Western Geography, 13/14 (2003/2004), pp. 109–131

[Re-] Designing Rural Residential Areas with Public Transit in Mind: Developing Indicators for Sustainable Transportation

Robert J. Patrick
PhD Candidate
Department of Geography
University of Guelph
Guelph, Ontario

The discipline of geography continues to provide a natural harbour for research in the field of sustainability. Research in this field has focused on the development of sustainability indicators as a means of measuring progress toward, or away from, sustainability. While sustainability indicators have been developed for urban, agricultural, and resource areas there has been little attention given to the sustainability of rural residential areas. Rural residential areas continue to attract growth at a pace often exceeding that of adjacent urban centres. A consequence of rural residential population growth is an increasing dependence on automobile mobility and associated negative externalities such as increased greenhouse gas emissions, ground-level air emissions, road congestion, and mobility deprivation for those without access to an automobile. It is suggested here that an alternative planning approach is needed for rural residential areas in order to reduce automobile dependency. This paper presents an alternative approach that emphasises the benefits of planning for community accessibility to public transit. An indicator methodology is introduced that provides for the evaluation of potential sustainability indicators. This research shows that land use and community design are critical factors influencing not only sustainable transportation but also the sustainability of rural residential areas.

Part I: Towards a definition of rural residential areas

The term *rural residential* is used throughout this paper to describe the semi-rural, predominantly non-agricultural areas dominated by the single-family dwelling. Rural residential population growth is partly the result of exurban migration beyond the urban fringe to semi-rural areas. The most telling feature of the rural residential landscape is its homogenous, single-family residential character. Other features include on-site servicing, a wide range of parcel sizes, relatively low population densities, the separation of land uses, and dependence on the private automobile as the principal mode of transportation.

Growth of a rural residential form

Many rural residential areas in North America are experiencing rapid population growth, partly the result of urban out-migration. For example, within British Columbia's Georgia Basin non-urban population growth during the 1990s outpaced that of adjacent urban areas including Vancouver and Victoria (British Columbia Statistics, July 2001).

Along with rural residential population growth is the transition of many rural economies from primary resource extraction to retail and commercial service industry. In many instances, local and regional governments have welcomed exurban population growth as a form of primary resource tax replacement, local economic boosterism, and as a source of local government revenue and activity. From an economic and social perspective, rural residential areas have contributed to an affordable housing stock while providing an alternate lifestyle option. From an ecological perspective, rural residential areas provide natural attributes by virtue of large land parcel sizes, proximity of resource lands, and reduced reliance on centralized infrastructure.

On the negative side, the most common mode of transportation in rural residential areas is the private automobile. The traditional planning approach in rural residential areas is emblematic of automobile mobility reflected in land use separation, roadway capacity, large residential land parcels, and other community design features favouring the private automobile. Current growth trends in rural residential areas will increase total automobile dependency exacerbating road congestion, ground level pollution, greenhouse gas emissions, and further isolate the mobility deprived.

A substitute for automobile dependency

Transportation planners since the 1950s have focused their efforts on improving community access by increasing automobile mobility. The belief was that better access to community amenities could only be provided with more automobiles moving more quickly on more roads. However the literature has shown the addition of road space only provides temporary relief from road congestion (Litman, 1999a; Roseland, 1998). An alternative planning approach is suggested in the literature that places greater emphasis on reducing the overall need for automobile mobility and increasing community access to public transit through improved land use and community design (Newman and Kenworthy, 1999; Cervero, 1987a; Blowers, 1978). Where the traditional transportation planning approach views automobile mobility as an end in itself, the alternative approach introduced in this paper, or sustainable transportation, focuses on opportunities for reducing the overall need for automobile mobility and improving community access to public transit.

Sustainable transportation in rural residential areas

The last decade has seen a shift in urban planning policy from private automobile mobility towards improved community access to public transit. The presence of public transit in the urban environment has been interpreted as a significant step towards urban sustainability. In the words of Newman and Kenworthy (1999), where transit growth does take place, it is a positive sign of sustainability. However, rural residential planning policy is largely silent on community accessibility and continues to facilitate private automobile mobility through planning regulations that set large land parcel sizes, land-use separation, auto-oriented building design, excessive vehicle parking requirements and relentless road capacity expansion. However, despite this condition, there are small signs of positive change. The expansion of regional bus transit services to small communities in British Columbia[1] has the potential to increase the sustainability of these areas for three reasons. First, improving access to public transit provides an alternative mode of transportation for those in society without access to an automobile, the mobility deprived. Second, access to public transit provides a mobility option to the private automobile owner thereby reducing auto emissions, road congestion, and the demand for new roads. Third, the presence of public transit has the potential to influence land-use activities and community design features thereby reducing the overall need for mobility.

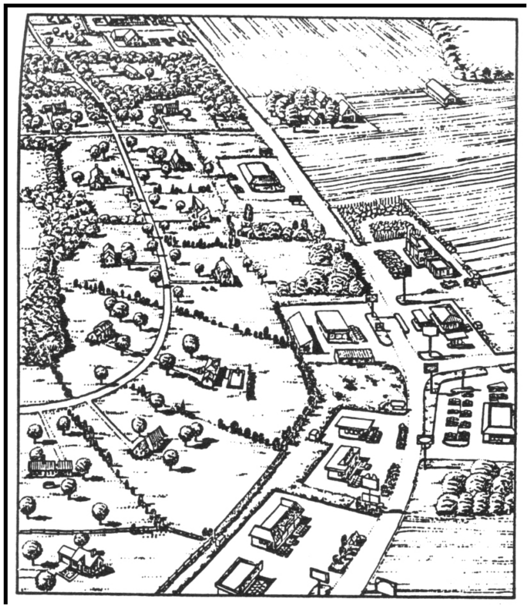
The following section will examine the potential for reducing rural residential automobile dependency and the promotion of sustainable transportation through greater attention to land use activities.

Land use and sustainable transportation

Land-use and transportation, in the words of Roseland (1998) are inextricably linked. The spatial distribution of land-use activities, whether residential, commercial, or industrial influence mode of transportation and frequency of travel. The transportation system, on the other hand, influences the distribution of land-use activities. This sub-section will examine how land-use, including the composition of land-use activities and density, influences access to sustainable mobility, namely public transit in rural residential areas. To exemplify what Cervero (1987b) terms the land use - transportation link, numerous authors have emphasized the need to adopt land use policies that reduce the overall need for transportation (Roseland, 1998; Newman and Kenworthy, 1999; Cullinane and Stokes, 1998). Roseland (1998), for example, finds that our current automobile dependency is the symptom of a planning approach that placed transportation decisions ahead of land use decisions. Land use planning that aims to reduce transportation demand will need to focus on reducing the distance between work, home, and recreation. This will be accomplished through clustering residential density and introducing mixed land-use activities such a commercial retail with single family residential.

Cluster density in rural residential areas

Locating activity sites, including shops and schools, in close proximity to areas of relatively large population density reduces the overall need for mobility. Blowers (1978) supports this approach in the name of increasing self-sufficiency and the strengthening of local villages. According to Newman and Kenworthy (1999) the creation of nodal, village centres will reduce automobile dependency and increase the efficiency of public transit. Moreover, Arendt (1994) has shown that clustering rural residential housing helps to preserve the natural amenities of the surrounding lands. Figures 1 and 2 present two development scenarios over the same track of land. Figure 1 presents a traditional rural residential landscape while Figure 2 presents a clustered development concept. While the same number of homes and commercial development are accommodated in both scenarios, a far greater amount of open space is preserved in Figure 2. Cluster development, especially in rural residential areas, yields environmental benefits including habitat preservation, increases opportunities for social interaction as well as increasing public transit viability.[2]

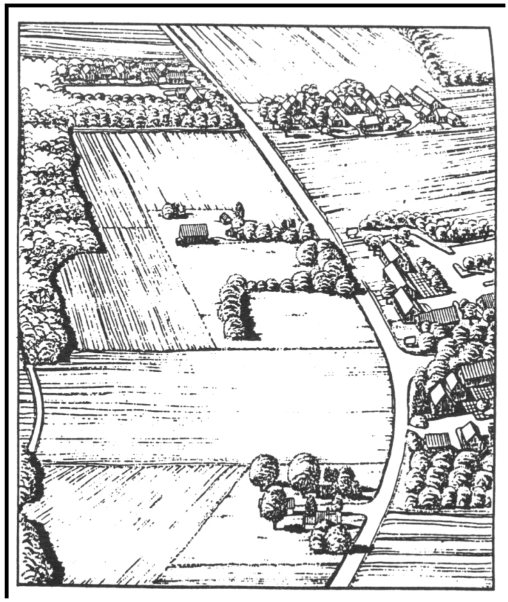


Source: Arendt, 1994

Figure 1: Conventional development scenario

Introduction of mixed land uses

Numerous authors now challenge the continuation of land use separation, particularly in light of its dependency on automobile mobility. Alexander and Tomalty (2001) stress that efforts need to be made at building more "complete communities", where people can meet a majority of their needs close to home. Sensible land-use, according to Litman (2001), would make automobile trips unnecessary by clustering a variety of land-uses within walking distance. The single most important contributor to sustainable transportation is a reduction in the need for travel, and the most effective approach towards reducing travel is through land-use planning that supports mixed development (Wadhwa 2000). Table 1 provides information to suggest that decisions around land use activities have a significant impact on vehicle travel.



Source: Arendt, 1994

Figure 2: Cluster development scenario

Table 1 Travel impacts of land use activities

Design Features	*Reduced Vehicle Travel*
Residential mixed-use around transit centres	15%
Commercial mixed-use around transit centres	20%
Residential mixed-use along transit corridors	7%
Commercial mixed-use along transit corridors	10%
Residential mixed-use development	5%
Commercial mixed-use development	7%

Source: Litman, 2001

The following section will examine the potential for reducing rural residential automobile dependency and the promotion of sustainable transportation through greater attention to community design.

Community design and sustainable transportation

Curvilinear road layouts, cul-de-sac road ends, and the lack of pathway easements to transit corridors all combine to isolate residents from public transit. Within the rural residential landscape, opportunities to create more accessible and livable neighbourhoods using public transit include establishing village centres, limiting road capacity expansion, as well as designing subdivisions and retail areas with the pedestrian in mind.

Improved subdivision design

Where rural residential subdivision takes place, consideration for the needs of bus transit service should produce designs that encourage, and not discourage, transit use. For example, dead-end roads, cul-de-sac features, and curvilinear road designs often operate counter to bus transit operation. Dead end roads and cul-de-sacs challenge bus turning radii and force bus routes to back track on the same road. Curvilinear subdivision roads that are isolated from established transit grid routes place residents at great distance from transit stops. Where curvilinear road designs are promoted as a form of traffic calming, pedestrian easements providing access to the transit corridor must be planned. Since access to bus transit mobility begins and ends with a walking component, distance to a transit stop is very significant. Research has shown that pedestrians are willing to walk, on average, approximately 350-450 metres to public transit[3]. Beyond this distance, other forms of transportation including the private automobile become more appealing.

Reduce road capacity

Ross (1999) shows that by reducing road capacity private automobile usage drops and public transport usage rises. Road capacity reduction limits the mobility of the private automobile and raises that viability of bus transit, especially where dedicated bus lanes are built. Within rural residential and small town areas, road capacity reduction may be achieved by allowing curbside parking, returning one-way street traffic to bi-directional traffic, retaining rural road character by maintaining open swale drainage systems, and by resisting provincial and federal funding incentives to straighten and widen existing roads. As road space becomes a shared space, more people will be attracted to public bus transit as well as other community modes including cycling and walking (Ross, 1999). Any increase in road space for automobiles, states Engwicht (1992), is a decrease in walking and cycling space for everyone. Figure 3 provides a schematic of an alternative approach to rural residential planning that emphasizes community accessibility to public transit. It is envisioned that the establishment of village nodes with limits on new road expansions will cause a cascade effect reducing settlement sprawl, automobile dependency, and road congestion while increasing road safety, transit viability and community livability.

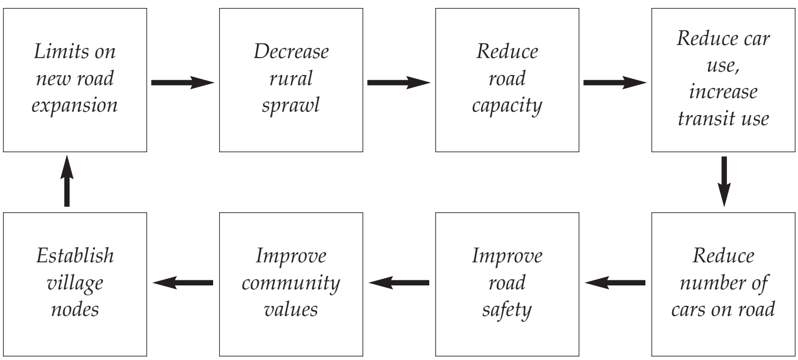


Figure 3 The accessibility approach to rural residential transportation planning (after Ross, 1999)

Commercial building design

Since all transit trips involve some degree of walking, it follows that transit-friendly environments must also be pedestrian-friendly (Bernick and Cervero, 1996). Transit supportive commercial design features include parking at the rear of commercial buildings, continuous sidewalks, street-orientation, good lighting, and pedestrian-marked road crossings (BC Transit Authority Briefing Book, 1997). Figure 4 provides an example of an automobile-orientated site design while Figure 5 provides an example of a transit-oriented site design. Figure 4 shows buildings located at the rear of the property and surface parking in the front. Under such conditions, transit and pedestrian access is inconvenient and unsafe. By contrast, Figure 5 provides for buildings located at the front of the property allowing direct access from the street.

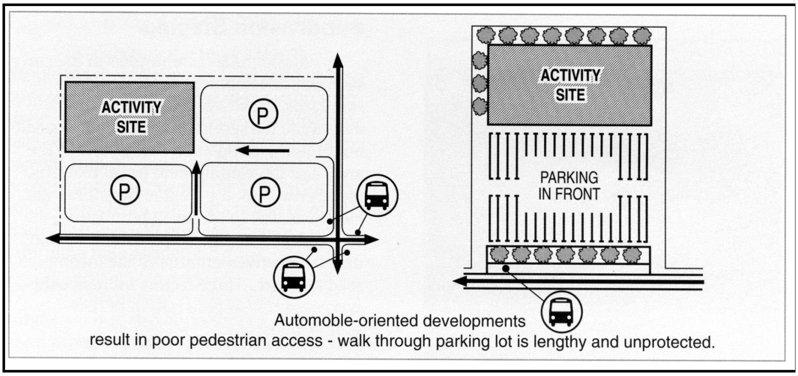


Figure 4 Automobile-oriented site design
Source: BC Transit Authority Briefing Book, 1997

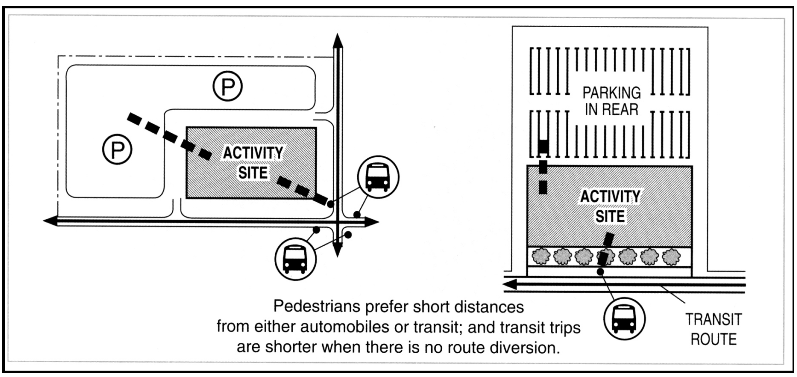


Figure 5 Transit-oriented site design
Source: BC Transit Authority Briefing Book, 1997

Part I of this paper introduced the rural residential landscape and the challenge of sustainable transportation. It has been suggested that greater attention be placed on land use and community design in order to reduce automobile dependency, encourage community access to public transit, and enhance quality of life in these increasingly popular areas. Part II of this paper will develop an indicator framework for promoting sustainable transportation in rural residential areas.

Part II: Research Design

This section of the paper will identify land use and community design indicators based on access to public transit. A broad list of sustainable transportation indicators will be taken from the literature. Using this list, a set of data quality criteria will be used to identify potential land use and community design indicators for further consideration. The final stage will apply sustainable transportation criteria to the previously identified potential indicators to yield a final list of high priority indicators.

Developing Sustainable Transportation Indicators

Concepts such as sustainability offer a unique challenge with respect to measurement. As a tool to measure progress toward, or away from, sustainability, proponents have come to rely upon the use of sustainability indicators (Sheltair Group Inc., 1998; Wilkinson and Baruah, 2001; Litman, 1999c; Sarmento et al., 2000; MacDonald, 2000).

Indicators, according to Babbie (1983), will be real and observable things that give evidence of the presence or absence of the concept we are studying. The Sheltair Group Inc. (1998) define indicators as a conceptual tool, expressed in clear and precise terms, that measure progress toward, or away from, an objective. Within the literature considerable attention is given to the qualities of "good" sustainability indicators. For example, Sarmento et al. (2000) state that a good indicator is responsive to external stimuli thus alerting the investigator to a problem before the problem grows too large and that a good indicator recognizes what needs to be done to remedy such a problem. Maclaren (1996) provides data quality criteria for the selection of sustainability indicators. A description of these criteria is presented in Table 3.

Table 3: Data quality criteria for sustainability indicators

	Criteria	*Description/Comments*
A	Validity	A fundamental requirement Does the indicator measure an aspect/dimension of sustainability The extent to which the indicator relates to the commonly accepted meaning of the particular concept under study, in this case sustainable transportation
B	Reliability	Ensures data is independent of the researcher
C	Representative	An indicator which is representative of the issue of concern or of a broad range of environmental, social, and economic conditions
D	Responsive	An indicator that can distinguish between normal cycles and movement away from or toward a sustainable state. An indicator that detects change from external stimuli, eg. policy intervention.
E	Relevant to users	Ensures that the needs of the target audience are met.
F	Relevant to goals (construct validity)	The indicator should be relevant to a predetermined set of goals.
G	Based on accurate, available, accessible data	Recognizes limitation of data. Over time data quantity/quality should improve.
H	Understandable by potential users	Scientific content of an indicator must match the assumed scientific knowledge of the target audience.
I	Comparable to thresholds or targets	Effective indicators allow for measuring progress towards a variety of goals and are therefore important from a policy perspective.
J	Comparable with other jurisdictions (external validity)	Allows local governments to compare progress towards sustainability. However, not all governments want to be compared. Different communities have different characteristics
K	Cost-effective	Need for organizations/governments to share data, reduce data acquisition costs. Costs need to be amortized over the long term.
L	Unambiguous	Indicators should be unambiguous. All should agree on how an indicator is to be interpreted, eg. is rapid population growth healthy or unhealthy for a community
M	Attractive to the media	The media is still the best way to get the sustainability word out. Well designed indicators provide for strong, coherent messages to the public, e.g., "Fate of the Strait" series (The Vancouver Sun, 1998/1999).

Source: Modified after Maclaren, 1996

Maclaren's data quality criteria are significant in that they have been utilized frequently by others engaged in developing sustainability indicators (Wilkerson and Baruah, 2001; MacDonald, 2000; Sarmento et al., 2000; Hart, 1999). The criteria that will be used in this paper are as follows:

- Data Validity (data truly measures an aspect of sustainable transportation)
- Data Reliability (data is reliable irrespective of the researcher)
- Representative (data is representative of the three spheres of sustainability)
- Responsive (data will readily respond to external stimuli?)
- Data Availability (data is accurate and readily available)
- Understandable (data is understandable by potential users)

Potential indicators of sustainable public transportation

The types of indicators available for research are almost limitless. For the purpose of this paper the indicators will be specific to land use activities and community design features. The public transit indicators listed in Tables 3 and 4 are the product of a broad literature review (Sarmento et al., 2000; MacDonald, 2000; Hart, 1999; Litman, 1999c; Newman and Kenworthy, 1999; Cullinane and Stokes, 1998; Sheltair Group Inc., 1998; BC Transit, 1997; Sargeant et al., 1991).

Tables 3 and 4 provide data quality criteria for the evaluation of land use indicators and community design indicators respectively. Only those potential indicators that contain all of the data quality criteria outlined above will be considered as candidates for priority indicators.

Table 4: Data quality criteria for land use indicators

Land Use Indicators	Data Quality Criteria: Data Validity	Data Reliability	Represent-ative	Respons-iveness	Data Availability	Under standable
1. Percent of housing stock within 450 metres of commercial shops	+	+	+	+	++	++
2. Percent of housing stock within 450 metres of a bus transit route	+	+	+	+	++	++
3. Percent of transit accessible housing stock per kilometre of transit road length	+	+	+	+	+	+
4. Percent of potential new lots within 450 metres of a bus route	+	+	+	+	++	+
5. Regional settlement density	+	+	0	+	+	0
6. Commercial Land Use density	+	+	0	+	+	0
7. Population density of transit service area (inter-regional conventional)	+	+	+	+	+	+
8. Automobile registration per capita	+	++	0	+	+	+
9. Percent of institutional/commercial parking that is free	+	+	+	+	+	+
10. Transit rides per capita (inter-regional, conventional service)	+	+	+	+	0	0
11. Total cost of transit service per ride	+	++	0	+	+	+
12. Transit cost recovery (total cost divided by fares)	+	+	0	+	++	++
13. Transit rides per hour of service (inter-regional conventional)	+	+	0	+	+	+
14. Percent of OCP Goals with reference to comm. accessibility	+	+	+	+	++	+
15. Percent of OCP residential land use objectives and policies with specific reference to nodal or clustered development	+	+	+	+	++	+
16. Percent of OCP land use policies in support for integrated land use, eg. home based business, auxil. uses	+	+	+	+	++	+
17. Percent of OCP transportation objectives and policies with specific reference to public transit amenities	+	+	+	+	++	+
18. Percent of all trips that are local, ie within the same community	+	0	+	+	0	+
19. Greatest demand for expanded transit service: village/ residential/or rural areas	+	+	0	0	+	+
20. Transit kilometers per capita service area	+	0	0	+	+	0
21. Mandatory referral of subdivision and rezoning applications from local government to transit committee, staff (Yes/No)	+	+	+	+	+	+

++ - denotes data quality criteria **strongly** represented in proposed indicator
\+ - denotes data quality criteria **moderately** represented in proposed indicator
0 - denotes data quality criteria not represented in proposed indicator

Table 5: Data quality criteria for community design indicators

Community Design Indicators	Data Quality Criteria: Data Validity	Data Reliability	Represent-ative	Respons-iveness	Data Availability	Under standable
1. Transit road length as a percent of total road length	+	+	+	+	+	+
2. Percent of population over age 75, under 19 years	0	++	0	+	+	+
3. Percent of choice rider (access to car but choose bus)	+	+	+	+	0	+
4. Percent of dedicated riders (use bus more than 3 days/week	+	+	0	0	0	+
5. Other non-bus transit options for riders (ie vehicle, walk, bike)	+	+	0	0	+	+
6. Weekday route productivity (rides per service period)	0	+	0	+	+	+
7. Weekday total passengers per service hour by route	0	+	0	0	+	+
8. Weekday total cost per ride per hour of service by route	0	++	0	0	++	++
9. Accident injuries and deaths resulting from public transit versus private automobile	+	++	+	+	++	++
10. Percent rider distribution by passenger group (BC Passes, senior, students, adults)	+	++	0	+	++	++
11. Total handyDART cost per ride (intra/inter-regional)	0	+	0	+	+	+
12. Total handyDART cost per hour (intra/inter-regional)	0	+	0	+	+	+
13. Total handyDART cost recovery (intra/inter-regional)	0	+	0	+	+	+
14. Percent of OCP development permit guidelines with reference to design criteria for transit	+	++	+	+	+	++
15. Percent of bus stops with dedicate pull-outs	+	++	+	+	+	+
16. Percent of major local employers that offer employee incentives to ride transit as opposed to providing (free) on-site parking	++	+	+	+	+	++
17. Presence of a centralized bus inter-change (Yes/No)	+	++	+	+	+	+
18. Percent of store-front bus stops	++	++	+	+	+	+
19. Mandatory building permit referrals from local government building/eng. department to local transit authority for all proposed commercial, indus-trial and multi-family buildings	+	++	+	+	++	+
20. Percent of community design features favouring access by public transit versus access by private automobile	+	+	+	+	+	+

++ - denotes data quality criteria **strongly** represented in proposed indicator
\+ - denotes data quality criteria **moderately** represented in proposed indicator
0 - denotes data quality criteria not represented in proposed indicator

Sustainable Transportation Criteria

To facilitate the evaluation of potential indicators that were identified in the previous section it is necessary to establish a set of sustainable transportation criteria. MacDonald (2000) suggests five criteria for sustainable transportation indicators: transportation efficiency, land use efficiency, environmental impact, human livability, economic efficiency.

Transportation Efficiency

Transportation efficiency contains three components. The first of these relates to the people moving capacity of any transport system (Table 6). When the people moving capacity of a transportation system has been increased so too has the transportation efficiency of that system. In this sense transportation efficiencies will be gained by transforming the rural residential region away from automobile dependency. This first component of transportation efficiency will express itself through sustainability indicators that examine alternate modes to the private automobile.

Table 6: Person moving capacity of a one lane roadway

Transport mode	*Person moving capacity per hour (based on a single lane, 4 metre road)*
Walk	7,200
Bicycle	6,000
Transit bus	4,000
Private automobile (occupancy = 1.2)	2,000

Source: after MacDonald, 2000

The second component of transportation efficiency relates to the inter-relationship between transportation and land use. The most efficient transportation system will be provided through land use patterns that minimize the need for travel. Minimizing the need for travel in rural residential areas will be enhanced through accessibility planning policies which include, but are not restricted to, home occupations, mixed land uses, and nodal growth centres. Indicators that emphasize the need for minimal travel will provide the second component of transportation efficiency. The third component of transportation efficiency will address mobility deprivation. Providing mobility indicators for the elderly, the young, the under-employed, and the disabled will offer a useful measure of transportation efficiency. Examples of transportation efficiency indicators include proximity of housing to commercial shops, commercial land use density, percent of official community plan policies supporting clustered development, percent of all trips that are local, and availability of special transit services such as handyDART[4], paratransit, and taxi ride share.

Land use efficiency

MacDonald (2000) defines land use efficiency as the optimization of spatial efficiencies through the minimization of land consumption. In rural residential areas, optimization of spatial efficiencies will contribute to more than land use efficiency. Arendt (1994) has illustrated that clustering not only places people closer to the goods and services they need, but also helps to preserve the natural features of the region (see Figures 1 and 2). Wetlands, agricultural lands, and woodlands provide natural capital to human settlement and enhance the economic and social value of development. Examples of sustainability indicators of land use efficiency include cluster development policies in Official Community Plans of local government, subdivision designs that facilitate public access to transit, presence of commercial development nodes and mixed use development nodes.

Environmental Impact

A sustainable community has been defined as being in balance with economic, social and natural systems by reducing and converting waste into non-harmful and beneficial products (Kline, 1997). To this extent, the private automobile stands in direct conflict with sustainability. Environmental impacts associated with automobile dependency include air, water and land pollution all of which have significant human health implications. For example, the transportation sector is the largest contributor of greenhouse gases per year (41%) in British Columbia. This translates into over eight tonnes of carbon annually per capita (Alexander and Tomalty, 2001). The trend in British Columbia is for more, and larger, automobiles with a commensurate increase in greenhouse gas emissions.[5] Examples of sustainability indicators of environmental impact will include the provision of bike rack equipped buses, percent of choice riders[6], provision for intermodal fare travel, percent of road system accessed by transit, and percent of transit vehicles using alternate fuels.

Economic Efficiency

Economic efficiency is an important criteria in that it aims to ensure all users of the transportation system pay the true cost of their transportation choice. For example, automobile users do not pay compensation for the negative impacts they impose on society as a result of automobile emissions. From another perspective, free parking provides an unfair subsidy to automobile users, encourages automobile use, and increases the cost of development for everyone, including those without access to an automobile (Shoup, 1995). A well-designed or innovative transit schedule will move people into commercial, entertainment, or recreational areas at optimal times. Examples of sustainability indicators of economic efficiency include proximity of residences to commercial shops, employer subsidized transit passes, Official Community Plan (OCP) policies favouring nodal development over sprawl, and the timing of transit service relative to other transportation services and community services.

Human Livability

Sometimes referred to as "quality of life", human livability reflects many of the qualitative aspect of a community. As such, human livability can be difficult to define, and even more difficult to measure. Kline (1997) defines human livability as something akin to human well-being which includes sense of place, sense of self-worth, and sense of safety. Appleyard (1981) proved that human livability is enhanced when citizens experience a sense of belonging and a sense of peace and safety with the streetscape. The introduction of public transit into rural residential areas has a significant benefit in terms of transport safety. Engwicht (1992) introduces the importance of public participation in community decision making. Public participation in decision making raises the level of community empowerment and equity (MacDonald, 2000; Engwicht, 1992). An example of a sustainability indicator of human livability will include public representation on transit committees.

Evaluation

A quantitative ranking system (see Tables 7 and 8) based on the work of MacDonald (2000) will rank each of the indicators as having a priority of high, medium or low. For example a "High" priority indicator will be one that has a significantly positive impact on sustainable transportation. Planners and policy makers should focus attention on "High" priority indicators to affect change in their communities with respect to improving access to public transit. Conversely, a "Low" priority indicator will be one that has no impact on sustainable transportation. The scoring system for each priority indicator is based on a single point for a moderately positive (+) indicator, a double point for a significantly positive indicator (++), and no score where an indicator has no impact (0). Indicators will be considered high priority when their aggregate score for all criteria is 8 or greater, medium when between 5 and 7, and low when below 5.

Table 7: Evaluation of Land Use Indicators

	Sustainable Transportation Criteria					Priority (Score)
Community Design Indicators	Transport Efficiency	Land Use Impact	Environ-mental Impact	Economic Efficiency	Human Livability	High/Med/Low
1. Percent of housing stock within 450 metres of commercial shops	++	++	++	++	++	H (10)
2. Percent of housing stock within 450 metres of a bus transit route	++	++	++	++	++	H (10)
3. Percent of transit accessible housing stock per kilometre of transit road length	++	++	++	++	++	H (10)
4. Percent of potential new lots within 450 metres of a bus transit route	++	++	++	++	++	H (10)
5. Commercial Land Use density	+	+	+	+	+	M (6)
6. Population density of transit service area	+	+	+	+	+	M (6)
7. Percent of institutional /commercial parking that is free	+	+	+	+	+	M (6)
8. Percent of OCP Goals with specific reference to community accessibility	++	++	++	+	++	H (9)
9. Percent of OCP residential land use objectives and policies with specific reference to nodal development	++	++	++	++	++	H (10)
10. Percent of OCP land use policies in support for integrated land use, eg. home based business, auxil. uses	++	++	+	+	+	M (7)
11. Percent of OCP transportation objectives and policies with specific reference to public transit accessibility	++	+	++	+	++	H (8)
12. Greatest demand for expanded transit service: village/residential/or rural areas	+	+	+	+	+	M (6)
13. Mandatory referral of subdivision, and rezoning applications from local government to transit committee/staff (Yes/No)	++	++	+	+	++	H (8)

Table 8: Evaluation of Community Design Indicators

Community Design Indicators	Sustainable Transportation Criteria: Transport Efficiency	Land Use Impact	Environmental Impact	Economic Efficiency	Human Livability	Priority (Score) High/Med/Low
1. Transit road length as a percent of total road length	++	++	+	++	++	H (9)
2. Accident injuries and deaths resulting from public transit versus private automobile	++	++	++	++	++	H (10)
3. Percent of OCP development permit guidelines with reference to design criteria for public transit	++	++	+	+	++	H (8)
4. Percent rider distribution by passenger group (BC Passes, senior, students, adults)	+	+	+	+	+	M (6)
5. Total handyDART cost per ride (intra/inter-regional)	+	+	+	+	+	M (6)
6. Percent of major local employers that offer employee incentives to ride transit as opposed to providing (free) on-site parking	+	++	++	++	++	H (9)
7. Mandatory building permit referrals from local government building/eng. department to local transit authority for all development permits and non-residential building permits	++	++	+	++	+	H (8)
8. Percent of community design features favouring access by public transit	++	++	+	+	++	H (8)

++ - denotes significantly positive impact on sustainability
\+ - denotes moderately positive impact on sustainability
0 - denotes no impact on sustainability

Conclusion

This paper introduces an alternative approach to planning in rural residential areas. The alternative approach favours the reduction of the overall need for automobile mobility while increasing community access to public transit. To operationalize this alternative approach a framework is presented for the evaluation of potential sustainability indicators. It is shown that in order to reduce automobile dependency and increase accessibility to public transit areas greater attention must be given to land use and community design in rural residential areas.

Acknowledgements

This paper is based on research from my masters thesis completed at Simon Fraser University in April 2002 entitled

"Developing Sustainability Indicators for Rural Residential Areas: The Public Transit Connection". Preliminary findings in this paper were presented at the Western Division of the Canadian Association of Geographers annual conference held at the University of Calgary in 2001. Special thanks to my graduate committee, Mark Roseland and Len Evenden at SFU, Greg Halseth at the University of Northern British Columbia, Jim Windsor at the College of New Caledonia, and an anonymous reviewer for valuable commentary on an earlier draft of this paper.

Notes

1. BC Transit Municipal Systems Program (1997).

2. Household density of 5 units per acre are necessary to support fixed route, one hour schedule bus transit service (Bernick and Cervero, 1996).

3. Guidelines for Public Transit in Small Communities, Urban Transit Authority of BC (1980).

4. handyDART—BC Transit custom transit program (handy Dial-A-Ride Transportation is a door-to-door service available for those persons unable to use conventional service for reasons of physical or mental disability (BC Transit Authority Municipal Systems Program Briefing Book, 1997).

5. Greenhouse gas emissions from cars and trucks in BC increased by almost 20% from 1990-1997 (Alexander and Tomalty, 2001).

6. Choice riders are those transit riders with access to a private automobile but instead choose to use public transit for a portion of their transportation needs.

References

Alexander, D. and R. Tomalty. (2001) *The BC Sprawl Report 2001.* [http://www.SmartGrowthBC] last accessed March 10-15, 2002.

Appleyard, D. (1981). *Liveable Streets.* Berkeley, CA: University of California Press.

Arendt, R. (1994). *Rural by Design: Maintaining small town character.* Chicago: American Planners Association Planners Press.

Babbie, E. (1983). *The Practice of Social Research* 3rd Edition. Belmont, California: Wadsworth Publishing Company.

Bernick, M. and R. Cervero. (1996). *Transit Villages in the 21st Century.* New York: McGraw-Hill.

Blowers, A. (1978). In *Rural Transport and Country* Planning, R. Cresswell, ed. Great Britain: Bishopbriggs Glasgow.

British Columbia Transit Authority. (1997). *Municipal Systems Program, Briefing Book.* Victoria.

Cervero, R. (1997). *Paratransit in America: Redefining Mass Transportation.* Westport, CT: Praeger Publishers.

Cervero, R. (1987a). *Transportation and Urban Development: Perspectives for the Nineties.* Working Paper No. 470. Institute of Urban and Regional Development, UC Berkeley.

Cervero, R. (1987b). Responding to Changing Commuter Markets: *Preserving Mobility Through Public and Private Initiatives,* Working Paper No. 460. Institute of Urban and Regional Development, UC Berkeley.

Cullinane, S. and G. Stokes. (1998). *Rural Transport Policy.* The Netherlands: Pergamon.

David Suzuki Foundation http://www.davidsuzuki.org/Climate_Change/Solutions/Transportation.asp Last accesses March 10-15, 2002.

Engwicht, D. (1992). *Towards An Eco-City: Calming The Traffic.* Sydney, Australia: Envirobook.

Federation of Canadian Municipalities (1997). Position on Transportation. *Forum* 23/4: 10.

Federation of Canadian Municipalities (2001). Municipal Governments are key to success of revised Kyoto deal. *Forum* 25/5: 36-41.

Geerlings, H. (1999). *Meeting the Challenge of Sustainable Mobility.* Berlin, Germany: Springer-Verlag.

Hart, M. (1999). *Guide to Sustainable Community Indicators* (Second Edition). North Andover, MA. Hart Environmental Data.

Haughton, G. and C. Hunter. (1994). *Sustainable Cities.* London, UK: Jessica Kingsley Publishers.

Kline, E. (1997). "Sustainable Community Indicators". In *Eco-City Dimensions: Healthy Communities, Healthy Planet,* M. Roseland, ed. Gabriola Island, BC: New Society Publishers.

Litman, T. (2001). "Transit Orientated Development". Victoria Transport Policy Institute: Victoria, B.C.

Litman, T. (1999a). "Issues In Sustainable Transportation". Victoria Transport Policy Institute: Victoria, B.C.

Litman, T. (1999b). "Reinventing Transportation". Victoria Transport Policy Institute: Victoria, B.C.

Litman, T. (1999c). "Sustainable Transportation Indicators". Victoria Transport Policy Institute: Victoria, B.C.

MacDonald, R. A. (2000). "Sustainable Transportation and Land Use Planning at Simon Fraser University: A Case Study of the Burnaby Mountain Campus". Research Project, School of Resource and Environmental Management Report No. 259. Simon Fraser University.

Maclaren, V. (1996). *Developing Indicators of Urban Sustainability: A Focus On The Canadian Experience.* Toronto: ICURR Press.

Newman, P. and J. Kenworthy. (1999). *Sustainability and Cities: Overcoming Automobile Dependence.* Washington, DC: Island Press.

Province of British Columbia. (2001). Ministry of Finance and Corporate Relations, (BC Stats). *P.E.O.P.L.E. Projections.* Victoria, B.C.: July 2001.

Roseland, M. (1998). *Toward Sustainable Communities: Resources for Citizens and their Governments.* Gabriola Island, BC: New Society Publishers.

Ross, W. (1999). *Community Accessibility or Personal Mobility: A Planning Choice with Environmental, Social and Economic Consequences.* (PhD Thesis. Institute for Sustainability and Technology Policy, Murdoch University, Perth Australia.

Sargeant, F. O., P. Lusk, J. A. Rivera, and M. Varela. (1991). Rural *Environmental Planning for Sustainable Communities.* Washington, DC: Island Press.

Sarmento R., F.M.B. Zorzal, A.J. Serafim, and L.B. Allmenroedr (2000). In *The Sustainable City,* C.A. Brebbia, A. Ferrante, M. Rodriguez, B. Terra, editors. London, UK: Wit Press.

Sheltair Group Inc. (1998). *Vision, Tools and Targets: Environmentally Sustainable Development Guidelines for Southeast False Creek.* Vancouver, BC: Sheltair Group Inc.

Shoup, D. (1995) "An Opportunity to Reduce Minimum Parking Requirements." *Journal of the American Planning Association* 61, no.1: 14-28.

Urban Transit Authority of British Columbia. (1980). Guidelines For Public Transit In Small Communities. Victoria, B.C.

Wadhwa, L.C. (2000). "Sustainable transportation: the key to sustainable cities". In *The Sustainable City,* C.A. Brebbia, A. Ferrante, M. Rodriguez, B. Terra, editors. London, UK: Wit Press.

Wilkerson, O. L. and B. Baruah (2001). Organized Complexity, Information, and State-of-Sustainability Reporting: A Case Study of the Tl'azt'en Nation. *Western Geography,* 10/11, 64-88.