Road Classification Schemes – Good Indicators of Traffic Volume?

Eleanor M. Setton, Perry W. Hystad, C. Peter Keller
Spatial Sciences Laboratories, Department of Geography, University of Victoria
Address correspondence to Eleanor Setton, Geography Department, University of Victoria, PO BOX 3050 STN CSC, Victoria, BC, Canada, V8W 3P5. E-mail: elsetton@uvic.ca.

We compare three road classification systems to actual traffic counts in order to assess how well the classification systems perform as indicators of traffic volume, assuming that clear differentiation of traffic volumes among classes is desirable. Actual traffic counts were obtained for 215 locations in the Greater Vancouver Regional District(GVRD); the British Columbia provincial Digital Road Atlas (DRA) and DMTI CanMap© road network provided road classification systems. Modelled traffic volumes for the GVRD, provided by TransLink, are also used to evaluate the classification systems. Based on the sample of actual traffic counts, we conclude that DRA road classes provide the best differentiation of traffic volume, although within class variation is substantial. Modelled traffic counts are not well differentiated by either the DRA road class or subclass, indicating either poor model performance or sample bias. A comparison of actual traffic count means for three regions in the study area with different total population and population densities showed no spatial pattern that would explain within class variation. Future research on within class variation is required, using a larger sample of actual traffic counts. Overall, the use of road classes to indicate level of exposure to traffic-related air pollution should be approached with caution, as significant exposure misclassification could occur.

Acknowledgements: This research has been funded by the BC Centre for Disease Control, via a grant provided by Health Canada as part of the ongoing Border Air Quality Strategy agreement between Canada and the United States. Special thanks to all participating municipalities for providing actual traffic count data, and to TransLink for providing modelled traffic volumes.

Key Words: actual traffic counts, modelled traffic volume, variability, exposure, GIS

Introduction

Methods for indirectly assessing personal exposure to traffic-related air pollution generally rely on measuring proximity to roads and may incorporate some estimate of traffic volume. Where traffic volumes are available, these numerical values can be used directly. In cases where traffic volumes are not available, road class may be used as a surrogate for traffic volume, assuming some hierarchy of traffic volume associated with, for example, highways, major roads, minor roads, and local roads.

When road class is used as a surrogate for traffic volume in an exposure assessment, each road class must represent a distinct traffic volume level in order to avoid exposure misclassification.

The objective of this report is to explore how well existing road classifications in British Columbia differentiate traffic volume, and to assess opportunities for developing a method for estimating traffic volumes in areas where no actual traffic counts exist, based on existing road classifications. We evaluate three road classifications that are available for the province of British Columbia (BC) – a six-level system used in the commercially available DMTI Canmap© street network; and a five- and eight-level system, both available in the BC government's Digital Road Atlas (DRA) (see Table1). Actual and modelled traffic counts in the Greater Vancouver Regional District (GVRD) are used to assess how well each classification system differentiates traffic volume and to explore regional differences that might support the development of a model of traffic volume based on road class.

Methods

Existing traffic counts (average daily traffic volume) at 215 locations in the GVRD were acquired from local jurisdictions, each of which was contacted and asked to provide traffic counts for at least 30 road segments covering a broad range of road classes. This method was deemed more feasible than developing a random sample based on road class, given the time frame and resources available for data collection, and the lack of data for many road segments throughout the study area. A geographic information system (GIS) was used to create point locations for each traffic count, and to associate the traffic count with the appropriate road segment in the DMTI and DRA street networks. TransLink (the transit authority in the GVRD) provided GIS-ready modelled traffic counts. Both actual and modelled traffic counts for each road class in the GVRD, and for each road class in three sub-regions of the GVRD were compared using simple descriptive statistics and box plots.

Table 1. Existing Road Classifications

DMTI - Class	Description
Expressway	Usually four lanes + and very limited access to adjacent land uses
Principal Highway	Conduits for intra-city traffic, multi-lane, large traffic capacity
Secondary Highway	Thoroughfare, large traffic capacity, generally multilane
Major Road	Routes for shorter trips within the city/
Local Road	Residential access

DRA – Class	Description
Freeway	Controlled access, typically divided
Highway	Primary or secondary provincial highway, single or multilane
Arterial	Thoroughfare, large traffic capacity, generally multilane
Collector	Connects areas to cross town, generally one lane each way.
Local	Residential roads

DRA – Subclass	Description
Freeway	Controlled access, typically divided
Highway Major	A primary provincial highway
Highway Minor	A secondary provincial highway
Arterial Major	Thoroughfare, large traffic capacity, more than 2 lanes
Arterial Minor	Thoroughfare, medium traffic capacity, 2 lanes (one each way)
Collector Major	Connects areas to cross town, more than 2 lanes
Collector Minor	Connects areas to cross town, one lane each way.
Local	Residential roads

Results and Discussion

Comparison of DMTI and DRA road classes based on actual traffic counts. A comparison of the mean actual traffic count for each class used in the DMTI and DRA datasets suggests that DRA ‘class’ may provide better distinction of traffic volume than DRA ‘subclass’ or the DMTI ‘class’ in terms of assigning traffic-related exposure. Table 2 shows that three of the five DMTI classes have similar means - major, highway secondary, and highway principal. DRA subclasses show similar means for minor and major collector, and for minor and major arterial and minor highway. The means of actual traffic counts for DRA classes suggest that DRA classes appear to capture distinct groups of traffic volumes, suitable for indicating different levels of exposure to traffic-related pollution.

Table 2. Mean of actual traffic counts for road classes

DMTI Class	Mean	DRA Class	Mean	DRA Subclass	Mean
Local	6,511	Local	3,976	Local	4,126
Major	15,207	Collector	8,953	Collector minor	8,580
				Collector major	9,694
Highway Secondary	18,254	Arterial	18,457	Arterial minor	15,321
				Arterial major	17,407
Highway Principal	21,025	Highway	27,961	Highway minor	22,242
				Highway major	36,684
Expressway	113,789	Freeway	113,789	Freeway	113,789

Box plots of the traffic counts associated with the DMTI classification (Figure 1) show good differentiation between local and other road classes, but there appears to be much less differentiation among major, secondary highway, and principle highway classes. Notably, only one actual traffic count was associated with a secondary highway, which may indicate that this class is rarely used or that the provided sample is biased. Within class variability as indicated by standard deviations is high for local and major roads (Table 3). For local roads, the mean is 6,511 and the standard deviation is 5,895. For major roads, the mean is 15,207 while the standard deviation is 10,831. Within class variability does decline moving up the hierarchy from local roads up to expressways. These large standard deviations support the conclusion that there is relatively poor differentiation of traffic volumes between classes in most cases.

In contrast, the box plots of traffic counts associated with DRA ‘class’ show there are reasonable sample sizes for local, collector and arterial classes (53, 86, and 65 respectively), but relatively few actual traffic counts available for highway and freeway classes (Figure 2). This is not unreasonable, as there are far fewer highways and freeways in comparison to local, collector, and arterial roads in the GVRD. There appears to be better differentiation among classes than that shown in the DMTI data, as there is less overlap between the boxes (representing the middle 50 percent of values) and whiskers (representing the lower 25 and upper 75 percent of values).

However, as shown by the standard deviations (Table 4), there is substantial within class variation.

Boxplots of the traffic counts associated with DRA subclass (Figure 3) show little distinction between minor and major collector and arterial roads. There is more distinction between minor and major highways, but small sample sizes (two in each category) preclude making a definitive statement regarding differences between these two categories. Again, standard deviations within each subclass are relatively high (Table 5), although less so for larger roads (highways and freeways).

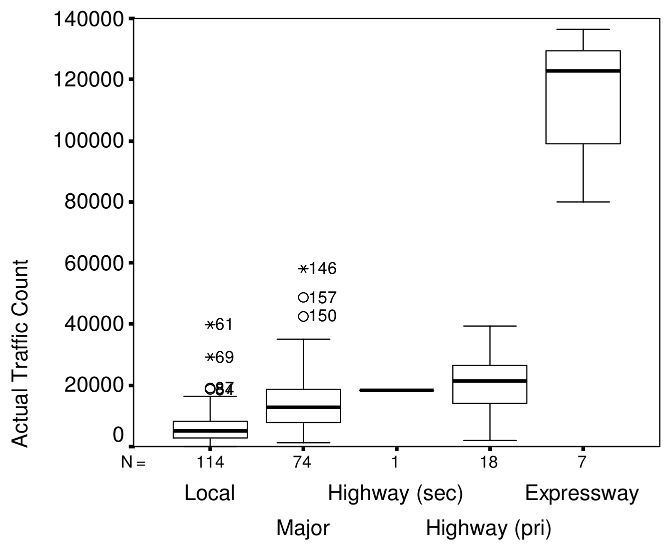

Figure 1. Actual traffic counts associated with DMTI road class

Table 3. Mean and standard deviation for actual traffic counts associated with DMTI road class

DMTI Class	Mean	Standard Deviation
Local	6,511	5,895
Major	15,207	10,831
Highway Secondary	18,254	One sample
Highway Principal	21,025	9,129
Expressway	113,789	22,685

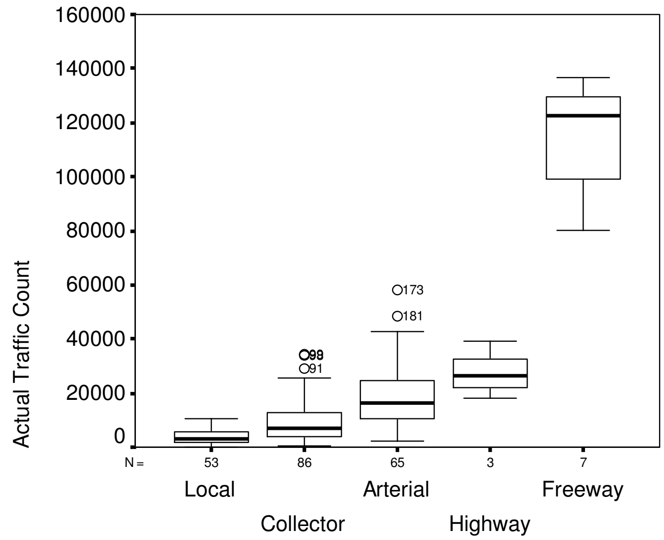

Figure 2. Actual traffic counts associated with DRA road class

Table 4. Mean and standard deviation for actual traffic counts associated with DRA road class

DRA Class	Mean	Standard Deviation
Local	3,976	2,779
Collector	8,953	6,812
Arterial	18,457	10,717
Highway	27,961	10,679
Freeway	113,789	22,685

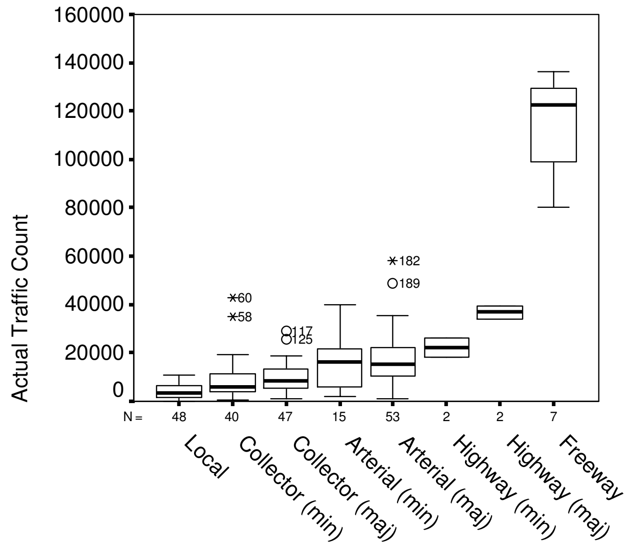

Figure 3. Actual traffic counts associated with DRA subclass

Table 5. Mean and standard deviation for actual traffic counts associated with DRA road subclass

DRA Subclass	Mean	Standard Deviation
Local	4,126	2,879
Collector minor	8,580	8,522
Collector major	9,694	6,015
Arterial minor	15,321	10,850
Arterial major	17,407	10,900
Highway minor	22,242	5,640
Highway major	36,684	3,841
Freeway	113,789	22,684

Comparison of DRA road classes based on modelled traffic volumes. TransLink provided traffic volumes predicted by EMME/2, a widely-used traffic demand modelling software program. In total, traffic volumes for 10,313 road segments in the Greater Vancouver Regional District were available for analysis. The following analyses focus on DRA road class and subclass, given that they appear to better differentiate traffic volume among classes using actual traffic counts than the DMTI classes.

Modelled traffic volumes for each DRA class are more poorly differentiated than actual traffic counts. Local and collector roads have similar means (4,378 and 5,377 respectively), while freeways show lower counts than highways (Table 6). Although DRA subclass shows a more reasonable separation of highways and freeways (means of 17,666 and 39,431 respectively), there are apparent overlaps and inconsistencies for many other subclasses. For example, local and collector minor roads have similar means, collector major and arterial minor roads have similar means, and the mean of arterial major roads is substantially higher than that of highway minor roads. Boxplots of the modelled traffic volumes for both DRA class and subclass (Figures 4 and 5) reflect these similarities and overlaps, and show substantial numbers of extreme values and outliers, particularly for local, collector, and arterial roads. Also of interest are the much lower means for freeways based on modelled volumes in comparison to actual counts – 13,546 or 39,431 (class and subclass) versus 113,789. Standard deviations within classes are high, as was the case when actual traffic counts were evaluated.

Table 6. Mean of modelled traffic counts for classes

DRA Class	Mean	Standard Deviation	DRA Subclass	Mean	Standard Deviation
Local	4,378	5,105	Local	4,033	5,061
Collector	5,377	4,412	Collector minor	3,899	3,200
			Collector major	6,223	4,775
Arterial	10,943	8,463	Arterial minor	6,853	5,298
			Arterial major	12,314	8,942
Highway	15,478	12,225	Highway minor	9,762	8,194
			Highway major	17,666	12,134
Freeway	13,546	10,612	Freeway	39,431	6,358

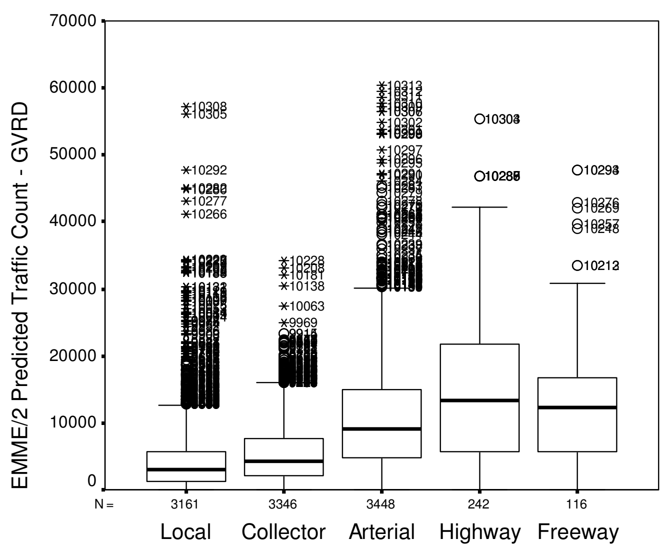

Figure 4. GVRD EMME/2 traffic volumes by DRA classifications.

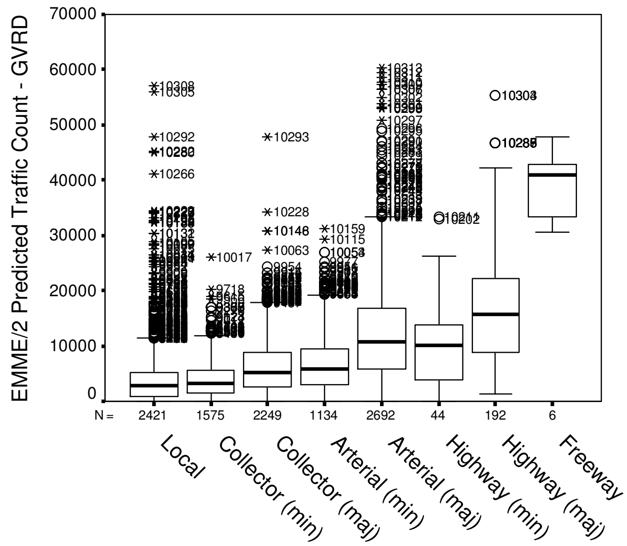

Figure 5. GVRD EMME/2 traffic volumes by DRA sub-classifications.

Assuming that the sample of actual traffic counts is representative of true traffic volume, it is possible to conclude that modelled traffic volume does not adequately predict differences in volume between local and collector roads, or among arterial roads, highways, and freeways (Table 7). Using modelled traffic volumes to indicate the level of exposure to traffic related air pollution therefore could create substantial exposure misclassification. Another possibility is that the sample of actual traffic counts is biased and coincidentally favours the DRA road class system.

Table 7. A comparison of actual traffic counts and modelled traffic volume for DRA road classes

DRA Class	Actual Count mean	Modelled Count mean
Local	3,976	4,378
Collector	8,953	5,377
Arterial	18,457	10,943
Highway	27,961	15,478
Freeway	113,789	13,546

Spatial Exploration of Variation in Traffic Counts by DRA Road Class. The variability of traffic counts within each road class may be due to systematic traffic volume variation depending on location within the study region. For example, it might be that a ‘local’ road in a high population urban area always has higher traffic volumes than a ‘local’ road in a lower population rural area.

We chose three regions within the study area, based on population, population density[1] and available sample size for actual traffic counts (Table 8) and focused on local, collector, and arterial road classes since these classes showed high internal variability.

Table 8. Characteristics of Compared Regions

Region	Population	Area (hectares)	Population Density (persons/hectare)
Vancouver	583,296	11,467	51
Richmond	172,714	12,869	14
Abbotsford	126,634	35,918	4

Source: BC Stats Community Fact Sheets
http://www.bcstats.gov.bc.ca/data/dd/facsheet/facsheet.htm

If there was systematic variation in traffic volumes based on regional differences in population, we would expect to see high traffic volumes in high population areas, moderate traffic volumes in moderately populated areas, and low traffic volumes in low population areas. Conversely, it might be expected that increasing density decreases the need to use a vehicle, and therefore traffic volume might decrease as population density increases. In fact, box plots of the mean traffic count for local, collector, and arterial roads (Figures 6, 7 and 8) in Abbotsford, Richmond, and Vancouver, suggest there is no systematic regional pattern. For local roads, Figure 6 shows similar mean traffic counts in Richmond and Abbotsford, areas with similar populations but different population densities, indicating no difference based on population density. The lower mean traffic count in Vancouver, however, indicates there might be a difference based on population density, assuming higher density causes lower traffic volumes. For both collector and arterial roads, Figures 8 and 9 show similar means for low density and high density areas (and therefore no difference based on total populations), but a lower mean for the moderate density area (and therefore no difference based on total population or on density). Based on this limited analyses, there is no evidence of a systematic spatial pattern in traffic counts that would explain variability within each road class.

[1] We note that in both Richmond and Abbotsford, substantial agricultural lands are included in the total area, therefore population density may be substantially higher in some parts of each area. For example, if we assume that 50 percent of Richmond is agricultural, population density could be 28 persons/hectare in residential areas. Available traffic counts are, however, generally located in the most densely populated areas of each region, and so it is likely reasonable to make direct comparisons among these regions.

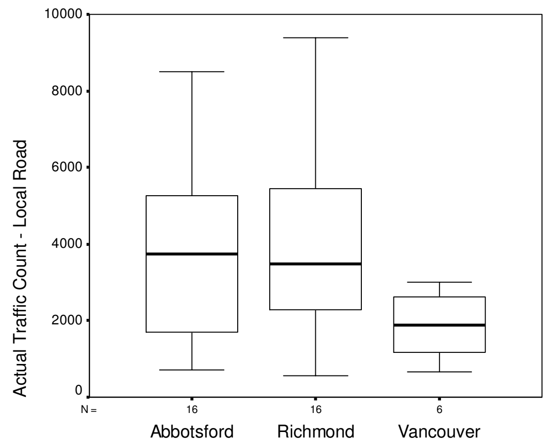

Figure 6. Actual traffic volumes on local roads in Abbotsford, Richmond, and Vancouver

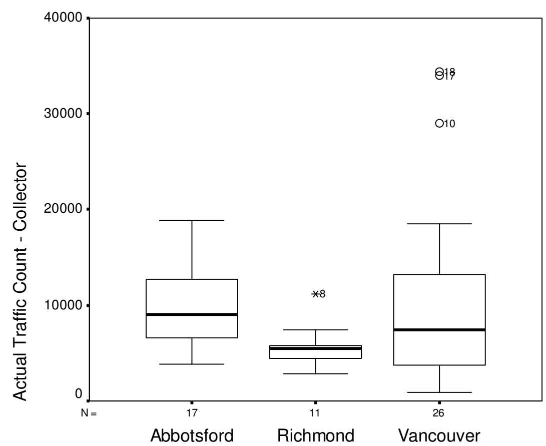

Figure 7. Actual traffic volumes on collector roads in Abbotsford, Richmond, and Vancouver

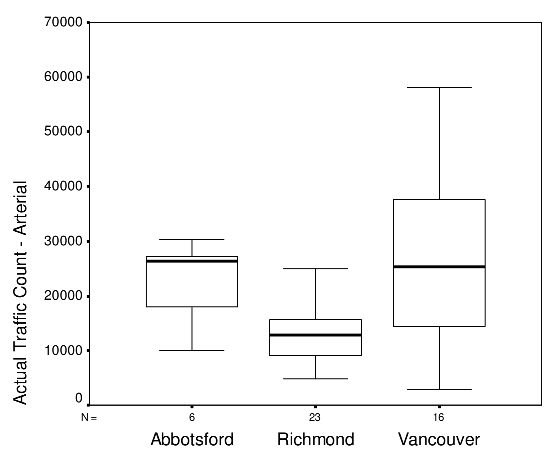

Figure 8. Actual traffic volumes on arterial roads in Abbotsford, Richmond, and Vancouver

Conclusion

Traffic volume on nearby roads has been used to indicate exposure to traffic-related air pollution. When few or no actual counts are available for a study area, road class may be used as a surrogate for traffic volume, assuming that higher capacity roads carry more traffic on average than do lower capacity roads. Modelled traffic volumes also may be used when actual counts are not available.

Analyses of road classification systems used for existing digital road data in British Columbia, and of modelled traffic volumes in the Lower Mainland suggest that, for the purposes of assigning levels of exposure to traffic-related air pollution, the road classes used in the provincial Digital Road Atlas provide a somewhat better differentiation in traffic volumes, than road subclasses. Road classes used in DMTI digital road data did not sufficiently differentiate traffic volume among classes. Modelled traffic volumes did not compare well to actual traffic counts and when associated with road classes from the DRA digital roads, were not well differentiated among classes. For the purposes of assigning exposure levels then, we conclude that at this point in time, based on the sample of actual counts, using the DRA digital road class provides the best chance for minimizing exposure misclassification, although more analysis of within class variation is required.

We found no apparent spatial pattern that would explain the within-class variation and between-class overlap in traffic volumes, although our analysis was limited by the small sample size for actual traffic counts for each region compared, and to the examination of the effects of total population and population density on traffic volume. Undoubtedly, there are more factors, both spatial and aspatial that may contribute to variation in traffic volume. Future research in this area should attempt to identify additional factors that influence traffic volume, and use a larger sample of actual traffic counts, optimized for each region included. If successful, these efforts could produce a model suitable for predicting traffic volumes in regions outside of the Lowe Mainland, based on the DRA digital road classes.