking. However, if the distance between home and work is not reduced and remains too great, then walking will not even be an option. Thus, while social, individual, and policy factors all play a role, this study focuses on the built environment as an essential facilitator of active transportation.

The built environment may influence different types of physical activity at different scales. At the site scale, design may influence the way we move around a building at work or at home – whether we take the stairs or use an escalator for instance. At the neighbourhood and regional scales, built form may influence the way we move ourselves to work or school as well as the types of leisure-time physical activities we engage in.

All of these types of physical activity occurring across the range of settings we encounter in daily life – around the home, at work, or at school; while traveling to a destination; and during leisure time – offer important avenues for exploration. However, this study focuses in particular on physical activity during destination-oriented travel and its interaction with the built environment.

5.3.2 Physical Activity Types

In order to meet Canada's recommended exercise target of 60 minutes per day, individuals can participate in a wide variety of physical activities (e.g. soccer, cycling, basketball, swimming, yoga, weight-lifting, walking, paddling, aerobics, downhill skiing etc.). Some of these activities require more time, energy, money and skill than others. Some are more difficult to adhere to on a regular basis than others. Some, like basketball, are undertaken in leisure time for recreational purposes. Others, namely walking and cycling, can be undertaken for both recreational purposes (e.g.

weekend strolls, bicycle touring) as well as for utilitarian purposes (e.g. cycling to work, running an errand, climbing stairs). In order to help understand these differences, Frank et al. (2003) propose a typology of physical activity based on three features:

- Level of exertion required (moderate or vigorous)
- Purpose of activity (recreational or utilitarian)
- Obstacles to participating - financial, equipment, time, skill (high or low)

The authors suggest that those activities that require lower levels of physical exertion, demand less time, money, equipment and skill, and have some practical purpose have distinct advantages over other types. Walking and bicycling meet all of these criteria – they are moderately intense, there are few barriers to participation, and they can be done in the course of carrying out other useful tasks – such as traveling to work or running an errand.

Based on two decades of conducting physical activity surveys, the Canadian Fitness and Lifestyle Research Institute argues that people are more likely to become and remain active if they participate in easily accessed activities that can fit into their daily schedules, that they feel competent to do, and that they find enjoyable (Craig et al. 1999). Active transportation, by its very nature, fits into daily routines. Walking, and to a lesser extent cycling, are easy to do. And, while walking to work accomplishes a utilitarian purpose, the experience can also be enjoyable and undertaken for the pleasure of the trip itself.

5.4 Appendix D – Background: Active Transportation

In an annual survey by the Canadian Fitness and Lifestyle Research Institute, walking has consistently ranked as Canada's most popular form of physical activity with cycling typically ranking in the top five (CLFRI 2002). While walking and cycling can be forms of leisure-time exercise, they are also means of transportation.

As a form of utilitarian physical activity, active transportation has the potential to be more important than recreational exercise because it is integrated into other activities. This integration is especially advantageous given that 76% of Canadians complain that they do not have enough free time to engage in exercise, 68% lack the energy to exercise, and 57% report a lack of interest or motivation (CLFRI 2002).

In the case of active transportation, exercise is a by-product of carrying out other useful tasks like commuting to work or buying groceries or visiting a friend. As such, active transportation may be one of the best ways that people who lack time, energy, skills, money or motivation could get exercise on a regular basis – as long as the built environment is structured to permit it.

In addition to physical activity and health benefits, increasing levels of active transportation can also facilitate reduced automobile use, which reduces air pollution and greenhouse gas emissions, reduces reliance on increasingly scarce and expensive fossil fuels, and reduces neighbourhood traffic congestion and noise. Promoting and facilitating active transportation thus has great potential to improve overall community health and quality of life.

Currently few utilitarian trips are made by non-motorized modes in Canada and the United States. In the US, 91% of commute trips are made by private motor vehicle compared with only 2% of commute trips made by walking (USDOT 2003). Furthermore, the trend data shows the single-occupant motor vehicle taking an increasing percentage of the mode-share for all trips in the North America (Hu and Young 1999).

The remarkably low rate of walking and cycling trips in Canada and the United States compared to most other countries could be explained by several factors such as:

- High average incomes and easy access to automobiles;
- A harsh winter climate in many regions that is unfavourable to walking and cycling;
- Cultural values and norms that favour automobiles

None of these explanations is satisfactory however, as they do not account for the dramatic differences in active transportation rates between North America and Europe (see Table 2-3). Pucher and Lefevre point out that most of these countries are as wealthy as Canada and the United States; winters are just as harsh in some of the northern European countries like Norway, Sweden, and Austria; and in many of these countries, most notably in Italy and in Germany, the automobile is just as much of a cultural status symbol as it is in North America.

Despite these similarities, active transportation rates are significantly higher in Europe where non-motorized modes account for 25% - 54% of all trips compared to Canada where walking and bicycling account for only 11% of all trips. In addition to policies and financial incentives that support non-motorized modes and discourage motorized travel – Pucher and Lefevre (1996) suggest that the compact, higher density, mixed-use, walkable environments found in many of these countries are the most likely explanation for the higher rates of active transportation.

Table 5-1 – Modal Split by country in urban areas, 1990 (Pucher and Lefevre 1996)

Country	Car	Public Transit	Bicycling	Walking
Austria	39	13	9	31
Canada	74	14	1	10
Denmark	42	14	20	21
France	54	12	4	30
Germany	52	11	10	27
Italy	25	21	54	
Netherlands	44	8	27	19
Norway	68	7	25	
Sweden	36	11	10	39
Switzerland	38	20	10	29
UK	62	14	8	12
USA	84	3	1	9
Average	**52**	**12**	**10**	**23**

Although non-motorized modes account for few overall commute trips, a national survey (Go for Green/Environics 1998) found that 58% of Canadians walk and 26% of Canadians cycle for transportation at least sometimes. As shown in Tables 7-2 to 7-5 below, Atlantic Canadians are the least likely regional group to ever use walking (44%) or cycling (14%) for transportation although they are the most likely to agree that they would like to walk for transportation more often (88%). More than half (54%) of Atlantic Canadians would like to cycle more often as a mode of transportation. Clearly, then, there is a significant latent demand for active transportation in Canada and especially in Atlantic Canada.

Table 5-2 – Walking as a Mode of Transportation 'At Least Sometimes' To Any Destination (%)
(Go for Green/Environics 1998: 4)

	Canada	Atl	Que	Ont	Man	Sask	Alta	BC
All Respondents	58	44	59	62	52	46	57	64
Those Living Within 2.5km (base: 64% of Canadians)	72	60	69	75	65	61	73	79

Table 5-3 – Cycling as a Mode of Transportation 'At Least Sometimes' To Any Destination (%)
(Go for Green/Environics 1998: 8)

	Canada	Atl	Que	Ont	Man	Sask	Alta	BC
All Respondents	26	14	27	28	30	23	34	24
Those Living Within 8 km (base: 84% of Canadians)	28	14	27	30	34	27	36	24

Table 5-4 - Would "Ideally Like to Walk More" as a Mode of Transportation
(Go for Green/Environics 1998: 4)

	Canada	Atl	Ont	Alta	Que	BC	Man	Sask
All Respondents	82	88	84	84	80	80	79	78

Table 5-5 - Would "Ideally Like to Cycle More" as a Mode of Transportation
(Go for Green/Environics 1998: 12)

	Canada	Alta	Que	Ont	Man	BC	Sask	Atl
All Respondents	66	74	68	67	65	63	61	54

Given this unmet demand for walking and cycling and the enormous health and community benefits associated with meeting this demand, Nova Scotia's Office of Health Promotion has prepared the "Nova Scotia Active Transportation Framework for Action" (2005) as a key document to guide active transportation policy and programming in the Province. The document calls for actions that fall under six categories: public education; policy and legislation; research and knowledge exchange; resource commitment; supportive social environments; and, of most interest to the current study, supportive physical environments -- defined as providing "physical environments where choosing active transportation is easy, safe, practical, and efficient" (2005: 9). In addition, one of the fundamental principles of the framework is that "community design should support active transportation" (2005: 12).

In order to support implementation of the proposed framework, this study seeks to determine what built environment characteristics make choosing active transportation easy, safe, practical, and efficient and then proposes indicators to track these characteristics. Making these indicators available on Community Counts will enable researchers, decision-makers, and the wider public to evaluate progress towards the goals set out in the Active Transportation Framework for Action.

5.4.1 Active Transportation and the Built Environment

The growing body of physical activity and travel behaviour literature seems to indicate that reducing barriers to physical activity in the built environment may have the potential to significantly increase physical activity more than policies aimed at influencing individual behaviour.

Public health and planning researchers and practitioners propose a variety of urban-form strategies to increase active transportation levels. However, the literature in this field is still relatively new and studies have not yet established conclusive causal relationships between urban form and active transportation. In addition, most of the research to date has used American data from a small sample of American cities. To date, researchers have only conducted one major study testing the built environment—active transportation relationship in Canada. Even less research has been conducted in Nova Scotia. The largely American literature is useful for understanding the broader concepts in this emerging field however less useful, perhaps, for understanding the built environment—active transportaton dynamics in Nova Scotia.

For instance, the most recent CFLRI survey (2002) found that Canadians living in small communities (of less than 10,000 residents) are unlikely to cite many available places to walk and bicycle, cite fewer recreational trails, and are less likely to be very satisfied with the number of opportunities for physical activity in their area. Aside from the urban communities of HRM, CBRM and the Town of Truro, the rest of Nova Scotia fits this description.

To be sure, the built environment of Nova Scotia poses significant challenges to those who would promote active transportation. Implementation of the built environment indicators proposed in this study will more clearly illustrate the scale and the nature of this challenge, could guide possible interventions, and can assist in evaluating progress and achievements.

5.5 Appendix E – Background: Indicators

We cannot be certain that we are building communities that support active transportation unless we have effective indicators in place to measure built form on the one hand and the resulting levels of active transportation on the other hand. The United Nations Commission on Sustainable Development (2001) recognized the central role that indicators can play in assisting planning and decision-making. Indicators help measure progress towards stated goals and targets; they point to potential problems before they occur; and they can provide a comprehensible unit of measurement to interpret and communicate complex social and physical information.

Without the existence of appropriate indicators and related data collection and analysis mechanisms, researchers would not fully understand many causal relationships nor could they measure the outcomes of certain policy decisions. Indeed, some outcomes may be hidden altogether.

Furthermore, providing communities (especially distressed communities) with the tools to gather factual information about their own physical environments in order to more effectively make claims and advocate their position to decision-makers is an empowering process that may contribute to positive neighbourhood change.

Indicators also serve to communicate wider societal values about what is important enough to measure and what is not. An administration can say that active transportation is important, it can promote non-motorized travel, and it can even provide funding support. However, if it does not have indicators in place to measure the relevant inputs and outputs, then active transportation will never be valued as highly by decision-makers or by the general public. To a certain extent, what society measures becomes what is important. It is thus imperative to measure the right things.

Miller refers to sustainability indicators as “metrics with a purpose: measures with an ax to grind” (Miller 2004: 247). Indeed, no indicators are value-neutral. Rather, their very existence says that we think certain things are worth measuring and that particular questions are worth answering.

This study reviews 121 potential indicators measuring aspects of the built environment that influence active transportation. The values embedded in these indicators hold that active transportation is important and worth understanding.

5.6 Appendix F - Indicator Evaluation Initial Filters

Filter 1: Empirical Evidence

While research has not yet proven causal connections between the built environment and active transportation, many studies agree that a few key elements of built form show strong positive correlations with non-motorized travel. These elements are: density, land use mix and supportive infrastructure.

This screen filters out any potential indicators with little or no empirical evidence linking them to active transportation.

While attractive spaces might play a more significant role in leisure time activities, none of the empirical studies reviewed found any correlation between the following design and aesthetics indicators and utilitarian walking and cycling.

- Quality of Lighting
- Path/lane obstruction
- % of area covered by tree canopy
- Garden maintenance
- Streetscape maintenance
- Cleanliness
- Ambient pollution
- Presence of parks
- Presence of views
- Architectural diversity
- Complexity of stimulus
- Potential "overload" of stimulus
- Visual interest
- Visual aesthetics

Filter 2: Relative Comparability

Several studies use dualistic categories to describe built environments such as standard suburb vs. neo-traditional suburb or automobile-oriented vs. pedestrian-oriented (Ewing et al. 1994; Friedman et al. 1994; Cervero and Gorham 1995; Cervero and Radisch 1996; Bagley and Mokhtarian 2002). These dualistic indicators obscure the diversity and range of built environments across the Province and attach implicit value judgements to "either-or" categories at the outset. Indicators should allow for relative comparisons between communities.

This screen filters out any potential indicators that employ dualistic categories.

- Community type: standard suburb vs. neo-traditional suburb
- Community type: automobile-oriented vs. pedestrian-oriented
- Community type: automobile-oriented vs. transit-oriented

Filter 3: Objective Measures

Many studies rely on detailed surveys to collect perceptual information about the neighbourhood level built environment. Survey respondents are asked, for instance, whether their community has enjoyable scenery or whether they feel safe cycling. These subjective indicators can help to clarify the relationship between perceived neighbourhood environment and actual neighbourhood environment. However, for the purposes of Community Counts, regularly updated, objectively measured and standardized data needs to be available for the entire Province.

<u>This screen filters out any potential indicators that rely on subjective or perceptual measures</u>.

- Surveillance
- Attractiveness for walking
- Attractiveness for cycling
- Difficulty for walking
- Difficulty for cycling

Filter 4: Community-Oriented

Many studies rely on detailed surveys and GIS to collect and analyze information about the individual's spatial relationship to the built environment. Measures such as "number of destinations nearby" are collected from the point of view of one individual, usually a randomly selected survey participant. Such individual-oriented approaches are appropriate for research studies but not for a continuously updated, Province-wide database.

<u>This screen filters out any potential indicators that measure the individual rather than the community experience.</u>

- Distance to different land uses

Appendix G – Indicator Evaluation Matrix

INDICATOR \ EVALUATION CRITERION (1 low, 2 med, 3 high)	Representative	Data Availability	Data Reliability	Data Frequency	Ease / Cost of Data Collection	Useful for Policy & Decision Making	Attractive to Public	Useful for Empirical Research
DENSITY:								
Area (2)								
Ecumene length/width ratio	1	3	3	3	3	3	2	3
Ratio of ecumene area to total area	2	3	3	3	3	3	2	3
Household Density (7)								
Gross household density (per sq km total area)	1	3	3	3	3	2	1	2
Net household density (per sq km ecumene)	3	3	3	3	3	3	3	3
Road household density (per road km)	3	3	3	3	3	3	3	3
% Dwellings single detached	3	3	3	3	3	3	3	3
% Dwellings semi-detached/row/duplex	3	3	3	3	3	3	3	3
% Dwellings apartments	3	3	3	3	3	3	3	3
Persons per household (average)	1	3	3	3	3	3	3	3
Population Density (3)								
Gross population density (per sq km total area)	1	3	3	3	3	2	1	2
Net population density (per sq km ecumene)	3	3	3	3	3	3	3	3
Road population density (per road km)	3	3	3	3	3	3	3	3

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EVALUATION CRITERION 1 low 2 med 3 high / INDICATOR	Representative	Data Availability	Data Reliability	Data Frequency	Ease / Cost of Data Collection	Useful for Decision Making	Attractive to Public	Useful for Researchers
Employment Density (6)								
Gross employment space density (per sq km total area)	1	1	1	1	1	3	2	2
Net employment space density (per sq km ecumene area)	1	1	1	1	1	3	2	2
Road employment space density (per road km)	1	1	1	1	1	3	2	2
Gross jobs density (per sq km total area)	2	2	3	3	3	3	3	3
Net jobs density (per sq km ecumene area)	3	2	3	3	3	3	3	3
Road jobs density (per road km)	3	2	3	3	3	3	3	3
Retail Density (6)								
Gross retail space density (per sq km total area)	1	1	1	1	1	3	2	2
Net retail space density (per sq km ecumene area)	1	1	1	1	1	3	2	2
Road retail space density (per road km)	1	1	1	1	1	3	2	2
Gross retail jobs density (per sq km total area)	2	3	3	3	3	3	3	3
Net retail jobs density (per sq km ecumene area)	3	3	3	3	3	3	3	3
Road retail jobs density (per road km)	3	3	3	3	3	3	3	3

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EVALUATION CRITERION 1 low 2 med 3 high / INDICATOR	Representative	Data Availability	Data Reliability	Data Frequency	Ease of Data Collection	Useful for Decision Making	Attractive to Public	Useful for Researchers
LAND USE MIX								
Comparative Land Use Mix (9)								
Number of retail establishments	3	3	2	2	2	3	3	3
Degree of residentialness	2	3	3	3	3	3	3	3
Employed residents-to-jobs	3	2	2	2	3	3	3	3
Employed residents-to-retail/services	3	3	2	2	2	3	3	3
Rural/Urban mix	1	3	3	3	3	3	3	3
Land Use Mix (Entropy)	3	3	2	2	2	3	2	3
Land Use Mix (Dissimilarity)	3	3	2	2	2	3	2	3
Land Use Mix (HHI)	3	3	2	2	2	3	2	3
Pedestrian Proximity (12)								
% dwellings within 2.5 km of sales	3	3	2	2	2	3	3	3
% dwellings within 2.5 km of services	2	3	2	2	2	3	3	3
% dwellings within 2.5 km of culture and recreation	2	3	2	2	2	3	3	3
% dwellings within 2.5 km of grocery stores	3	3	2	2	2	3	3	3
% dwellings within 2.5 km of convenience stores	2	3	2	2	2	3	3	3
% dwellings within 2.5 km of general merchandise stores	3	3	2	2	2	3	3	3

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EVALUATION CRITERION 1 low 2 med 3 high / INDICATOR	Representative	Data Availability	Data Reliability	Data Frequency	Ease of Data Collection	Useful for Decision Making	Attractive to Public	Useful for Researchers
% dwellings within 2.5 km of business/office	3	3	2	2	2	3	3	3
% dwellings within 2.5 km of community service	2	3	2	2	2	3	3	3
% dwellings within 2.5 km of educational	2	3	2	2	2	3	3	3
% dwellings within 2.5 km of neighbourhood schools	2	3	2	2	2	3	3	3
% dwellings within 2.5 km of food and beverage	2	3	2	2	2	3	3	3
% dwellings within 2.5 km of personal services	2	3	2	2	2	3	3	3
Cyclist Proximity (12)								
% dwellings within 8 km of sales	3	3	2	2	2	3	3	3
% dwellings within 8 km of services	2	3	2	2	2	3	3	3
% dwellings within 8km of culture and recreation	2	3	2	2	2	3	3	3
% dwellings within 8 km of grocery stores	3	3	2	2	2	3	3	3
% dwellings within 8 km of convenience stores	2	3	2	2	2	3	3	3
% dwellings within 8 km of general merchandise stores	3	3	2	2	2	3	3	3
% dwellings within 8 km of business/office	3	3	2	2	2	3	3	3
% dwellings within 8 km of community service	2	3	2	2	2	3	3	3

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EVALUATION CRITERION 1 low 2 med 3 high / INDICATOR	Representative	Data Availability	Data Reliability	Data Frequency	Ease of Data Collection	Useful for Decision Making	Attractive to Public	Useful for Researchers
% dwellings within 8 km of educational	2	3	2	2	2	3	3	3
% dwellings within 8 km of neighbourhood schools	2	3	2	2	2	3	3	3
% dwellings within 8 km of food and beverage	2	3	2	2	2	3	3	3
% dwellings within 8 km of personal services	2	3	2	2	2	3	3	3
INFRASTRUCTURE								
Walking (7)								
Average width of sidewalks	2	1	3	2	3	3	3	3
Presence of sidewalks	3	2	3	3	3	3	3	3
Continuity of sidewalks	2	2	3	3	3	3	3	3
Condition of sidewalks	2	1	2	2	1	3	3	3
% dwellings fronting onto sidewalk	2	2	3	3	3	3	3	3
Ratio sidewalk km - street center line km	3	2	3	3	3	3	3	3
Difficulty for walking	3	1	1	1	1	3	3	3
Bicycling (8)								
Presence of bikeways	3	1	3	3	3	3	3	3
Average width of bikeways	2	1	3	3	3	3	3	3
Continuity of bikeways	2	1	3	3	3	3	3	3
Condition of bikeways	2	1	2	2	1	3	3	3
Difficulty for cycling	2	1	1	1	1	3	3	3

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EVALUATION CRITERION 1 low 2 med 3 high / INDICATOR	Representative	Data Availability	Data Reliability	Data Frequency	Ease of Data Collection	Useful for Decision Making	Attractive to Public	Useful for Researchers
Curb type	1	2	3	3	3	2	1	2
Number of bicycle parking spaces per sq km	2	1	2	2	2	3	3	3
Number of bicycle parking spaces per person	2	1	2	2	2	3	3	3
Transit (3)								
Transit Service Level	3	3	3	3	3	3	3	3
Number of transit stops total	1	3	3	3	3	3	3	3
% dwellings within 500 m of transit stop	3	3	3	3	3	3	3	3
Streets and Roads (15)								
Average intersection distance	2	3	3	3	3	3	3	3
Average block size	3	3	3	3	3	3	3	3
Number of car parking spaces per sq km	1	2	2	2	3	3	3	3
Number of car parking spaces per person	1	2	2	2	3	3	3	3
Number of crossing devices per road km.	2	3	3	3	3	3	3	3
Number of driveway crossovers per road km.	2	3	3	3	3	3	2	3
Average weekday arterial traffic speeds	3	2	3	2	2	3	3	3
Average weekday local street traffic speeds	3	1	2	1	2	3	3	3
Average weekday arterial traffic volumes	3	2	3	3	2	3	3	3
Average weekday local street traffic volumes	3	1	2	1	2	3	3	3

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EVALUATION CRITERION 1 low 2 med 3 high INDICATOR	Representative	Data Availability	Data Reliability	Data Frequency	Ease of Data Collection	Useful for Decision Making	Attractive to Public	Useful for Researchers
Arterial road coverage by area	3	3	3	3	3	3	3	3
Arterial road coverage by resident	3	3	3	3	3	3	3	3
Local street coverage by area	2	3	3	3	3	3	3	3
Local street coverage by resident	2	3	3	3	3	3	3	3
Arterial roads as % of total road kilometers	3	3	3	3	3	3	3	3
Connectivity (2)								
Non-motorized connectivity	3	3	3	3	3	3	3	3
Motorized connectivity	3	2	3	3	3	3	3	3
Topography (1)								
Average slope	1	3	3	3	3	3	2	3
TRAFFIC SAFETY								
Walking (8)								
Number of Pedestrian - Motor Vehicle Collisions per person	2	2	1	1	1	3	3	3
Number of Pedestrian - Motor Vehicle Injuries per person	2	2	2	2	2	3	3	3
Number of Pedestrian - Motor Vehicle Fatalities per person	2	2	3	3	3	3	3	3
Number of Pedestrian - Motor Vehicle Collisions per person per road km.	2	2	1	1	1	3	3	3
Number of Pedestrian - Motor Vehicle Injuries per road km.	2	2	2	2	2	3	3	3

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Evaluation Criterion (1 low, 2 med, 3 high) / Indicator	Representative	Data Availability	Data Reliability	Data Frequency	Ease / Cost of Data Collection	Useful for Decision Making	Attractive to Public	Useful for Researchers
Number of Pedestrian - Motor Vehicle Fatalities per road km.	2	2	3	3	3	3	3	3
Local pedestrian collisions/injuries/fatalities as % of provincial totals	2	2	2	2	2	2	2	2
Ratio local pedestrian collisions/injuries/ fatalities to provincial figures	2	2	2	2	2	2	2	2
Cycling (8)								
Number of Cyclist - Motor Vehicle Collisions per person	2	2	1	1	1	3	3	3
Number of Cyclist - Motor Vehicle Injuries per person	2	2	2	2	2	3	3	3
Number of Cyclist - Motor Vehicle Fatalities per person	2	2	3	3	3	3	3	3
Number of Cyclist - Motor Vehicle Collisions per person per road km.	2	2	1	1	1	3	3	3
Number of Cyclist - Motor Vehicle Injuries per road km.	2	2	2	2	2	3	3	3
Number of Cyclist - Motor Vehicle Fatalities per road km.	2	2	3	3	3	3	3	3
Local pedestrian collisions/injuries/fatalities as % of provincial totals	2	2	2	2	2	2	2	2
Ratio local pedestrian collisions/injuries/ fatalities to provincial figures	2	2	2	2	2	2	2	2

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EVALUATION CRITERION 1 low 2 med 3 high / INDICATOR	Representative	Data Availability	Data Reliability	Data Frequency	Ease of Data Collection	Useful for Decision Making	Attractive to Public	Useful for Researchers
ACTIVE TRANSPORTATION (OUTPUT)								
Journey to Work (by mode)								
% car/truck/van to work (driver)	3	3	3	3	3	3	3	3
% car/truck/van to work (passenger)	3	3	3	3	3	3	3	3
% public transit to work	3	3	3	3	3	3	3	3
% walk to work	3	3	3	3	3	3	3	3
% bicycle to work	3	3	3	3	3	3	3	3
% motorcycle to work	3	3	3	3	3	3	3	3
% taxicab to work	3	3	3	3	3	3	3	3
% 'other non-motorized' to work	3	1	1	1	3	3	3	3
% 'other motorized' mode to work	3	1	1	1	3	3	3	3
Journey to School (by mode)								
% car/truck/van to school (driver)	3	1	N/A	N/A	2	3	3	3
% car/truck/van to school (passenger)	3	1	N/A	N/A	2	3	3	3
% public transit to school	3	1	N/A	N/A	2	3	3	3
% walk to school	3	1	N/A	N/A	2	3	3	3
% bicycle to school	3	1	N/A	N/A	2	3	3	3
% motorcycle to school	3	1	N/A	N/A	2	3	3	3
% taxicab to school	3	1	N/A	N/A	2	3	3	3
% 'other non-motorized' to school	3	1	N/A	N/A	2	3	3	3
% 'other motorized' mode to school	3	1	N/A	N/A	2	3	3	3

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EVALUATION CRITERION 1 low 2 med 3 high / INDICATOR	Representative	Data Availability	Data Reliability	Data Frequency	Ease / Cost of Data Collection	Useful for Decision Making	Attractive to Public	Useful for Researchers
Non-Home-Based Trips (by mode)								
% car/truck/van non-home trips (driver)	3	1	N/A	N/A	2	3	3	3
% car/truck/van non-home trips (passenger)	3	1	N/A	N/A	2	3	3	3
% public transit non-home based trips	3	1	N/A	N/A	2	3	3	3
% walk non-home based trips	3	1	N/A	N/A	2	3	3	3
% bicycle non-home based trips	3	1	N/A	N/A	2	3	3	3
% motorcycle non-home based trips	3	1	N/A	N/A	2	3	3	3
% taxicab non-home based trips	3	1	N/A	N/A	2	3	3	3
% 'other non-motorized' non-home trips	3	1	N/A	N/A	2	3	3	3
% 'other motorized' non-home based trips	3	1	N/A	N/A	2	3	3	3
Discretionary Home-Based Trips (by mode)								
% car/truck/van home discretionary (driver)	3	1	N/A	N/A	2	3	3	3
% car/truck/van home discretionary (pass.)	3	1	N/A	N/A	2	3	3	3
% public transit home discretionary trips	3	1	N/A	N/A	2	3	3	3
% walk home-based discretionary trips	3	1	N/A	N/A	2	3	3	3
% bicycle home-based discretionary trips	3	1	N/A	N/A	2	3	3	3
% motorcycle home discretionary trips	3	1	N/A	N/A	2	3	3	3
% taxicab home-based discretionary trips	3	1	N/A	N/A	2	3	3	3
% 'other non-motorized' home discretionary	3	1	N/A	N/A	2	3	3	3
% 'other motorized' home discretionary trips	3	1	N/A	N/A	2	3	3	3

~ End of Evaluation Matrix ~

Appendix H – Land Use Classification in Nova Scotia

Nova Scotia Standard Land Use Classification System
www.gov.ns.ca/snsmr/land/standards/lucs

The Nova Scotia Committee on Standards for Geographic Information developed the land use classification system outlined below in order to replace the various older systems in place in Nova Scotia. The Province intends this system to become the standard land use classification system for all agencies, public and private, which have an interest in land use. (SNSMR 2005).

Most of the earlier classification systems used ambiguous and outdated categories such as "commercial," "institutional" and "industrial" to describe "ownership" in some cases and "use" in other cases. These older systems are unable to account for contemporary situations such as university offices sharing building space with private sector firms. The new system is not concerned with ownership (institutional or commercial) but rather activity (office/administration) making the data significantly more useful for land use analyses (SNSMR 2005).

In 2000-2001, the Province began building the Nova Scotia Civic Address File (NSCAF) – a digital, geo-referenced civic address database primarily designed to support more efficient emergency response. One of the fields in the database is "building use" which is populated according to the Standard Land Use Classification System attached below. The application of this system to the building-use field in NSCAF allows Community Counts to integrate reliable building use data in a GIS in order to calculate the land-use mix indicators recommended in this study. The building uses of most interest from an active transportation perspective are: Residential; Sales; Services; and Recreation, Culture and Entertainment.

A standardized system also allows provincial land use data to be stored centrally and accessed by many different agencies. Data can then be updated continuously by all users, maintaining a high degree of currency and reducing duplication of effort by multiple agencies (SNSMR 2005).

Table 5-6 - Nova Scotia Standard Land Use Classification System (SNSMR 2005)

PRIMARY	SECONDARY	TERTIARY
AGRICULTURE	-	-
"	LAND BASED	-
"	"	LONG TERM CROPPING SYSTEM
"	"	ROTATIONAL CROPPING SYSTEM
"	SITE BASED	-
"	"	HOUSING ANIMALS
"	"	HOUSING PLANTS
"	"	STORAGE
FISHERY	-	-
FORESTRY	-	-

"	HARVESTING	-
"	SILVICULTURE	-
"	"	INFRASTRUCTURE
"	"	TREATMENT
IN TRANSITION	-	-
"	RESTORATION	-
"	"	AGRICULTURE
"	"	FISHERY
"	"	FORESTRY
"	"	MANUFACTURING
"	"	MINING
"	"	PROTECTED AND LIMITED USE
"	"	RECREATION, CULTURE & ENTERTAINMENT
"	"	RESIDENTIAL
"	"	SALES
"	"	SERVICES
"	"	TRANSPORTATION, TRANSMISSION & STORAGE
"	UNDER CONSTRUCTION	-
"	"	AGRICULTURE
"	"	FISHERY
"	"	FORESTRY
"	"	MANUFACTURING
"	"	MINING
"	"	PROTECTED AND LIMITED USE
"	"	RECREATION, CULTURE & ENTERTAINMENT
"	"	RESIDENTIAL
"	"	SALES
"	"	SERVICES
"	"	TRANSPORTATION, TRANSMISSION & STORAGE
"	UNDER DEMOLITION	-
"	"	AGRICULTURE
"	"	FISHERY
"	"	FORESTRY
"	"	MANUFACTURING
"	"	MINING
"	"	PROTECTED AND LIMITED USE
"	"	RECREATION, CULTURE & ENTERTAINMENT
"	"	RESIDENTIAL
"	"	SALES
"	"	SERVICES
"	"	TRANSPORTATION, TRANSMISSION & STORAGE
"	VACANT	-
"	"	AGRICULTURE
"	"	FISHERY
"	"	FORESTRY
"	"	MANUFACTURING
"	"	MINING
"	"	PROTECTED AND LIMITED USE
"	"	RECREATION, CULTURE &

		Entertainment
"	"	Residential
"	"	Sales
"	"	Services
"	"	Transportation, Transmission & Storage
Manufacturing	-	-
"	Assembly	-
"	Disposing and Treating	-
"	Generating	-
"	Processing	-
"	"	Agriculture
"	"	Chemical
"	"	Fishery
"	"	Forestry
"	"	Mineral
"	"	Secondary
"	"	Water Purification
Mining	-	-
"	Surface	-
"	Underground	-
Protected and Limited Use	-	-
"	Bird Sanctuary	-
"	Historic Site	-
"	"	National
"	"	Provincial
"	Park	-
"	"	National
"	"	Provincial
"	Protected Beach	-
"	Reserve	-
"	Wildlife Management Area	-
"	"	National
"	"	Provincial
Recreation, Culture and Entertainment	-	-
"	Indoor	-
"	"	Active
"	"	Passive
"	Outdoor	-
"	"	Active
"	"	Passive
Residential	-	-
"	Communal	-
"	Mobile Home Park	-
"	Single Unit Dwelling	-
"	"	Apartment
"	"	Attached
"	"	Detached

"	THREE OR MORE UNITS	-
"	"	APARTMENT BUIDLING
"	"	ATTACHED
"	"	CONVERTED
"	"	DETACHED
"	TWO UNIT DWELLING UNITS	-
"	"	APARTMENT
"	"	ATTACHED
"	"	CONVERTED
"	"	DETACHED
SALES	-	-
"	CONVENIENCE STORE	-
"	FACTORY HOME	-
"	GENERAL MERCHANDISE	-
"	"	BUILDING SUPPLIES
"	"	DEPARTMENT/WAREHOUSE STORE
"	"	FARM MARKET
"	"	GARDEN SUPPLIES
"	"	SPECIALTY
"	GROCERY	-
"	"	FARM MARKET
"	"	FOOD
"	"	LIQUOR
"	"	PHARMACY
"	"	SPECIALTY
"	MOTOR VEHICLE & RELATED	-
"	"	AIRBORNE VEHICLE
"	"	AUTOMOTIVE
"	"	GAS STATION
"	"	HEAVY EQUIPMENT
"	"	MARINE
"	"	RECREATIONAL VEHICLE
"	"	SMALL ENGINE
"	SHOPPING MALL	-
"	"	ENCLOSED FACILITY
"	"	STRIP MAP
"	WHOLE SALE	-
"	WORKSHOP	-
"	"	ARTISAN
SERVICES	-	-
"	ACCOMODATIONS	-
"	"	BED AND BREAKFAST
"	"	HOTEL/MOTEL/INN
"	"	OTHER
"	ANIMAL	-
"	"	DOMESTIC
"	"	FARM
"	BUSINESS/OFFICE	-
"	"	ADMINISTRATIVE
"	"	FINANCIAL
"	"	HEALTH CARE PROVIDER
"	"	PROFESSIONAL

"	"	Technical
"	Cleaning and Repair	-
"	"	Small Engine
"	Community Service	-
"	"	Assembly Hall
"	"	Day Care
"	"	Funeral
"	"	Library
"	"	Place of Worship
"	"	Residential Care Facility
"	Educational	-
"	"	Neighbourhood/Community School
"	"	Trade School
"	"	University/College
"	Food and Beverage	-
"	"	Alcohol Based
"	"	Fast Food/Take Out
"	"	Sit Down
"	Health Care	-
"	"	Clinic
"	"	Hospital
"	Heavy Equipment and Construction	-
"	Motor Vehicle and Related	-
"	"	Auto Body
"	"	Auto Glass
"	"	Auto Repair
"	"	Detailing
"	Office Complex	-
"	Personal	-
"	Protection	-
"	"	Correctional
"	"	Fire
"	"	Judicial
"	"	Military
"	"	Police
"	Scientific	-
"	"	Lab Testing
"	"	Research and Development
"	Workshop	-
"	"	Artisan
"	"	Technical
"	"	Trades
Transportation, Transmission and Storage	-	-
"	Accessory Structures	-
"	"	Air
"	"	Marine
"	"	Rail
"	"	Road

"	BULK TERMINAL	-
"	"	MARINE
"	"	RAIL
"	"	ROAD
"	CONTAINER TERMINAL	-
"	"	MARINE
"	"	RAIL
"	"	ROAD
"	FLEET MAINTENANCE AND STORAGE	-
"	"	AIR
"	"	MARINE
"	"	RAIL
"	"	ROAD
"	INTERCITY TERMINAL	-
"	"	AIR
"	"	MARINE
"	"	RAIL
"	"	ROAD
"	OTHER FREIGHT TERMINAL	-
"	"	AIR
"	"	MARINE
"	"	RAIL
"	"	ROAD
"	PERSONAL TRANSPORTATION	-
"	"	MARINE
"	"	PARKING
"	"	PRIVATE AIRPLANE
"	PIPELINE INFRASTRUCTURE	-
"	"	GAS
"	"	OTHER
"	"	SEWER
"	"	WATER
"	TRANSIT TERMINAL	-
"	"	BUS
"	"	MARINE
"	TRANSMISSION FACILITY	-
"	"	ELECTRICITY
"	"	GEOTHERMAL
"	"	INFORMATION

Shaded rows = potential indicators
White rows = existing indicators

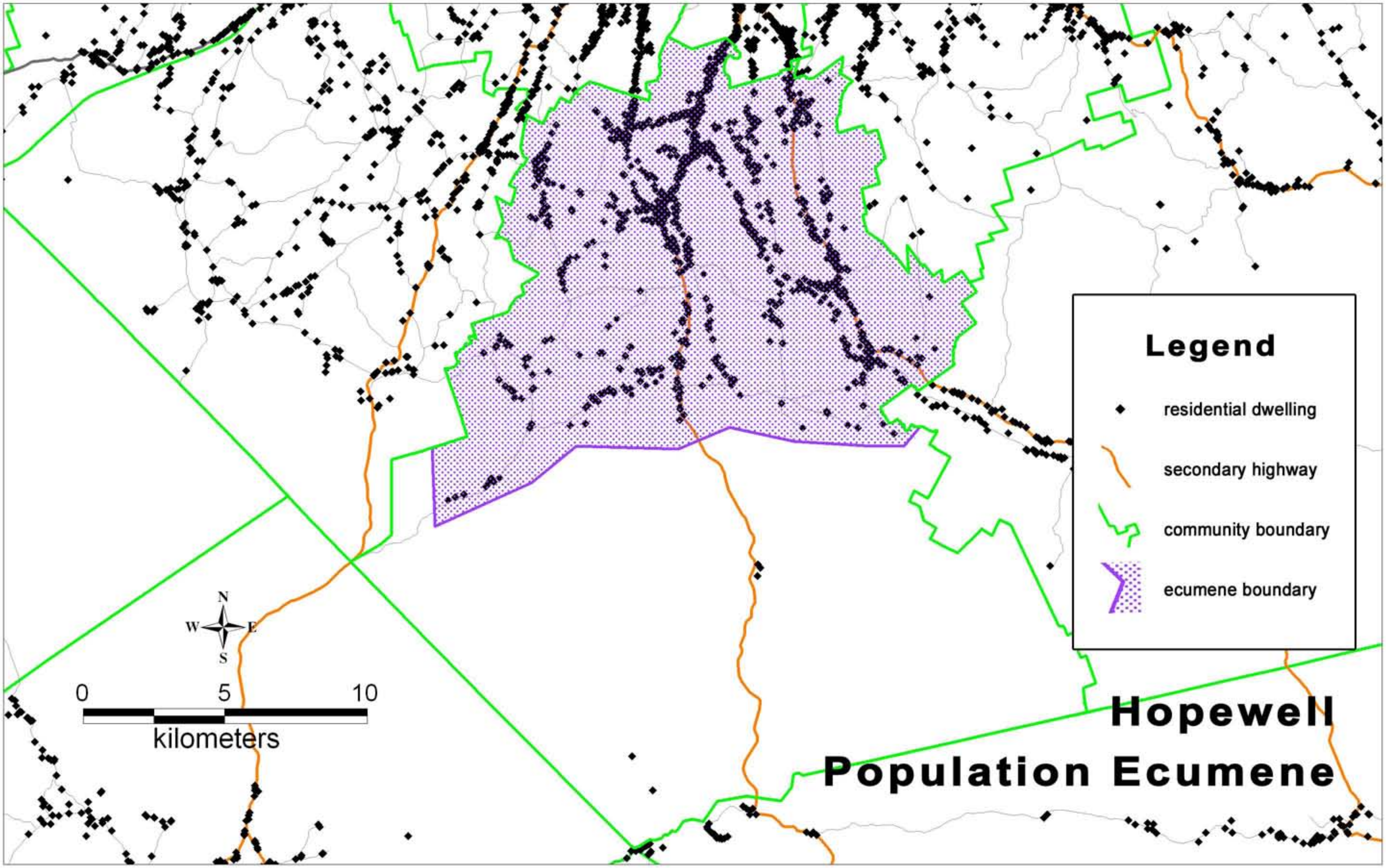
Appendix I – Test Communities Maps & Data Results

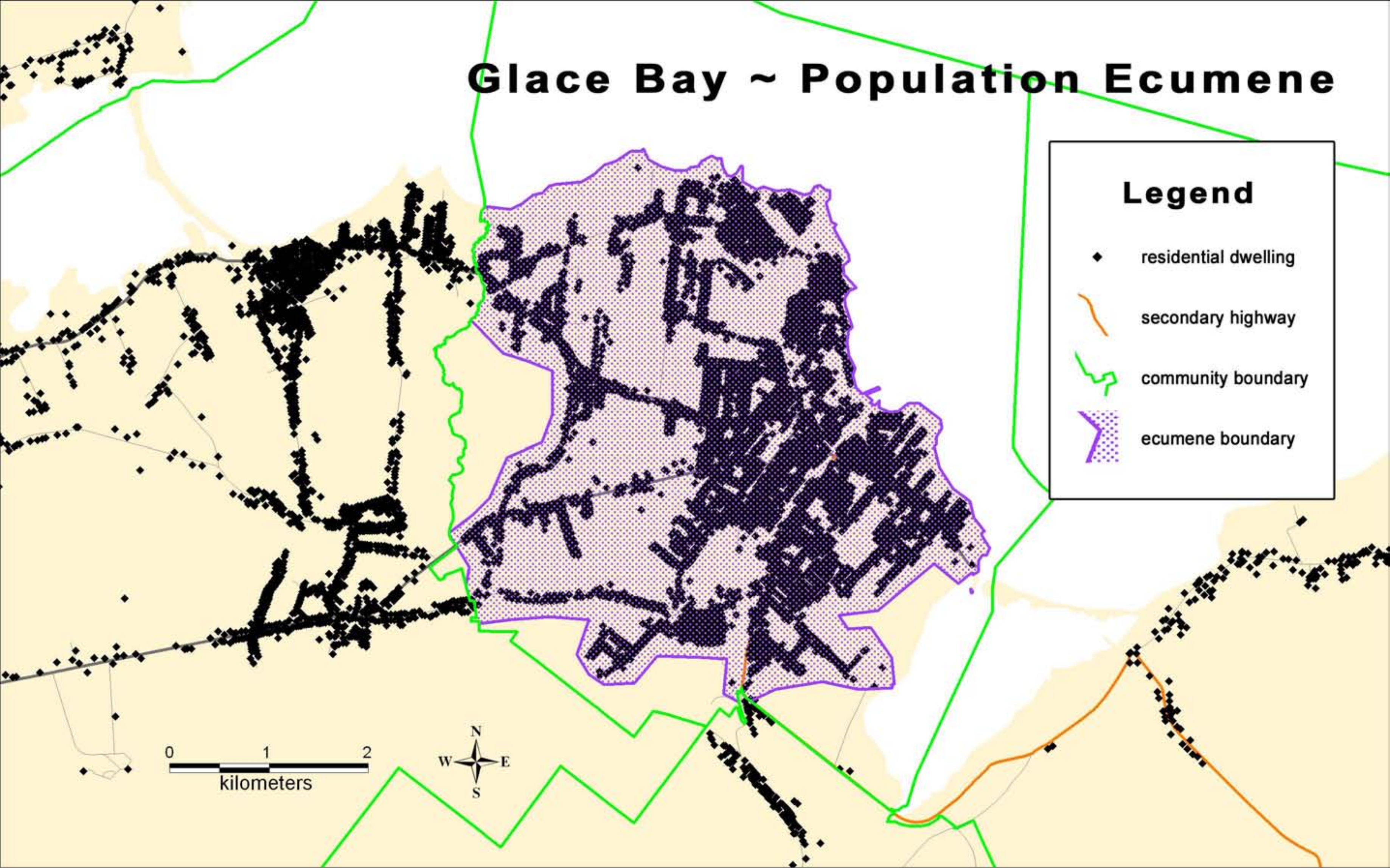
Active Transportation – Built Environment Indicator	Hopewell	Glace Bay	Spryfield	Halifax Citadel
density				
Total Community Land Area (sq km)	425.0	23.0	4.8	7.0
Ecumene / Inhabited Area (sq km)	192.1	19.5	3.2	5.7
Ecumene Length - north-south (km)	13	4.5	2.75	2.25
Ecumene Width - east-west (km)	15	4	1.5	2.5
Roads (km)	192.9	121.8	58.2	60.4
Roads in Ecumene (km)	174.4	119.2	58.0	60.4
Roads outside Ecumene (km)	18.5	2.6	0.2	0.0
Ecumene as % of Total Area	45%	85%	66%	81%
Total Occupied Dwellings	976	6665	1895	10314
% Single Detached Dwellings	78.1%	73.2%	29.8%	17.3%
% Semi-detached/Row/Duplex	1.0%	18.5%	25.3%	8.1%
% Apartments	19.0%	8.3%	42.5%	74.4%
Total Residential Population	2,588	17,095	4,460	19,506
Total Persons in Households	2,575	16,835	4445	18925
Persons per Household	2.6	2.5	2.4	1.8
Total Employed Residents	1,024	4885	235	10808
Total Jobs	*	*	*	*
Total Retail Jobs	*	*	*	*
Total Employment Floor Area (sq m)	*	*	*	*
Total Retail Floor Area (sq m)	*	*	*	*
Population density (per sq km total area)	6.1	737.2	929.2	2862.5
Population density (per sq km ecumene)	13.5	877.6	1402.5	3422.1
Population density (per road km)	13.4	140.3	232.8	322.8
Employment density (per sq km total area)	*	*	*	*
Employment density (per sq km ecumene area)	*	*	*	*
Employment density (per road km)	*	*	*	*
Retail density (per sq km total area)	*	*	*	*
Retail density (per sq km ecumene area)	*	*	*	*
Retail density (per road km)	*	*	*	*
land use mix				
Total number of buildings	1125	6689	2433	4162
Number of residential buildings	1035	6352	2329	3390
Number of residential units	*	7558	*	*
Residential-ness (% buildings residential)	92%	95%	96%	81%
Number of sales buildings	1	102	*	*
Number of services buildings	27	179	*	*
Retail provision (% buildings sales/service)	0%	12%	*	*
Employed residents - jobs ratio	*	*	*	*
Employed residents - retail/services ratio	*	*	*	*
Rural/Urban (% of buildings on piped water or sewer)	*	*	*	*
Number of grocery stores	0	28	*	*

AT - Built Environment Indicator	Hopewell	Glace Bay	Spryfield	Halifax Citadel
Number of convenience stores	0	22	*	*
Number of general merchandise stores	0	41	*	*
Number of business/office	2	39	*	*
Number of community service	17	46	*	*
Number of neighbourhood schools	0	10	*	*
Number of food and beverage	1	28	*	*
Number of personal services	0	21	*	*
Dwellings within 2.5km of grocery stores	0	6274	*	*
Dwellings within 2.5km of convenience stores	0	6352	*	*
Dwellings within 2.5km of general merchandise stores	0	6351	*	*
Dwellings within 2.5km of business/office	452	6345	*	*
Dwellings within 2.5km of community service	969	6352	*	*
Dwellings within 2.5km of neighbourhood schools	0	6352	*	*
Dwellings within 2.5km of food and beverage	135	6190	*	*
Dwellings within 2.5km of personal services	0	6352	*	*
% dwellings within 2.5km of grocery stores	0%	99%	*	*
% dwellings within 2.5km of convenience stores	0%	100%	*	*
% dwellings within 2.5km of general merchandise stores	0%	100%	*	*
% dwellings within 2.5km of business/office	35%	100%	*	*
% dwellings within 2.5km of community service	75%	100%	*	*
% dwellings within 2.5km of neighbourhood schools	0%	100%	*	*
% dwellings within 2.5km of food and beverage	11%	97%	*	*
% dwellings within 2.5km of personal services	0%	100%	*	*
Dwellings within 8km of grocery stores	0	6352	*	*
Dwellings within 8km of convenience stores	0	6352	*	*
Dwellings within 8km of general merchandise stores	0	6352	*	*
Dwellings within 8km of business/office	928	6352	*	*
Dwellings within 8km of community service	1034	6352	*	*
Dwellings within 8km of neighbourhood schools	0	6352	*	*
Dwellings within 8km of food and beverage	842	6352	*	*
Dwellings within 8km of personal services	0	6352	*	*
% dwellings within 8km of grocery stores	0%	100%	*	*
% dwellings within 8km of convenience stores	0%	100%	*	*
% dwellings within 8km of general merchandise stores	0%	100%	*	*
% dwellings within 8km of business/office	78%	100%	*	*

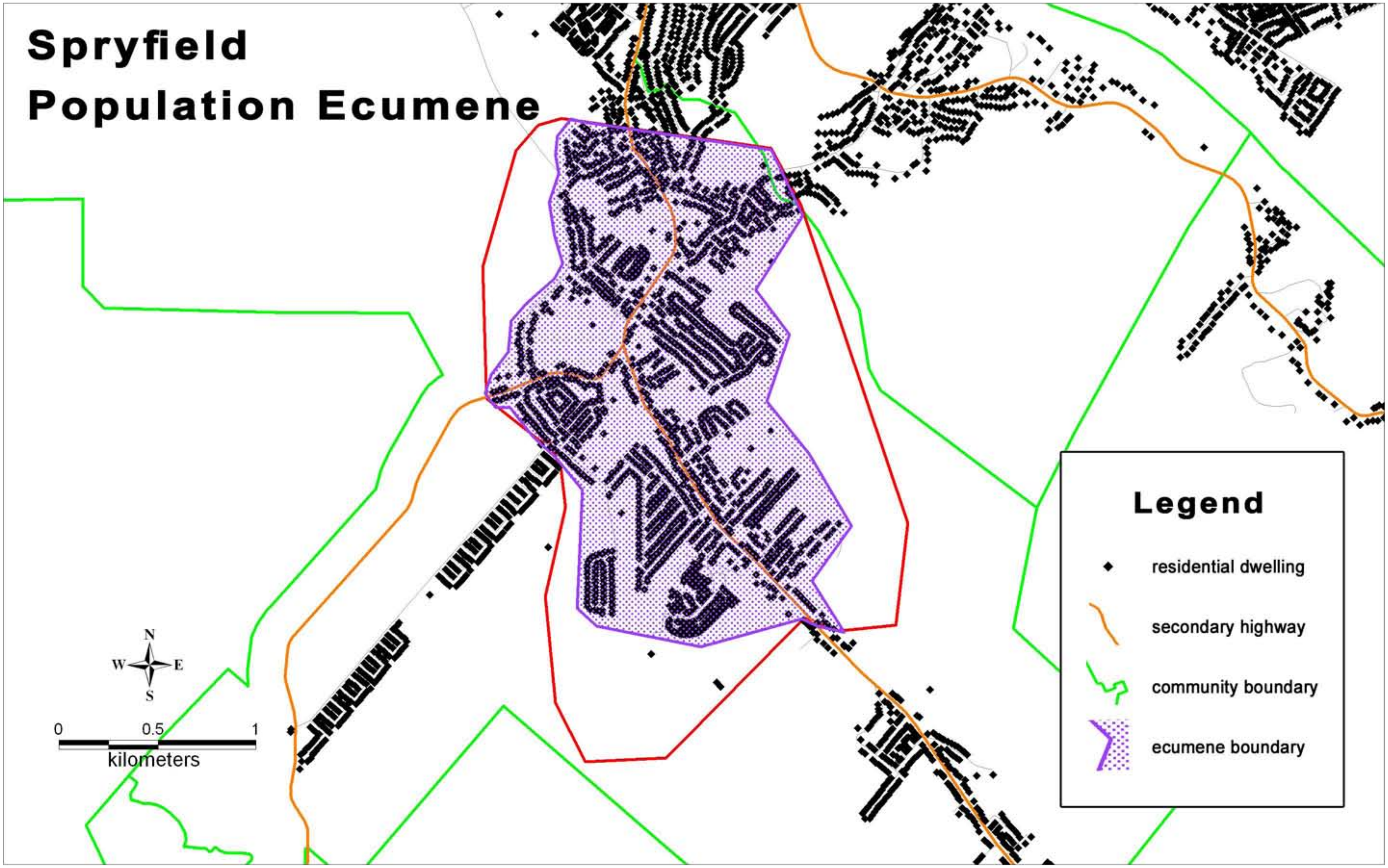
AT - Built Environment Indicator	Hopewell	Glace Bay	Spryfield	Halifax Citadel
% dwellings within 8km of community service	87%	100%	*	*
% dwellings within 8km of neighbourhood schools	0%	100%	*	*
% dwellings within 8km of food and beverage	70%	100%	*	*
% dwellings within 8km of personal services	0%	100%	*	*
Dissimilarity index	*	*	*	*
HHI index	*	*	*	*
Comparative land use mix / entropy index	*	*	*	*
infrastructure				
Roads (km)	192.9	121.8	58.2	60.4
Sidewalks (km)	*	*	*	*
Transit Service (total # buses/week)	*	*	*	*
Total # of bus stops	*	*	45	260
Dwellings within 500 m of bus stop	*	*	2,232	3385
% dwellings within 500 m of bus stop	*	*	95.8%	99.8%
Total # of dedicated bicycle parking spaces	*	*	*	*
Ratio of sidewalk km to street centreline km	*	*	*	*
Ratio of population to bicycle parking spaces	*	*	*	*
Dwellings fronting onto sidewalk	*	*	*	*
Average block size	*	*	*	*
Number of street links	*	*	147	*
Number of street nodes	*	*	117	*
Motorized connectivity index (street links / street nodes)	*	*	1.256	*
Number of non-motorized links	*	*	157	*
Number of non-motorized nodes	*	*	120	*
Non-motorized connectivity index	*	*	1.308	*

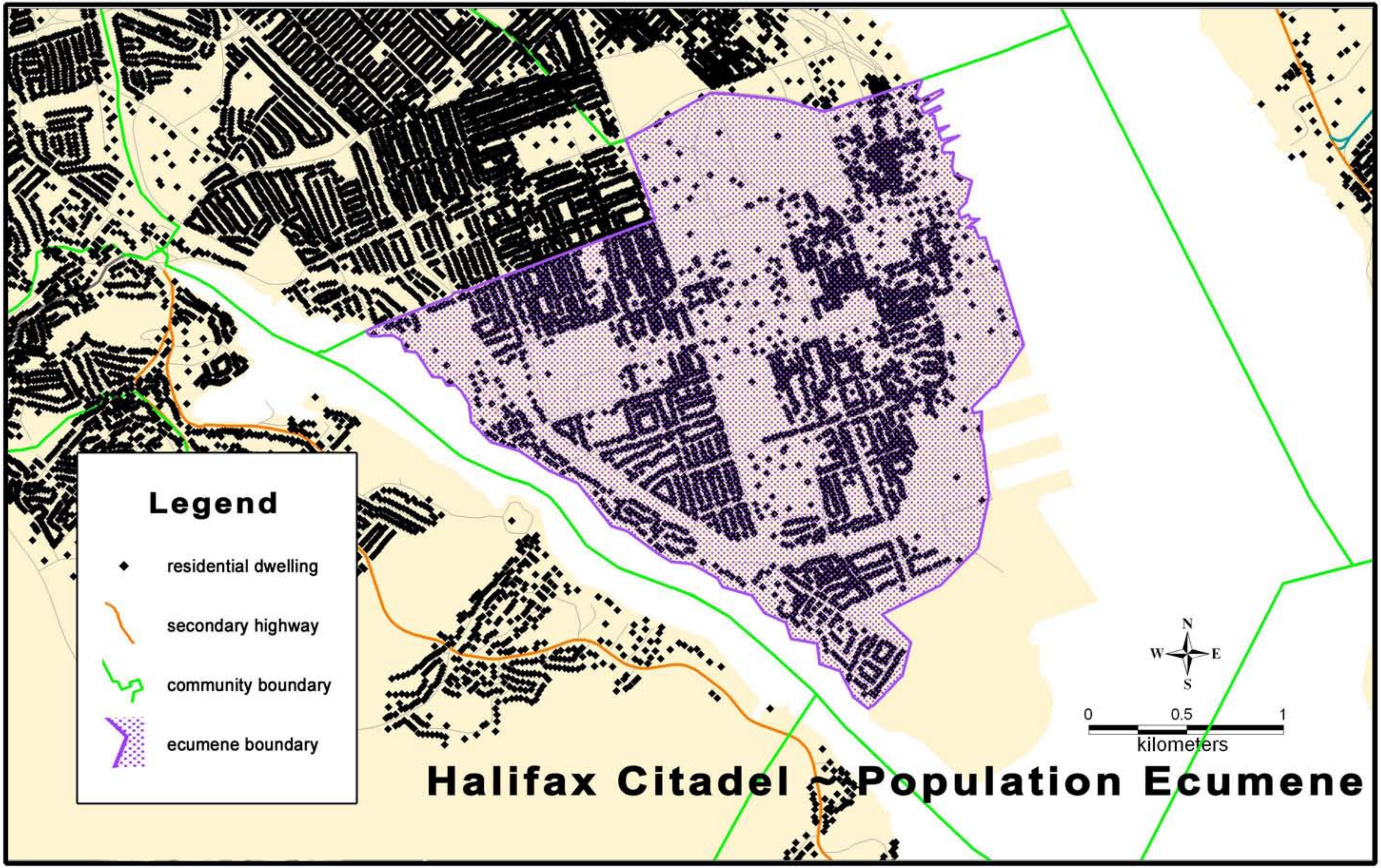
Active Transportation Output Indicators	Hopewell	Glace Bay	Spryfield	Halifax Citadel
journey to work (by mode)				
% car/truck/van to work (driver)	88.9%	79.4%	60.7%	33.3%
% car/truck/van to work (passenger)	8.5%	11.7%	11.7%	4.4%
% public transit to work	0.4%	1.3%	19.3%	6.6%
% walk to work	1.0%	5.1%	6.7%	52.5%
% bicycle to work	0.0%	0.0%	0.3%	2.7%
% motorcycle to work	0.4%	0.0%	0.0%	0.0%
% taxicab to work	0.0%	2.2%	0.5%	0.4%
% other mode to work	0.6%	0.4%	0.8%	0.3%
journey to school (by mode)				
% car/truck/van to work (driver)	*	*	*	*
% car/truck/van to work (passenger)	*	*	*	*
% public transit to work	*	*	*	*
% walk to work	*	*	*	*
% bicycle to work	*	*	*	*
% motorcycle to work	*	*	*	*
% taxicab to work	*	*	*	*
% other mode to work	*	*	*	*
non-home based trips (by mode)				
% car/truck/van to work (driver)	*	*	*	*
% car/truck/van to work (passenger)	*	*	*	*
% public transit to work	*	*	*	*
% walk to work	*	*	*	*
% bicycle to work	*	*	*	*
% motorcycle to work	*	*	*	*
% taxicab to work	*	*	*	*
% other mode to work	*	*	*	*
home-based discretionary trips (by mode)				
% car/truck/van to work (driver)	*	*	*	*
% car/truck/van to work (passenger)	*	*	*	*
% public transit to work	*	*	*	*
% walk to work	*	*	*	*
% bicycle to work	*	*	*	*
% motorcycle to work	*	*	*	*
% taxicab to work	*	*	*	*
% other mode to work	*	*	*	*
traffic safety				
Pedestrian - Motor Vehicle Collisions	*	*	*	*
Pedestrian - Motor Vehicle Injuries	*	*	*	*
Pedestrian - Motor Vehicle Fatalities	*	*	*	*
Cyclist - Motor Vehicle Collisions	*	*	*	*
Cyclist - Motor Vehicle Injuries	*	*	*	*
Cyclist - Motor Vehicle Fatalities	*	*	*	*

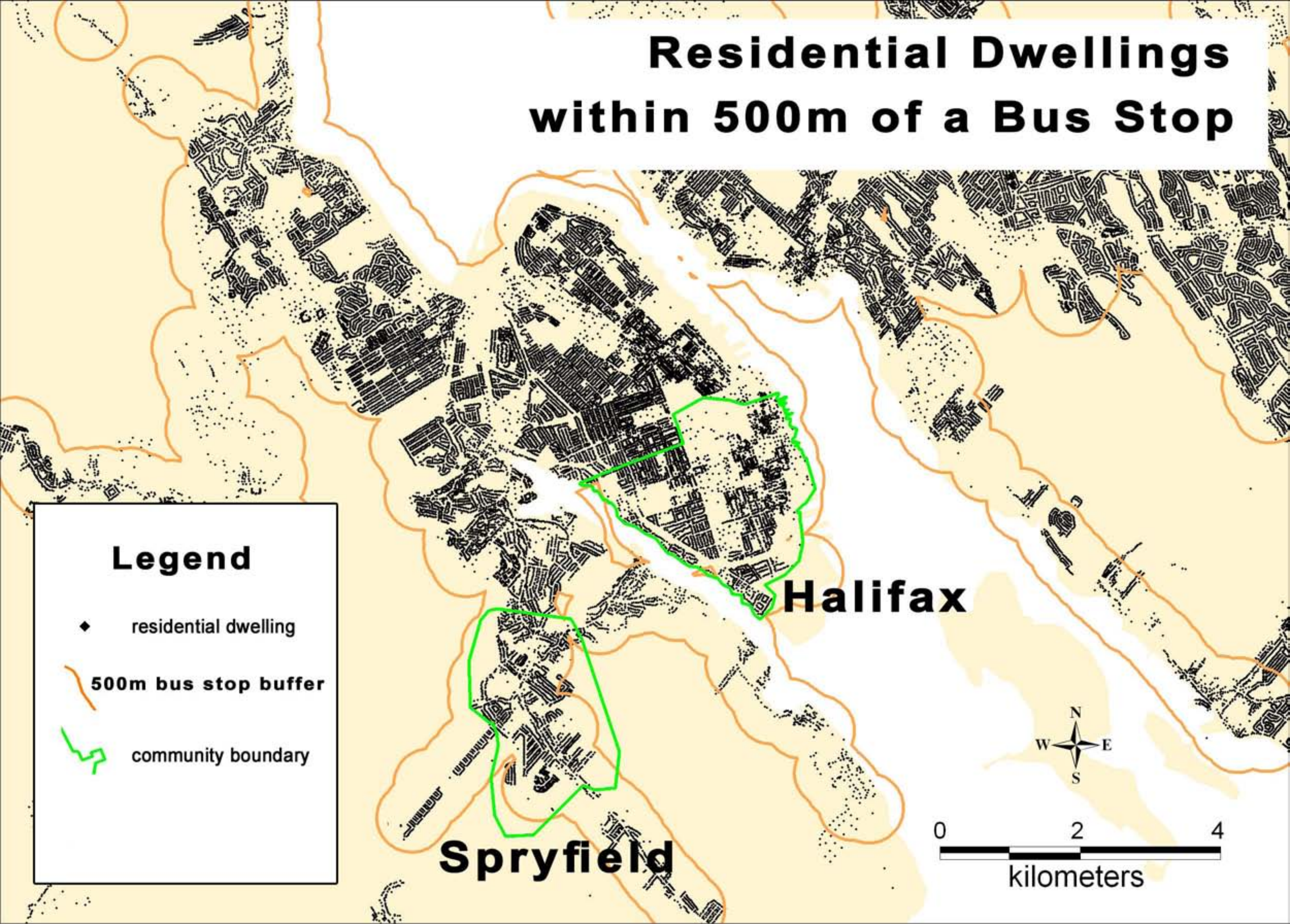

Legend
residential dwelling
secondary highway
community boundary
ecumene boundary
N
W
E
S
0
5
10
kilometers
Hopewell
Population Ecumene

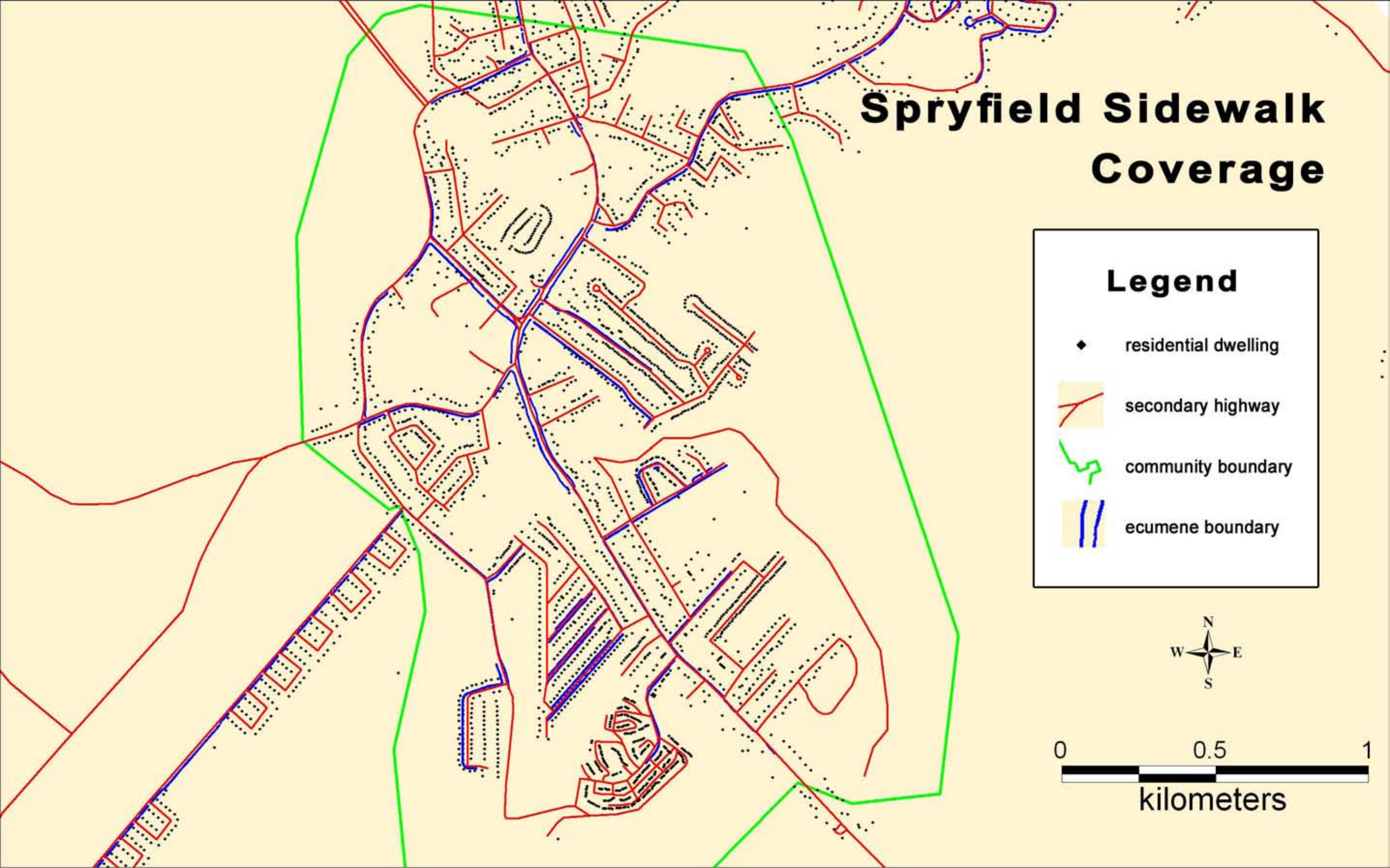


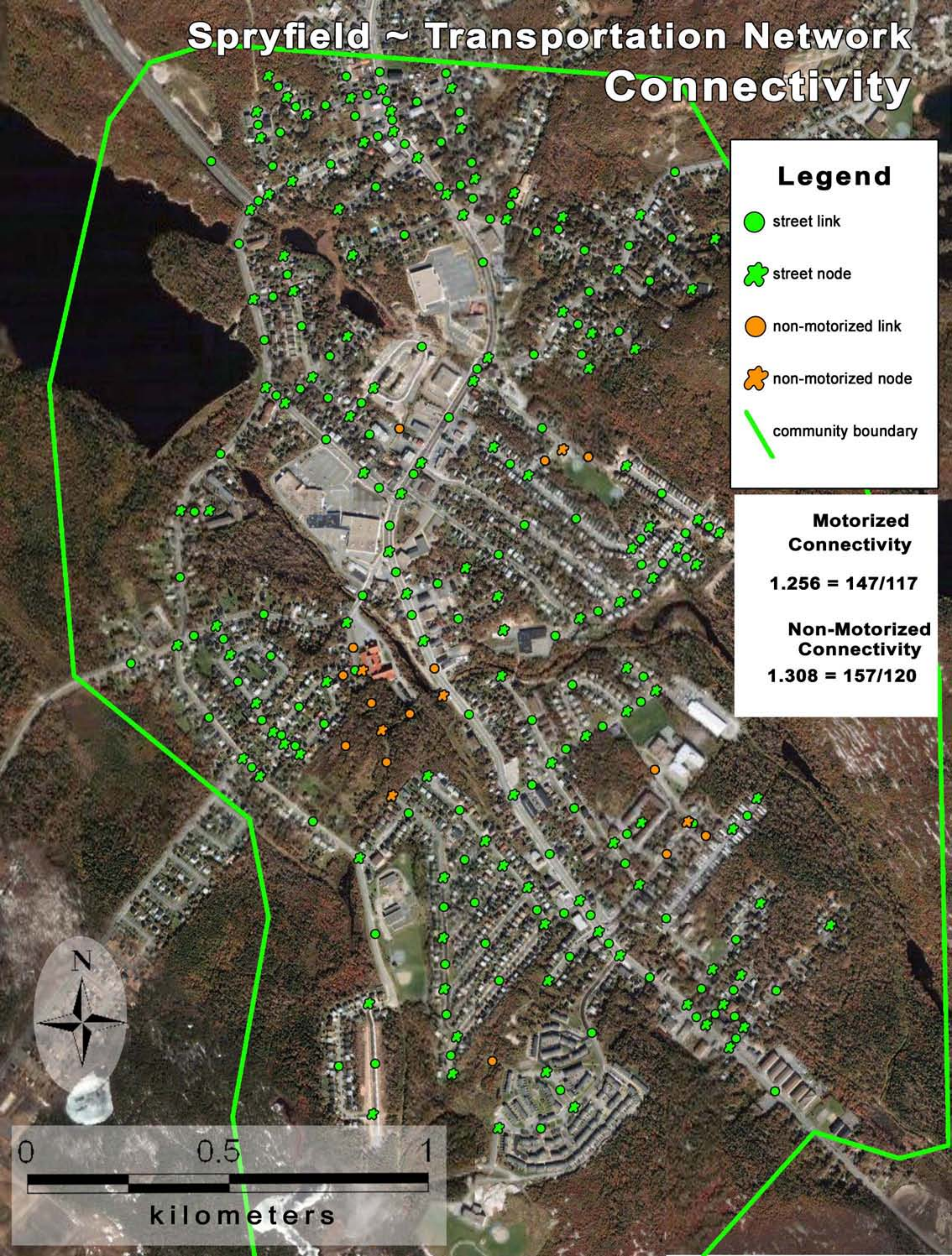
Glace Bay ~ Population Ecumene
Legend
residential dwelling
secondary highway
community boundary
ecumene boundary
0
1
2
kilometers
N
S
E
W


Spryfield
Population Ecumene
Legend
residential dwelling
secondary highway
community boundary
ecumene boundary
N
W
E
S
0
0.5
1
kilometers


Legend
residential dwelling
secondary highway
community boundary
ecumene boundary
N
W
E
S
0
0.5
1
kilometers
Halifax Citadel ~ Population Ecumene


Residential Dwellings
within 500m of a Bus Stop
Legend
residential dwelling
500m bus stop buffer
community boundary
Halifax
Spryfield
N
W
E
S
0
2
4
kilometers


Spryfield Sidewalk
Coverage
Legend
residential dwelling
secondary highway
community boundary
ecumene boundary
N
W
E
S
0
0.5
1
kilometers



Spryfield ~ Transportation Network
Connectivity
Legend
street link
street node
non-motorized link
non-motorized node
community boundary
Motorized Connectivity
1.256 = 147/117
Non-Motorized Connectivity
1.308 = 157/120
N
0
0.5
1
kilometers

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