

ESTIMATING TRAFFIC VOLUMES FOR LOW- CLASS ROADS USING TRAVEL DEMAND MODELING

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Introduction

Many Departments of Transportation (DOTs) use asset management programs to help plan, build, and maintain transportation infrastructure at a statewide level. There are several benefits to implementing an asset management program, such as lower long-term costs and improved service to users. Decisions made in asset management need to be based on quality information. In areas such as pavement management, maintenance and repair are usually performed on a periodic basis set by factors such as road class and traffic volume. Often, traffic count data are not available for significant portions of the network because it would be prohibitive to cover all roads, particularly lower class and rural roads. In cases where traffic volumes are needed but unavailable, travel demand models (TDMs) can be used to estimate such information. This study implements a travel demand model for a few regions in New Brunswick in order to examine the feasibility of using travel demand modeling to estimate traffic volumes on low-class roads.

Scope

This study examines the feasibility of using travel demand modeling to estimate low-class road traffic volumes. Two regions in New Brunswick were chosen to test and implement a TDM. Literature for this topic indicated that previous studies were typically performed at the county-wide level. York County was arbitrarily chosen for this study. The county covers a large area on the western side of the

province, has a population of approximately 86,000, and contains the provincial capital city of Fredericton.

In order to examine the TDM at a smaller scale and study the approaches with better accuracy, the scope was reduced to the Census Consolidated Subdivision (CCS) level. Beresford is located at the north of the province and has a population of approximately 10,000.

Traffic Data Collection Practices for Low-Volume/Low-Class Roads

Traffic count data are extremely useful in many applications, particularly in pavement management. Most jurisdictions assign traffic volumes to roads based on sample counts for the particular road class. Actual count data are often not available for large portions of the network. In the case of low-class/low-volume roads traffic count data are almost non-existent (Seaver *et al.*, 2000).

Low-class road traffic counting practices vary widely among the Canadian provinces. How effectively these roads are managed depends on two factors: the current state of the province's asset management program, and the amount of funding the province has available. British Columbia is fairly advanced in its asset management program and has included all of its roads (B.C. Ministry of Transportation, 2007). Traffic counts are taken to classify each road. Since traffic on low-volume roads tends to stay fairly predictable from year to year, the province only needs to take a small number of counts on these roads to monitor trends and can allocate more resources to high volume facilities. This way both high and low-class roads are managed effectively.

In the case of Alberta, permanent traffic counting sites are installed on all provincial roads regardless of class (Alberta Infrastructure and Transportation, 2007). This is ideal as it provides decision makers ample data to work with; however this practice is not feasible for most highway agencies. New Brunswick is still in the process of implementing its asset management program (NBDOT, 2007). Local named roads, which represent 45% of the surface treated provincial

road network, have no traffic count data available. It is not financially feasible for the province to include all of these roads into the traffic counting program. It is necessary to develop another method for obtaining such data.

In the United States, sampled counts are typically taken to determine AADT then assigned to all roads of the same class within a particular zone for the purpose of calculating aggregate vehicle miles traveled (FHWA, 2003). Applying the same treatment to all roads in the same class (blanket approach) tends to be inefficient and TDM has not been used to estimate low-class road traffic. A method to distinguish between high and low-volume links within low-class roads is needed.

Roads in Australia are classified based on traffic volumes. Additionally, factors such as importance to the community and community satisfaction are assigned to each road segment. Roads that the public deem of high importance and low satisfaction are considered to be high priority for improvement, regardless of classification (Austroads, 2006).

Estimating Traffic Summary Statistics with Traffic Count Data Based Regression

Most AADT estimates in research are made using a short term traffic count and either a factor method or a more advanced method, such as neural networks (Sharma *et al.*, 2000). According to Zhao and Chung (2001), literature on estimating AADT for roads that do not have traffic counts is limited. In most cases they are low-class roads and thus not included in traffic counting programs. The few attempts that have been made have had varying degrees of success.

Travel Demand Modeling for Estimating Low-Class Road Traffic

Literature on using a TDM to estimate low-class road traffic is scarce. Blume *et al.* (2005) implemented a model that used census data and sample counts. Sample counts were taken for eight strata and an AADT based on median traffic volumes was estimated for each

group. This study did not address the issue of estimating traffic volumes for individual road links.

Many U.S. jurisdictions have implemented statewide travel demand models. According to Horowitz and Farmer (1999), Michigan's statewide TDM is considered to be the "state-of-the-practice". This model does not address the issue of low-class/low-volume roads. Roads classified as collector or above are generally included in the network, with local roads occasionally included for the purpose of connectivity. The vast majority of local roads are omitted (Michigan DOT, 1999).

Study Data and Methodology

The goal of this research was to develop a non-invasive financially feasible method to estimate traffic volumes on low-class roads that can be implemented at a statewide level. The socioeconomic data used in this model were taken from Statistics Canada's 2001 Census. Each dissemination area (DA) in New Brunswick was designated as a TAZ, resulting in a total of 1497 TAZs. It was noticed that the size of the DAs was linked to population density (i.e. there are more, smaller, DAs in dense population areas), therefore it is felt appropriate to use DAs as TAZs.

The travel demand model was developed using the built in four step model (omitting the mode choice step) in the TransCAD Transportation GIS Software package by Caliper Corporation. The Quick Response Method (QRM) was used for trip generation, trip attraction, and trip balancing. Production and attraction rates were taken from NCHRP report 187 (NCHRP, 1978). The gravity model was used for trip distribution with parameters from NCHRP report 365 (NCHRP, 1998). Trips were assigned to the road network using a Stochastic User Equilibrium method (Sheffi, 1985).

Case Study 1: York County

The NBDOT manages a total of 1420 km of roads in York County, of which 643 km (45%) are considered to be included in the traffic

counting program. The AADT on each of these roads is derived from 55 locations throughout the county using either short term counts or data from permanent count sites. Table 1 shows the breakdown of roads by functional class. All road classes down to and including local numbered roads are covered by the traffic counting program. Local named roads represent 345 km of the provincial road network in York County. This represents 24% of the total York County road network, and 35% of all paved roads. Except for one small segment, local named roads are not included in the traffic counting program.

Table 1: Roads by Functional Class in York County

Road Type	Road in Counting Program (km)	Total Road (km)	% in Counting Program
Highway/Freeway	88	88	100
Arterial	117	117	100
Collector	210	210	100
Local Numbered	228	228	100
Local Named	2	345	0.5
Non-Surface Treated	0	432	0

Traffic volumes were estimated for 935 km (66%) of the 1420 km of provincial roads in the county. The NBDOT currently has 645 km (45%) of the road network covered by the traffic counting program. Traffic volumes were estimated for 290 km of road that previously did not have any traffic count data available. This represented an increase in available data of 45% compared to the current traffic count data. Traffic volumes were estimated for 183 km (52%) of local named provincial roads. Figure 1 shows the York County road network with labeled numbered highways.

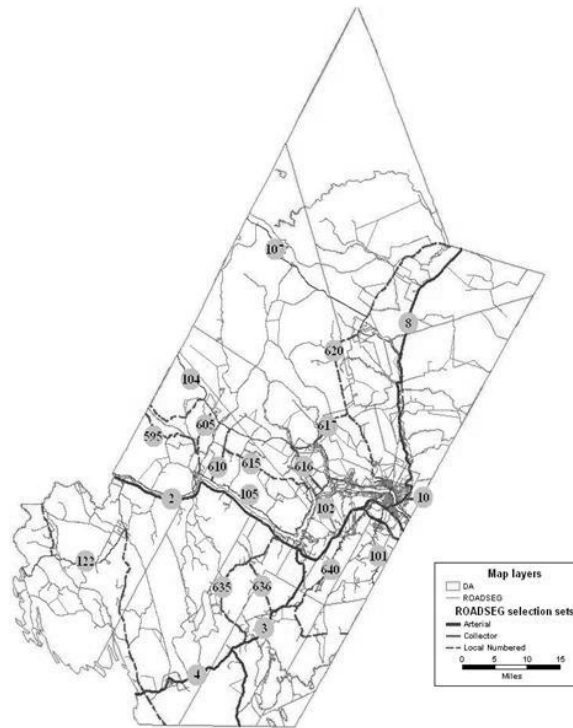


Figure 1: York County Road Network

Study Results

There are four Arterial highways in the County. Traffic volumes from the hardcopy map provided by the NBDOT were used to compare the traffic volumes estimated by the TDM. Nine counts were used in the comparison of the Arterial road segments. The estimates for the arterial highways had a fairly low average error. The average error was 9% with only one of the nine comparisons made had an error greater than 10%. Since these trunk roads are expected to carry the majority of the traffic throughout the zone, the low percentage error indicates that the trip productions and attractions are being modeled very well. There was no clear tendency toward over or

underestimating volumes. A regression analysis was performed resulting in an R-squared value of 0.9807, which emphasizes that there is a strong linear relationship between the estimated and observed values.

There are six Collector highways in the County. Sixteen observed traffic volumes were used to compare with the estimated collector values. Collector volumes were over estimated on all but two cases, which indicates that the traffic did not get assigned appropriately at this level. Average error for the class was 44% with a 90% percentile error of 104%. Low-volume roads tended to have the worst estimates, while high volume estimates had a relatively low error. The regression analysis produced a high R-squared value of 0.9665, which indicates that there is still a strong correlation between observed and estimated traffic. This suggests that the regression model could be used to improve the overall accuracy of estimates for road segments with no traffic count data. Four traffic counts were removed so they could be used for model validation and the regression analysis was performed on the remaining twelve to calibrate the model, which produced the following equation:

$$\textit{Observed} = 0.8254 \times \textit{Output from TDM} + 63.567 \quad [1]$$

The average and percentile errors were all reduced by applying the regression equation. For example, the average error for the test group was reduced from 53% to 36%, and the P90 was reduced to 86% from about 120%. This reinforces the indication that the calibration regression model can improve the accuracy of the TDM estimates for road segments with no traffic count data.

There are eleven Local Numbered highways in the County. Ten observed traffic volumes were used to compare with the estimated local numbered values. The observed values of collector traffic were manually added to the corresponding road segments as the capacity in the road network file. The traffic assignment was performed and the estimates on the local numbered roads were compared with the observed values.

The R-squared value was 0.6965, which indicates a fairly strong correlation between the estimated and observed values. Four traffic counts were removed so they could be used for model validation and the regression analysis was performed on the remaining six to calibrate the model, which produced the following equation:

$$\text{Observed} = 0.4375 \times \text{Output from TDM} + 67.237 \quad [2]$$

The average error for the test group estimates was reduced by 115% to 38.6%. The 50th, 75th, and 90th percentile errors were all reduced by over 120%. These results clearly show that using regression to modify the TDM estimates on local roads with no traffic data can increase the accuracy and reduce the overall error in the estimations on these roads.

There are 345 km of local named roads in York County. The TDM estimated traffic volumes for 231 km (67%) of these roads. In order to address the issue of variability in the estimates, roads could be classified into a volume range rather than be assigned a specific number. Table 2 provides an example of this type of classification by showing the breakdown of estimated traffic volumes on local named roads in the zone.

Table 2: York County Local Named Roads by Traffic Volume

Estimate Traffic Volume (veh/day)	Kilometres of Road	% of Total
0-500	150	43
500-1000	30	9
1000-2000	41	12
2000+	124	36

This can be useful for identifying high priority road segments within roads of the same class. According to these results, 36% of local named roads have traffic volumes greater than 2000 vehicles per day, which is quite high. Factoring the local named traffic volume estimates using the regression equation obtained from the local numbered regression analysis should reduce the overall error.

Another solution could be to use a relative classification system (i.e. low-high priority) rather than assigning a specific value or range to a road segment.

Case Study 2: Beresford CCS

In order to examine the Travel Demand Model at a smaller scale, the analysis area was reduced to the Census Consolidated Subdivision level. The CCS of Beresford encompassed an area for which available traffic counts could be intuitively linked to local traffic, that is, it encompassed the central business district and surrounding residential area. There are a total of 224 km of road in the Beresford area. The NBDOT manages 178 km of these roads. The breakdown of roads by classification is shown in Table 3.

Table 3: Beresford Area Roads by Functional Class

Road Type	Kilometres of Road (km)	%
Arterial	13	7
Collector	16	9
Local Numbered	16	9
Local Named	72	41
Other	61	34

Traffic count data were available for the one arterial, one collector, and two local numbered roads. This represented 45 km (25%) of the provincial road network which comprised one permanent count site and two short term count sites on the arterial highway; two short term count sites on the collector; and one short term count site on each of the local numbered roads. The travel demand model implemented in the study produced traffic volumes for 110 km (62%) of the provincial road network in the Beresford CCS. This represents an increase in available data of 65 km (144%) compared to the existing traffic count data. Figure 2 shows the Beresford area road network and DAs.

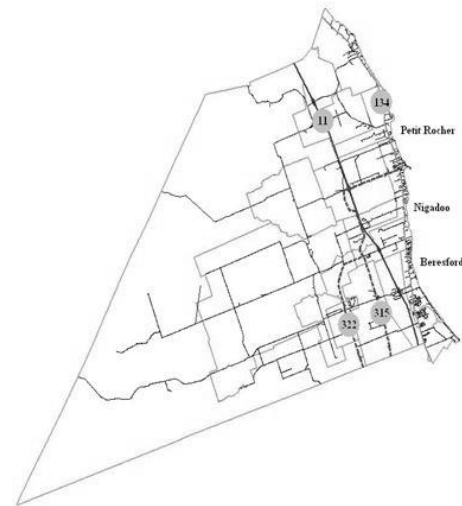


Figure 2: Beresford Area Road Network

Study Results

The analysis zone was chosen so that it would encompass an area for which the majority of the traffic in the region was generated within that zone. The Beresford area is located on the waterfront of the Baie des Chaleur. The main road, which services the central business district, is collector highway 134 which runs North-South along the waterfront. The population density is highest close to the water on the east side of the zone and becomes progressively lower heading west. Arterial highway 11 runs through the zone parallel to highway 134. On both highways, observed traffic volumes on sections to the north and south of the zone were significantly lower than traffic volumes in the center of the zone. This indicates that the majority of traffic is being generated within the zone.

A through traffic modifier was applied to the arterial and collector highways as both traverse the entire zone. Volumes on the collector were underestimated by 23% and 11% as compared to the two observed values. Volumes on the arterial were overestimated with an error of 4% and underestimated with an error of 12% as compared to

the two observed values. There are two local numbered highways in the zone: highways 315 and 322, both running north-south. Both volumes were overestimated, with an associated error of 39% for highway 322 and 12% for highway 315. The model did not show a clear tendency to overestimate or underestimate. The lowest error occurred on the arterial highway, which is consistent with the York County case. The largest error occurred on highway 322. Traffic on both local numbered roads was overestimated.

The R-squared value for all predictions was 0.9785. This indicates a strong correlation between observed and estimated traffic. Such information could be used in the future as a factor to apply to estimates for other links within the area. In this case, the small sample size makes this impossible and therefore no analysis was carried out.

Surface treated local named roads under the jurisdiction of the province represented 84 km of road in the analysis zone. The travel demand model used in this study estimated traffic volumes for 50 km (60%) of these roads. There is currently no way to assess the accuracy of individual estimations on local named roads without taking additional traffic counts for comparison. It should be noted that with a reduced study area size, the magnitude of the estimation error on low-class roads will be reduced, as it is the case here.

In order to address the issue of variability in the estimates, roads could be classified into a volume range rather than be assigned a specific traffic volume. Table 4 provides an example of this type of classification by showing the breakdown of estimated traffic volumes on local named roads in the zone.

Table 4: Beresford Local Named Roads by Traffic Volume

Estimate Traffic Volume (veh/day)	Kilometres of Road	% of Total
0-500	45	54
500-1000	7	8
1000-2000	19	23
2000+	13	15

Unlike the York County case, the majority of these roads are low-volume (54%). This indicates that the model is providing a better representation of actual road traffic. Rather than assigning a specific value or range, a relative classification scheme could also be used (e.g. low-high) to describe road links.

Conclusions and Recommendations

A total of 35 traffic counts were estimated and analyzed in York County. Counts were divided by functional class into three analysis groups. Estimates for arterial roads had an average error of 9%. Estimates for collector roads had an average error of 45%. Estimates for local numbered roads had an average error of 160%. Traffic estimates for both the collector and local numbered highways were consistently overestimated. The calibration regression models were developed based on the estimates from the TDM and the observed traffic counts. These calibration models were proven to be effective to remove consistent estimation bias. Their applications to York County reduced the overall average error for the collector roads to 36%, and that for local roads was limited to 40%.

The study area size was reduced and the model was implemented in the Beresford Census Consolidated Subdivision level. The traffic patterns on the roads surrounding the CCS indicated that most of the traffic in the region was generated internally. The CCS contained four roads that had traffic count data available for comparison which comprised six observed traffic volumes. The overall average error in the zone was reduced to 17% and in particular the average errors for the local numbered roads were limited to less than 40%.

The following conclusions were made based on the study results:

- Travel demand modeling for estimating traffic on low-class/low-volume roads is practical and useful. For local roads, the relative magnitude of traffic estimates is more important than the accuracy of individual links. TDM provides an effective way to identify high priority segments within the

local road class. That is, those roads with assigned traffic, especially high volume, should be given priority.

- Using a TDM increases the amount of traffic count information available for a road network. Traffic count information does not exist for the majority of low-class roads in New Brunswick. A TDM is non-invasive financially feasible method to obtain these data. Classifying these roads based on traffic volume, volume range, or relative volumes will help decision-makers allocate resources amongst these roads more effectively from an asset management perspective.
- The TDM should be implemented for a small area rather than county or province-wide. The majority of local road traffic is generated within the same zone, or from neighboring zones. Reducing the study area size is the best way to model local traffic behavior and reduce the magnitude of estimation errors.
- Study area boundaries should be chosen to reflect the urban influencing area. Using an arbitrary jurisdictional area, such as a county, may result in inaccurate area-wide travel patterns as it is shown by the “York County” study in this study. Boundaries should be chosen such that the majority of local traffic in the area can be assigned to one or more central business districts, regardless of whether the area is urban or rural.
- The TDM approach does not assign traffic to some roads and tends to overestimate traffic on the rest. Regression can be used to adjust the estimates in order to remove this bias and increase the overall accuracy, particularly for lower class roads.
- Travel demand modeling achieves very good estimations for higher functional class roads. Low estimation errors for these roads indicate that the TDM generates the total traffic volume for the area fairly accurately.
- Modeling accuracy for low-class roads is still fairly large. For example, the lowest average error for local roads achieved in this study was still around 40%. Refinements to the traffic assignment method need to be done in order to reduce these errors.

- Dissemination areas provided the highest resolution possible of disaggregated data. Socioeconomic information used in the model (Households, Income, Retail Employment, and Non-Retail Employment) is available for all DAs in the province. This means that the model can be applied to any region, and that transferability has been achieved.
- Through-trips are typically not an issue when estimating local road traffic as long as the study area boundaries are chosen appropriately. The majority of local road traffic is generated within the study area as there is little external traffic on these roads.
- Choosing an appropriate method of traffic assignment is very important. The Stochastic User Equilibrium assignment method provides a better distribution of traffic on the road network than traditional all-or-nothing methods. The addition of available traffic counts as capacity constraints improves the model accuracy.
- The model should be implemented using an iterative ‘top down’ approach. Each iteration should apply the following process:
 - Trip Generation
 - Trip Distribution
 - Trip Assignment
 - Identify Issues
 - Refine/Calibrate Model
 - Repeat

The initial focus should be on higher class roads such as arterials or major collectors. Once the activity on these roads has been modeled correctly the focus should shift to lower class roads. This iterative approach will result in higher accuracy in low-class road traffic estimations.

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