**A North Carolina Sign Study:**

# Sign Count Approximation Using Field Inventory Sampling and Calculated Sign Densities: Analysis, Improvements, and Methods

**Technical Report**


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May 2001

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# 1.0 INTRODUCTION

## 1.1 Background

Road signs are an integral part of North Carolina's roadway infrastructure. The North Carolina Department of Transportation (NCDOT) has the primary responsibility for the design, erection, and maintenance of these signs. Maintenance responsibilities include replacing signs that are stolen, damaged, or deficient in some manner. One way a sign can become deficient is through the loss of its reflective properties. Without these reflective properties, a sign is very difficult to see during nighttime driving. This difficulty increases as the speed of the observer increases.

Virtually every sign made by the NCDOT is constructed with reflective sheeting. As a motorist drives down the road, light from their headlights hits the sheeting and is reflected back towards the driver's automobile. This reflectivity enables the motorist to clearly see the sign. But over time the reflective properties of a sign gradually diminish, making it more difficult to see the sign during nighttime driving.

The Federal Highway Administration (FHWA) is expected to release minimum levels for sign retroreflectivity in the near future [Vereen 2002]. The NCDOT will be responsible for adhering to these this new standard. The purpose of this standard is to ensure that all roadway signs are adequately visible at night, thus making nighttime travel safer. The NCDOT is therefore concerned with performing its sign management programs in an efficient manner to both meet the standard and promote safety. There are many strategies that the NCDOT may employ in response to the evolving regulations, but an assessment of cost and liability cannot be made without knowing how many signs the Department is responsible for. The NCDOT has only a general estimate of the number of signs it maintains. The purpose of this study is to determine a more accurate estimate of the number of NCDOT maintained signs in North Carolina.

## 1.2 Previous Work

A previous study, titled "Sign Count Approximation Using Field Inventory Sampling and Calculated Sign Densities" initially undertook the sign counting effort [Kirtley 2001]. This study estimated the number of road signs along North Carolina primary routes (Interstates, US Routes, and NC Routes).

Due to the vast number of roadway miles, it was not logistically feasible to physically drive every mile of roadway and individually count each sign. The study team therefore needed to develop a sampling approach that was both feasible and accurate. It was decided that a sign density approximation method met both of these criteria. This method counted sings along representative sample sets of primary roads and used the number of signs and miles driven to determine a representative sign density. Total roadway mileages are already known by the NCDOT, and all the study needed to do was determine an average number of signs per mile.

To ensure a reasonable amount of accuracy, the Kirtley study initially anticipated that signs on approximately 40% of Interstate, 20% of U.S. Route, and 5% of N.C. Routes would need to be physically counted. These targets, for all intents and purposes, were met. The study actually counted signs on 55.2% of Interstates, 12.3% of US Routes, and 5.2% of NC Routes. Once these counts were finished, the data was compiled to find an average sign density. The study identified road location, road structure, and road type as three factors that could possibly affect the sign densities. Roadway sample sections were chosen as to very these factors, and thereby limit the amount they could possibly influence the data.

The Kirtley study used sign color as the basis for identifying and counting signs. Sign color was chosen because is an easily identifiable sign property and also relates to the sign's intended purpose and function. Signs of similar functions typically have the same color to aide motorists in identifying signs and in understanding their meaning and intent. Seven color types were identified in the Kirtley study. An eighth category was added for stop signs. Since stop signs represent greater liability than the average road sign, they were counted separately.

## 1.3 Purpose

The purpose of this study is provide a more accurate total sign count by improving and extending the previous study. Improvements on the Kirtley study essentially fill in the gaps of the previous counts. This includes counting special areas that were not tallied in previous counts, such as rest areas, and truck weigh stations. Extensions include counts of secondary roadways, which were not completed in the previous study. Secondary roads are a type of roadway maintained by the NCDOT, but are not considered Interstate, US Route, or NC Route. There are approximately 63,500 miles of secondary road in North Carolina, making them a substantial majority of all roads

maintained by the NCDOT. This report also offers recommendations to improve the sign counting activity.

# 2.0 METHODOLOGY

## 2.1 Primary Route Improvements

In order to obtain a more accurate estimate of the number of NCDOT maintained signs, it was necessary to examine the Kirtley study to see if ways to improve the count could be discovered. The previous sign count methodology primarily focused on road specific signs and did not include NCDOT maintain areas supporting these roads. This includes areas such as welcome centers, visitor centers, rest areas, and truck weigh stations. These areas were therefore visited and included in the present study.

### 2.1.1 Welcome Centers

Welcome centers are part of North Carolina's rest area system, and are located on Interstates close to state borders. The purpose of a welcome center is to provide information resources concerning North Carolina to travelers. There are seven welcome centers in North Carolina, and their primary function is to provide both a resting area for motorists and statewide information to tourists [NCDOT Rest Areas]. Signs in and near welcome centers are maintained by the NCDOT, but these were not counted in the Kirtley study. Since welcome centers are essentially Interstate rest areas that contain a small information office, it was assumed that their average sign density would not be significantly different from that of an average Interstate rest area. For this reason, signs for Interstate welcome centers were estimated as if they were Interstate rest areas.

### 2.1.2 Visitor Centers

Visitor centers are much like welcome centers except they are located on US Routes. There are eight visitor centers in North Carolina [NCDOT Rest Areas]. Since they too are essentially rest areas with a small information office, they have also been counted as if they were simply US Route rest areas.

### 2.1.3 Rest Areas

Rest areas are located along Interstates, US Routes, and NC Routes. The purpose of rest areas is to allow travelers a location to rest during their journey. In the Kirtley study, signs in rest areas were not counted. But rest areas do contain signs maintained by the NCDOT, and therefore, they have been estimated in the present study. Tables 2.1 and 2.2 show the location of all North

Carolina rest areas. In Table 3.1 rest areas that contain welcome centers are also identified. In Table 2.2, the rest areas with visitor centers are shown. In all, North Carolina has a total of 47 rest areas, 8 welcome centers, 7 visitor centers

| Milepost | I-95 Northbound Lane |
|---|---|
| 5 | Robeson, 5mi. north of S.C. (Welcome Center) |
| 47 | Cumberland, 1 mi. south of Fayetteville |
| 99 | Johnston, 2 mi. north of Selma |
| 142 | Nash, 1.5 mi. north of Dortches |

| Milepost | I-95 Southbound Lane |
|---|---|
| 181 | Northampton, 5 mi. south of V.A. (Welcome Center) |
| 142 | Nash, 1.5 mi. north of Dortches |
| 99 | Johnston, 2 mi. north of Selma |
| 47 | Cumberland, 1 mi. south of Fayetteville |

| Milepost | I-85 Northbound Lane |
|---|---|
| 2 | Cleveland, 2 mi. north of S.C. (Welcome Center) |
| 59 | Cabarrus, 1mi. north of Concord |
| 99 | Davidson, 1 mi. southwest of Thomasville |
| 139 | Alamance, 3 mi. west of Burlington |
| 199 | Granville, 6 mi. south of Oxford |

| Milepost | I-85 Southbound Lane |
|---|---|
| 231 | Warren, 2 mi. south of V.A. (Welcome Center) |
| 199 | Granville, 6 mi. south of Oxford |
| 139 | Alamance, 3 mi. west of Burlington |
| 99 | Davidson, 1 mi. southwest of Thomasville |
| 59 | Cabarrus, 1mi. north of Concord |
| 5 | Cleveland, 2 mi. south of Kings Mountain |

| Milepost | I-77 Northbound Lane |
|---|---|
| 1 | Mecklenburg, 1.5 mi. north of S.C. (Welcome Center) |
| 39 | Iredell, 4 mi. north of Mooresville |
| 72 | Yadkin, 1 mi. south of U.S. 421 |

| Milepost | I-77 Southbound Lane |
|---|---|
| 106 | Surry, at V.A. / N.C. line (Welcome Center) |
| 63 | Iredell, 4 mi. north of Mooresville |
| 39 | Iredell, 1 mi. south of U.S. 421 |

| Milepost | I-40 Eastbound Lane |
|---|---|
| 10 | Haywood, 10.5 mi. east of T.N. (Welcome Center) |
| 82 | McDowell, 1 mi. west of Marlon |
| 136 | Catawba, 10 mi. east of Hickory |
| 177 | Davie, 18 mi. west of Winston-Salem |
| 324 | Johnston, 1 mi. north of U.S. 301, near Benson |
| 364 | Duplin, at N.C. 24 near Warsaw |

| Milepost | I-40 Westbound Lane |
|---|---|
| 364 | Duplin, at N.C. 24 near Warsaw |
| 324 | Johnston, 1 mi. north of U.S. 301, near Benson |
| 177 | Davie, 18 mi. west of Winston-Salem |
| 136 | Catawba, 10 mi. east of Hickory |
| 82 | McDowell, 1 mi. west of Marlon |
| 10 | Haywood, 10.5 mi. east of T.N. |

| Milepost | I-26 Eastbound Lane |
|---|---|
| 10 | Buncombe, 12 mi. east of Asheville |

| Milepost | I-26 Westbound Lane |
|---|---|
| 36 | Polk, 3 mi. north of S.C. (Welcome Center) |
| 10 | Henderson, 12 mi. east of Ashville |

Table 2.1 North Carolina Interstate Highway Rest Area System [NCDOT Rest Areas]

A sign density estimation method was used to account for the total number of signs in rest areas. Signs were counted at 7 rest areas (4 Interstate, 2 US Route, and 1 NC Route), as shown in Table 3.1. The results of these counts were complied to find an average sign density for an individual rest area. This average density was then multiplied by the total number of rest areas in North Carolina to arrive at a total rest area sign count.

| Route # | US Routes |
|---|---|
| 17 | Camden, 1 mi. south of V.A. (Visitor Center) |
| 17 | Craven, 11 mi. north of New Bern |
| 17 | Brunswick, at Shallotte (Visitor Center) |
| 19A/129 | Cherokee, at S.R. 1388 near Andrews |
| 23/74 | Haywood, 1 mi. north of Blue Ridge Pkwy. |
| 29 | Caswell, 2 mi. south of V.A. (Visitor Center) |
| 64 | Washington, at Plymouth |
| 64 | Tyrrell, at Columbia (Visitor Center) |
| 64/264 | Dare, 2 mi. west of Manteo |
| 70 | Craven, at S.R. 1225 near Clarks |
| 70 | Carteret, at Morehead City (Visitor Center) |
| 158 | Currituck, 1.5 mi. south of Coinjock |

| Route # | US Routes |
|---|---|
| 158 | Dare, at Kitty Hawk (Visitor Center) |
| 220 | Richmond, 1 mi. north of Ellerbe |
| 221 | Wartauga, 2 mi. west of Blowing Rock |
| 221 | McDowell, at S.R. 1195 (Visitor Center) |
| 258 | Hertford, 1 mi. west of Blowing Rock |
| 264 | Hyde, at Englehard |
| 421 | Sampson, 10 mi. south of Clinton |
| 421 | Watauga, at Deep Gap, 8 mi. east of Boone |
| 441/23 | Macon, 4 mi. south of Franklin (Visitor Center) |
| | **NC Route** |
| 705 | Moore, south of Westmoore |

Table 2.2 North Carolina Highway Route Rest Area System [NCDOT Rest Areas]

Some Interstate rest areas have two separate stops at the same location, one on each direction of travel. In these cases, the sign count methodology treated each side as a separate stop.

### 2.1.4 Truck Weigh Stations

The NCDOT owns, operates, and maintains truck weigh stations. A weigh station typically consists of a set of weight scales, a staging area for inspection, an enforcement office, and a set of entrance and exit roadways. The size and scope of each of these areas may vary based upon the NCDOT's needs. There are a total of 10 permanent truck weigh stations in North Carolina; 8 of them are located along Interstates and the other 2 are located along US Routes [NCDOT Weigh Stations]. A list of the location of these truck weigh stations is shown in Table 2.3.

It was assumed that Interstate weigh stations would be larger than those along US Routes because of the greater volume of shipping traffic along Interstates. It was thought that the increased weigh station size would naturally lead to an increased number of signs, thereby making the Interstate average different from the US Route average. The number of signs at Interstate and US Route weigh stations were therefore separately counted and estimated.

As with rest areas, a sign density estimation method was also used to account for the total number of signs in truck weigh stations. Signs were counted at 2 Interstate and 1 US Route weigh

stations. The results of these counts were assumed to be representative of other North Carolina weigh stations. Using these totals, these figures were then multiplied by the total number of signs in weigh stations was estimated.

| | |
|---|---|
| **Asheville (Buncombe County)**<br>I-40, approximately 12 miles west of Asheville | **Hillsborough (Orange County)**<br>I-40 / I-85, approximately 15 miles west of Durham |
| **Charlotte (Mecklenburg County)**<br>I-85, approximately 10 miles southwest of Charlotte | **Kinston (Lenoir County)**<br>US 70 and US 258, within the city limits of Kinston |
| **Halifax (Halifax County)**<br>I-95, approximately 18 miles south of Roanoke | **Lumberton (Robeson County)**<br>I-95, approximately 10 miles north of Lumberton |
| **Hendersonville (Henderson County)**<br>I-26, approximately 7 miles north of Hendersonville | **Mount Airy (Surry County)**<br>I-77, approximately 3 miles south of the Virginia state line |
| **Hertford (Perquimans County)**<br>US 17, approximately 7.5 miles south of Elizabeth City | **Statesville (Iredell County)**<br>I-40, approximately 6 miles west of Statesville |

Table 2.3 North Carolina Permanent Truck Weigh Stations [NCDOT Weigh Stations].

## 2.2 Secondary Route Extensions

In addition to the Kirtley primary route study, it was necessary to perform a secondary route survey to complete the estimate of the total number of NCDOT maintained signs. The main contribution of this study is these secondary route results. The methodology used and the key assumptions made during this secondary road count are detailed in this section.

### 2.2.1 Methodology

**Color**

Many of the methods used in this study are intended to mirror those of the Kirtley study so that a reasonable comparison can be made between the results of both studies. For example, sign color was determined to be the most efficient way to count signs in the Kirtley study. Sign color was therefore used as the method to count signs along secondary roads.

The reason that sign color was initially used in the Kirtley study is that counting and recording the specific nature and type of each individual sign along the roadway would be impractical. There are hundreds of different types of signs; there are far fewer colors. Sign color was found to be an efficient way to classify signs because it relates to the underlying function of a sign and it is easily identifiable. Signs are grouped into color classifications based upon on their purpose, thereby allowing motorists to determine the nature of a sign before they can actually read it. There are currently 7 sign background colors in use by the NCDOT. These are shown in Table 2.4. To the right of each color is a brief description of the function that each type of color serves.

| Background Color | Description |
|---|---|
| Blue | Indicates services available to road users |
| Brown | Indicates recreational and cultural facilities |
| Green | Indicates movement permitted or gives directional guidance |
| Orange | Warns of temporary traffic conditions with a high hazard potential |
| Red | Indicates right-of-way control, prohibition, or exclusion |
| Yellow | Indicates a law, regulation, legal requirement, or direction |
| White | Warns of a typical potential hazard |

Table 2.4: Signs Background Color Descriptions [Kirtley 2001]

**Characterization**

Within each of these sign color classifications are a set of individual signs that serve a similar purpose. Table 2.5 gives a brief listing of some of the different types for each respective color.

| Blue | Brown | Green | Orange | Red | White | Yellow |
|---|---|---|---|---|---|---|
| Rest Area | Monument | Bike Route | Flag Man Ahead | Stop | Keep Right | Deer Crossing |
| Interstate | Camping | Directions | Men Working | Wrong Way | No Parking | Stop Sign Ahead |
| Evacuation Route | Historic Site | Fire District | Construction Zone | Do Not Enter | Speed Limit | Pedestrian Crossing |

Table 2.5: Example of Sign Types by Color [Kirtley 2001]

**Background**

This sign classification system describes the primary color of a sign's background. Most signs typically consist of two colors; one for the sign's lettering, and one for its background. The color of a sign's background was therefore defined to be the color which was not its lettering color. For example, Figure 2.1 shows a "Wrong Way" sign. These signs have white lettering and a red background. The color of a sign is taken to be opposite of the lettering. Therefore, the color of this sign is counted as a red sign.


Figure 2.1: Wrong Way Sign

**Exceptions**

The two exceptions to this rule are "Yield" and "Stop" signs. Due to the high level of liability that a stop sign poses, they were counted as a separate category. All sign counts therefore have tallies for 8 subsets: 7 for the main background colors, and one for stop signs. Stop signs were not included in any red counts. Yield signs have red lettering, and white and red in the background. Normally, these signs would be counted as white. Yield signs, however best fit into the red classification in terms of their underlying meaning. Also, the majority of the background of a yield sign is red. These signs were therefore counted as red.

**Recording**

The Kirtley study also determined that the most efficient way to count signs was through the use of an audio recorder. Sign data would be recorded into the audio recorder as roads were driven, and then compiled at a later date. It was found to be too difficult for one person to take down written tallies while driving.

**Sample Size**

Wake and six surrounding counties were chosen to sample. These counties were chosen for convenience, and because they have a good mixture of both rural and urban areas. Urban areas

are defined as areas located within the city limits of municipalities whose populations are greater than 5000 persons. Rural describes are all other areas. Table 2.7 lists each selected sample county along with its respective rural and urban roadway mileages. Rural road samples were taken from all seven counties, whereas urban samples were taken from only two (Wake & Durham). This is because only Wake and Durham had large enough urban mileage totals to allow for an efficient count.

| County Secondary Road Mileages | | | |
|---|---|---|---|
| County | Rural | Urban | Total |
| Chatham | 879.7 | 21.7 | 901.4 |
| Durham | 454.5 | 134.2 | 588.7 |
| Franklin | 623.8 | 11.9 | 635.7 |
| Granville | 696.8 | 19.6 | 716.4 |
| Harnett | 839.1 | 27.9 | 866.9 |
| Johnston | 1,241.6 | 53.2 | 1,294.8 |
| Wake | 1,541.1 | 259.3 | 1,800.4 |

Table 2.6: County Mileages [NCDOT Highway and Road]

**Route Selection**

Roads within each county were selected in such a manner as to achieve what was believed to be a representative sample of roads in each county. Many factors were considered when selecting roadways to ensure that a representative sample was in fact obtained. Roads were chosen based upon structure (paved vs. unpaved), length, and geographical location. Attention was paid to ensure that each set of countywide road samples had a mixture of all these characteristics. This meant that the approach used in this study was to drive roads that were both paved and unpaved, long and short, and from all geographic areas within the county.

## 2.2.2 Count Verification Study

In the Kirtley study, sign densities were based upon sign counts in one direction of travel only. This meant that signs were counted along one side of the roadway and then multiplied by 2 to estimate the total number of signs along that road sample. Signs densities could accurately be calculated in this manner because primary routes are very uniform in composition along both directions of travel.

It was uncertain if secondary roadways had a high enough degree of uniformity to use this same method for calculation. For this reason, a count verification study was performed using approximately 50 miles of rural secondary roadway. In this study, signs were first counted on a set of roads in one direction (forward direction). This same set of roads was then driven in the opposite direction (backward direction), and signs were again counted. The total number of signs counted were tallied for each individual direction, and compared to one another (Forward vs. Backward).

The raw data from this study is shown in Table 2.7. The road number is listed in the first column, with the number of signs in each respective direction in the subsequent columns. The totals for both count directions are shown in the last row of the table.

| Road | Count # | Forward Direction | | | | Backward Direction | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Green | White | Yellow | Stop | Green | White | Yellow | Stop |
| SR 1705 | 13 | 0 | 8 | 5 | 1 | 0 | 5 | 4 | 1 |
| SR 1700 | 14 | 0 | 0 | 5 | 0 | 0 | 0 | 5 | 0 |
| SR 1715 | 15 | 0 | 0 | 10 | 1 | 0 | 1 | 7 | 1 |
| SR 1716 | 16 | 1 | 6 | 12 | 7 | 1 | 7 | 11 | 4 |
| SR 1733 | 17 | 0 | 4 | 7 | 5 | 0 | 3 | 8 | 5 |
| SR 2110 | 18 | 2 | 3 | 37 | 4 | 3 | 2 | 35 | 4 |
| SR 2143 | 19 | 1 | 1 | 8 | 1 | 0 | 1 | 6 | 0 |
| SR 1934 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| SR 2145 | 21 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| SR 2146 | 22 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 0 |
| SR 1934 | 23 | 0 | 0 | 5 | 2 | 0 | 0 | 5 | 0 |
| SR 2149 | 24 | 0 | 0 | 2 | 0 | 1 | 0 | 3 | 0 |
| SR 2151 | 25 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 2 |
| SR 2153 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| SR 2170 | 27 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| SR 2117 | 28 | 1 | 10 | 3 | 2 | 1 | 9 | 3 | 2 |
| SR 2121 | 29 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| SR 2120 | 30 | 1 | 0 | 4 | 1 | 1 | 0 | 3 | 1 |
| SR 1934 | 31 | 0 | 0 | 7 | 3 | 1 | 0 | 6 | 1 |
| SR 2113 | 32 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| SR 2112 | 33 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 1 |
| Totals | | 6 | 32 | 109 | 35 | 8 | 30 | 101 | 27 |

Table 2.7 Count Verification Study Field Data

The totals of both directions are further shown in Table 2.8, along with an average of the 2 tallies. From this table, it can be seen that the totals of the two directions are relatively precise with respect to one another. Based upon this information it was decided that roads would be driven in one direction only, and then multiplied by 2 to arrive at a total number of signs for that sample. This method of one-directional driving would allow for a greater coverage of secondary road sampling, while maintaining a reasonable accuracy.

| Count Direction | Green | White | Yellow | Stop |
|---|---|---|---|---|
| Forward Direction | 6 | 32 | 109 | 35 |
| Backward Direction | 8 | 30 | 101 | 27 |
| Average | 7 | 31 | 105 | 31 |

Table 2.8 Count Verification Study Summary

## 2.2.3 Parallel Facing Signs

Signs along secondary roads are oriented both parallel and perpendicular to the direction of travel. Parallel signs are a little bit trickier to count than perpendicular signs because they may be visible from multiple roadways. This could potentially lead to a higher probability of double counting signs. A set of stringent rules was therefore developed to ensure that parallel signs would be only counted on one roadway. The basic premise of these rules was to develop a procedure that would ensure parallel signs would not be double counted. Figure 2.2 will be used to illustrate the principles of parallel sign counting.

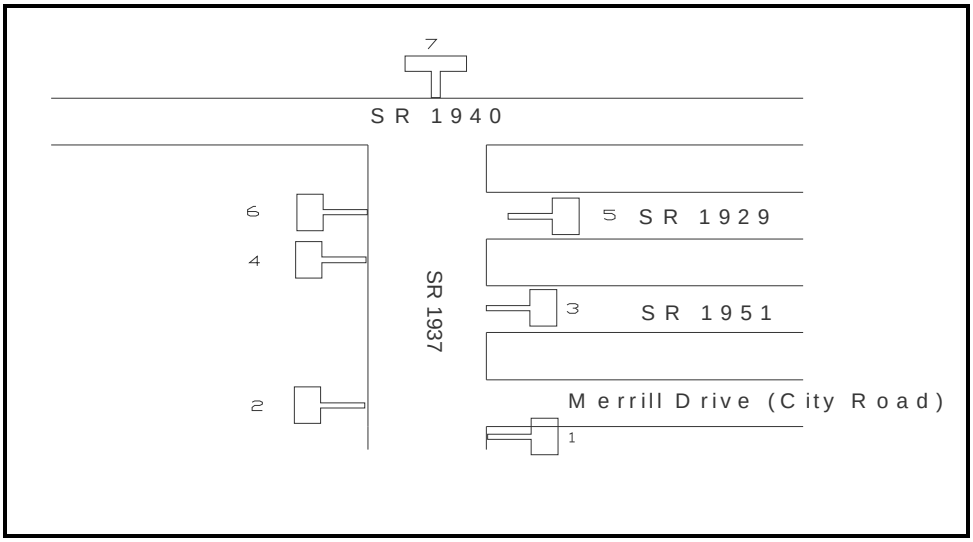


Figure 2.2 Parallel Signs

The purpose of this figure is to help illustrate the procedure used for counting parallel signs. In this example the road being driven is SR 1937. The other roads shown are SR 1940, SR 1951, SR 1929, and Merrill Drive, which is a city maintained road. Several parallel signs configurations have been shown in the figure, and each sign has been assigned a reference number (#1-7). The manner in which each sign will be counted is discussed below.

Sign #1 & 4: These signs represent signs that are located along SR 1937, but are not readily visible from any other roadway. These signs would be counted as part of SR 1937's sample count.

Sign #6 & #7: These signs face one roadway, but are located and parallel on another. For instance sign #7 is located on SR 1940, but faces SR 1937. In this case sign #7 would be counted as part of SR 1937 sample count. This is because sign #7 is most easily viewed from SR 1937. Likewise, sign #6 would be counted as part of SR 1929's sign count totals. Therefore, the counting rule for "T" intersections is to not count a parallel sign that faces another secondary road. It is important to note that although sign #4 is across from SR 1929, it would be counted as part of SR 1937's sign count. Only sign directly across the intersection are counted in this manner.

Sign #2: This, like Signs #1 and #4, also is a sign at a "T" intersection. The difference is this case, however, is that Sign #2 is perpendicular to a city maintained road. If Merrill Drive was a NCDOT maintained road, sign #2 would be counted as being part of Merrill Drive, and not SR 1937. Since Merrill Drive is city maintained, and sign #2 is state maintained, this procedure would leave this sign uncounted. Therefore, it is necessary to include this sign as part of SR 1937's sign count. Therefore, the rule for counting "T" intersections with a city maintained road is to include the sign as part of the secondary road's total.

Sign#3 & #5: These signs are both located parallel to SR 1937, at the entrances to other roads. The method for counting these signs depends on how close they are to the edge of the roadway entrance. In the case of sign #3, the sign is right on the edge of SR 1937. This sign would be counted as being part of 1937's sample data because the sign would not be easily seen when turning onto SR 1951. Sign 5, however, is setback a few feet into SR 1929. In these cases, the

signs would most likely be seen when turning onto SR 1929. They were therefore not include in SR 1937's totals, and include it as part of SR 1929's totals.

In the event that SR 1929 and SR 1951 crossed over SR 1937, signs #3 and #5 would be counted differently. This is shown in Figure 2.1. In this case signs #3 and #5 would be counted as part of SR 1951 and 1929, respectively. This is because they are now perpendicular to these roadways (SR 1951 & SR 1929). So if, for example, SR 1929 was sampled sign #5 would show up as a perpendicular sign and therefore be counted as part of SR 1929.

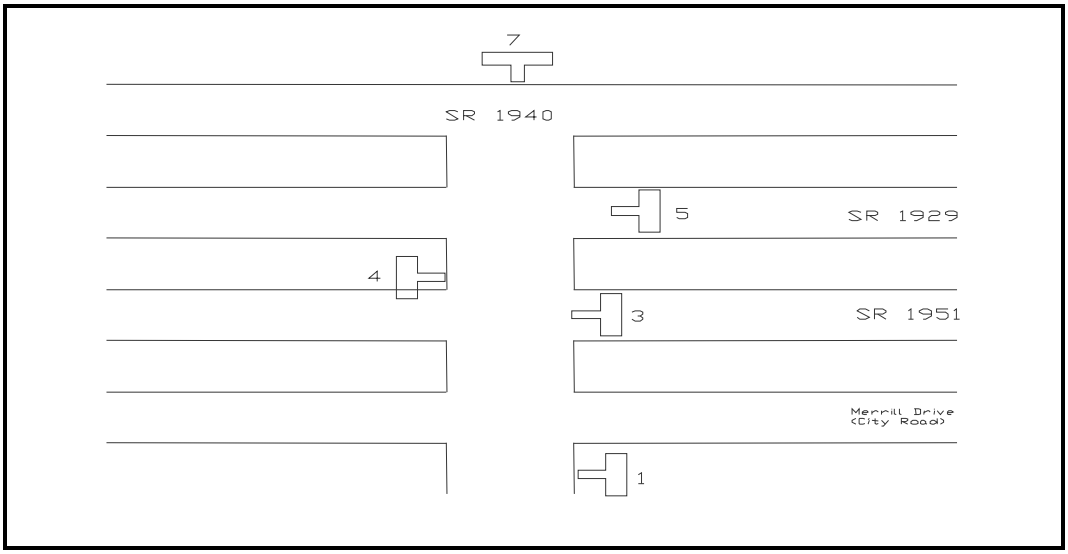


Figure 2.3 Parallel Signs Continued

There is also a highly specialized count methodology pertaining to divided highways which needs to be discussed. In the Kirtley study, all visible one-way street signs were counted along divided primary routes. To remain consistent, this study did not count any one-way signs along a divided highway. There is one exception, however, which is illustrated in Figure 2.4.

Figure 2.4 shows a series of one-way signs (#1-6), which frequent intersections with primary routes (US 401). Each sign has been given a reference number. In this case, if a motorist were driving along SR 1507, no one-way parallel signs would be counted, because all of these signs were counted in the Kirtley study. If the driver were going along SR 1500, sign #1 would be counted. This sign actually faces towards SR 1500, with its back towards the primary route (US 401). This sign could not be identified from the primary route because its lettering faces away

form US 401, and therefore was not counted. These signs were therefore counted in the secondary count tallies. Note that this rule only pertains to one-way signs. All other types of signs adhere to the rules set forth in Figures 2.2 and 2.3.

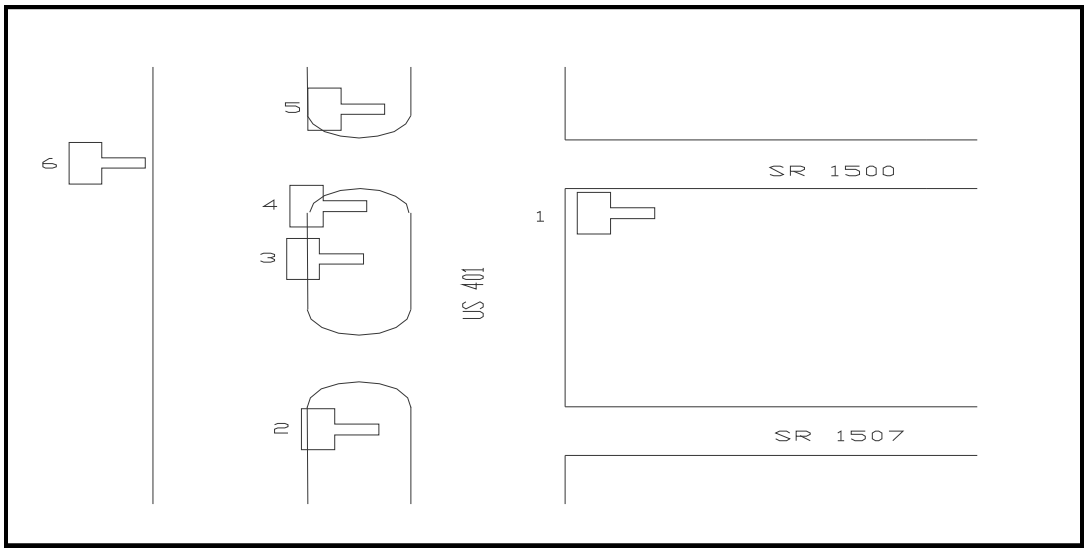


Figure 2.4 One-Way Signs on Divided Primary Routes

It is important to remember the overall philosophy is to ensure that parallel signs are not double counted. In any other highly specialized situation that may have arisen, parallel signs were counted based on two questions:

- Is this sign NCDOT maintained?
- If so, would it be counted as part of another road?

If the answer to the second question is "yes", the sign would not be included in the sample.

### 2.2.4 Divided Secondary Roads

Sometimes, a roadway has a central barrier that clearly divides the two directions of travel. A roadway with this sort of barrier is termed "divided", and the divisor is typically a concrete barrier, metal railing, grass median, or some sort of vegetation. Since additional signs are needed to help direct the flow of traffic around the barrier, a divided roadway will have a different sign density than one that is undivided.

As can be seen in Table 2.9, there are 144.55 miles (133.5 + 11.0) of divided secondary roadway in North Carolina. Since this only represent 0.2% all secondary roadways, divided roadways were not considered statistically significant enough to count. In planning which roads to drive, divided roadways were intentionally avoided. The structure of a road, can however, suddenly change from undivided to divided and then back to undivided. In these cases, the entire section of road way treated as undivided, as long as the divided portion was only a few hundred feet or so.

| | Roadway Characteristic | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2 Lanes | 3 Lanes | Four Lanes | | Six Lanes or More | | 1Way Pair | Total |
| | | | Divided | Undivided | Divided | Undivided | | |
| Rural Secondary Roads | 59,054.9 | 4.2 | 42.9 | 60.3 | 0.4 | 5.6 | | 59,168.2 |
| Urban Secondary Roads | 3,821.9 | 26.3 | 90.7 | 336.7 | 10.7 | 12.6 | 0.1 | 4,298.9 |
| Totals | 62,876.8 | 30.5 | 133.5 | 396.9 | 11.0 | 18.2 | 0.1 | 63,467.1 |

Table 2.9 Secondary Road Mileages by Road Structure [NCDOT Highway and Road]

## 2.2.5 Excluded Signs

There are a great variety of signs along Secondary roads that are not installed or maintain by the NCDOT. These signs were therefore excluded for the sign counting activity. Signs excluded from counts include hotel signs, community watch signs, bus stop signs, and private business signs. Consider Hotel sign. Hotels often have metallic signs that provide directional instructions to motorists. A hotel sign typically consists of two signs, one with the name of the hotel, and the other is simply a directional arrow. Since hotel signs were not thought to be maintained by the NCDOT, neither of these signs was counted. Figure 2.5 illustrates examples of these signs.


Figure 2.5: Hotel Signs

In addition to these non-NCDOT maintained signs, street signs and directional markers are also non-NCDOT maintained signs. Street signs are illustrated in Figure 2.6 below.


Figure 2.6: Street Signs

## 2.2.6 Damaged Signs

It is not uncommon to come across signs that have been hit or damaged in some manner. These types of signs are most often seen in rural areas, and are typically severely leaning on their post, or are propped up by nearby vegetation. Since the DOT will eventually replace these signs as part of their ongoing maintenance efforts, they were included in the sign counts.

## 2.2.7 Split Exits

Occasionally, a secondary road will split into a divided section upon the intersection with another road. This is illustrated in Figure 2.7. In this example, SR 1119 splits at the intersection of NC 29 into two separate exit paths. In these cases, all signs (#1-#3) were counted as part of SR 1900's sample. All three signs must be counted, because they would not be counted along any other route.

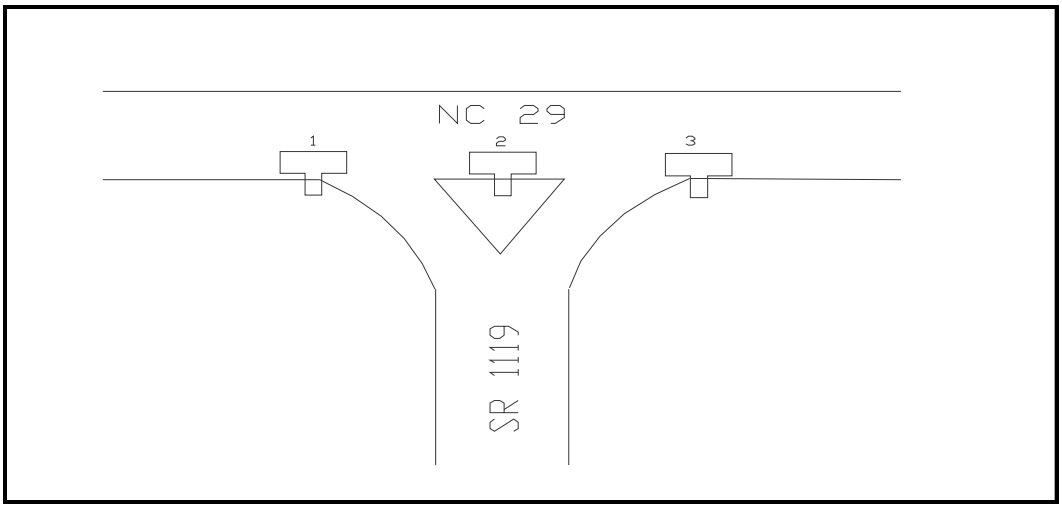


Figure 2.7: Split Exits

## 2.2.8 Dead Ends

After deciding to count roads in a one-directional manner, dead end roads were identified as potential problems. A dead end road typically has a stop sign(s) at its exit. Under the methodology used, a stop sign would never be included in the count if these roads were driven from their intersection until the end. An effort was therefore made to drive some dead end roads from their end to the intersection, as well as from their intersection until the end. This principle is depicted in Figure 2.8.

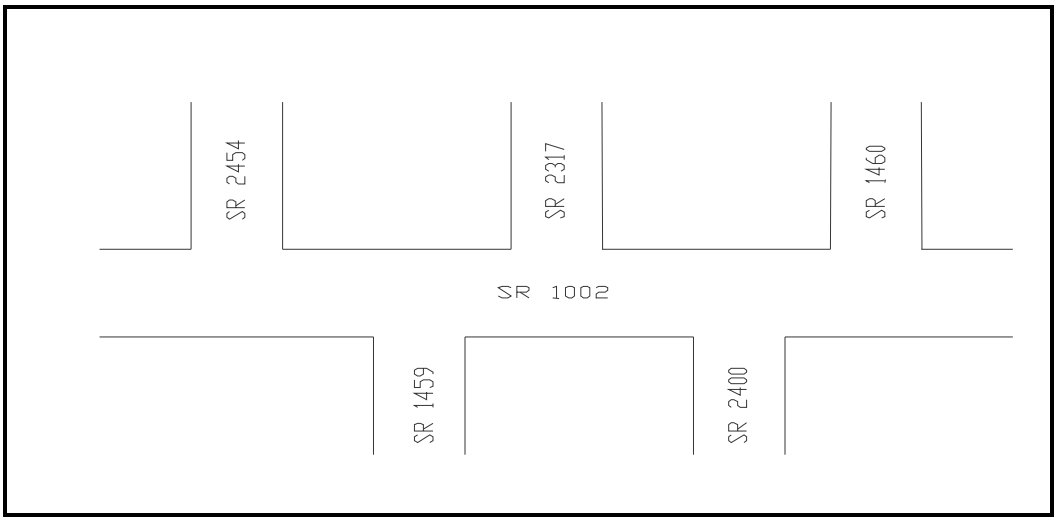


Figure 2.8: Dead Ends

In this figure 5 sampled roads are shown (SR's 2454, 2317, 1460, 1459, and 2400). For example, SR 2400 has a stop sign located at its intersection with SR 1002. If this road was driven from the intersection of SR 1002 to the end, the stop sign would never be counted. If the road was driven from its end to the intersection of SR 1002, its stop sign would be counted. Dead-end roads were therefore driven in both directions. In this particular example SR 2454 and SR 2400 were driven from the end to their intersection with SR 1002. SR's 2317, 1460, and 1459 were all driven from their intersections with SR 1002 until their respective endings.

### 2.2.9 Urban Issues

Urban secondary routes have some properties which made them difficult to sample. First of all, urban routes tend to be poorly and infrequently marked. This made it difficult to ascertain exactly were an urban route began or ended. In addition, it was difficult to determine if a particular parallel sign should be counted, based upon the methodology described in section 2.2.3. The reason for this difficulty is that the road faced by a parallel sign may not be clearly marked as secondary or non-secondary. Therefore, it could not be determined if the sign fell under the rules for sign #5 or for signs #6 & #7, as set explained in Figure 2.2. The sampler must therefore make a judgment call as whether to include the sign in his count totals. In addition to the lack of clear marking, many urban routes weave in and out of municipalities. When these routes are outside of a city limit, they are considered to be a rural route. Many urban secondary routes will suddenly switch to a defined rural route and then back to a defined urban route. Routes that did this were difficult to sample because of the uncertainty of classification (urban or rural). The combination of this with the unclear labeling of primarily urban routes, limited the total number of urban secondary mile suitable for sampling. In this study, only clearly marked roads were driven, but the results of the sampling were thought to have some imperfections because of the problems cause by parallel sign counting.

# 3.0 RESULTS

In this section the results of the study are presented for review. Two sets of tables are included. The first table provides the number of signs actually counted. The second table presents the total number of estimated signs in the state. This second table is a projection of the data from the first table.

## 3.1 Primary Route Improvements

### 3.1.1 Rest Areas, Welcome Centers, and Visitor Centers

Rest stops exist along Interstate, US routes, and NC routes. There are 40 Interstate, 21 US Route, and 1 NC Route rest areas in the state [NCDOT Rest Areas]. Table 3.1 shows the total number of signs for each rest area classification by sign type.

| Road Type | Rest Area Sign Field Data | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Blue | Brown | Green | Orange | Red | White | Yellow | Stop |
| I-85 Southbound Mile 139 | 6 | 0 | 0 | 0 | 9 | 18 | 2 | 0 |
| I-85 Northbound Mile 139 | 9 | 0 | 0 | 0 | 8 | 20 | 2 | 0 |
| I-40 Westbound Mile 324 | 3 | 0 | 0 | 0 | 7 | 24 | 0 | 0 |
| I-40 Eastbound Mile 324 | 5 | 0 | 0 | 0 | 5 | 15 | 1 | 0 |
| **Interstate Average** | **5.8** | **0** | **0.0** | **0.0** | **7.3** | **19.3** | **1.3** | **0.0** |
| US 220 | 3 | 0 | 1 | 0 | 4 | 9 | 0 | 1 |
| **US Route Average** | **3** | **0** | **1** | **0** | **4** | **9** | **0** | **1** |
| NC 705 | 1 | 0 | 0 | 0 | 4 | 11 | 0 | 2 |
| **NC Route Average** | **1** | **0** | **0** | **0** | **4** | **11** | **0** | **2** |

Table 3.1: Number of Signs Counted in Rest Areas by Color

Table 3.1 shows that 6 rest areas were visited and inventoried. The number of each color of sign is shown at each rest area. The Interstate average was calculated using the four rest areas as being representative of any typical North Carolina Interstate rest area. The same was done for US and NC routes. The averages are shown in the bolded areas of Table 3.1. These averages were then multiplied by the total number of rest areas in the state for each Interstate, U.S. Route, and N.C. Route categorization to arrive at an estimated total rest area sign count. Table 3.2 shows these figures. In total, rest areas add 1,736 signs to the original counts done in the Kirtley study.

| Road Type | Estimated Total Number of Rest Area Signs in North Carolina | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Blue | Brown | Green | Orange | Red | White | Yellow | Stop |
| Interstate (40) | 230 | 0 | 0 | 0 | 290 | 770 | 50 | 0 |
| US Route (21) | 63 | 0 | 21 | 0 | 84 | 189 | 0 | 21 |
| NC Route (1) | 1 | 0 | 0 | 0 | 4 | 11 | 0 | 2 |
| Total by Color | 294 | 0 | 21 | 0 | 378 | 970 | 50 | 23 |
| **Total of All Colors** | **1,736** | | | | | | | |

Table 3.2: Total Number of Signs Estimated in Rest Areas by Color

### 3.1.2 Truck Weigh Stations

Weigh Stations are located along Interstates and US Routes. Signs were counted at three weigh stations: the I-40 / I-85 weigh station (located approximately 15 miles west of Durham), the I-95 weigh station (located approximately 18 miles south of Roanoke Rapids) and the US 70 / US 258 weigh station (located within the city limits of Kinston) Table 3.3 shows the number of signs at each weigh station by color.

| Truck Weigh Station | Truck Weigh Station Field Data | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Blue | Brown | Green | Orange | Red | White | Yellow | Stop |
| I-40 / I-85 Hillsborough | 8 | 0 | 24 | 0 | 14 | 59 | 11 | 6 |
| I-95 Halifax | 0 | 0 | 0 | 0 | 0 | 13 | 8 | 4 |
| US 70 / US 258 Kinston | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 |

Table 3.3: Number of Signs Counted at Truck Weigh Stations by Color

Each of these weigh stations was assumed to representative of other weigh stations for the same roadway classification. The field data was therefore multiplied by the total number of weigh stations (8 Interstate, 2 US Route) to arrive at an estimated total truck weigh station sign count. The estimated totals are shown in Table 3.4. These values result in the addition of 594 signs to the original counts done in the Kirtley study.

| Truck Weigh Station | Truck Weigh Station Field Data | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Blue | Brown | Green | Orange | Red | White | Yellow | Stop |
| Interstate | 32 | 0 | 96 | 0 | 56 | 288 | 76 | 40 |
| US Route | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 |
| Total by Color | 32 | 0 | 96 | 0 | 58 | 292 | 76 | 40 |
| **Total of All Colors** | **594** | | | | | | | |

Table 3.4: Total Number of Signs Estimated at Truck Weigh Stations by Color

## 3.2 Secondary Route Extensions

The results of the secondary roadway study are detailed in this section. In the study, signs were counted on 1277.5 miles (1156.2 Rural, 121.0 Urban) of North Carolina secondary roadways. As discussed in the methodology, all of the study samples were taken from a seven county area centered around Wake county. Detailed information about the sample data can be found in Appendices B, C, and D. A summary of these 3 appendices can be found in Appendix A.

Table 3.5 shows both the rural and urban two-way sign densities for each of the counties sampled in this study. Of the seven counties, urban samples were only taken from Wake and Durham counties. These were the only two counties in the sample area with a substantial number of state-maintained urban secondary roadways. A more detailed summary of each county's sign density can be found in Appendix A.

| | Sign Densities | |
|---|---|---|
| County Name | Rural | Urban |
| Chatham | 9.0 | -NA- |
| Durham | 12.6 | 26.6 |
| Franklin | 7.3 | -NA- |
| Granville | 7.2 | -NA- |
| Harnett | 6.2 | -NA- |
| Johnston | 7.1 | -NA- |
| Wake | 15.4 | 38.6 |

Table 3.5 County Sign Density Summary

As can be seen in Table 3.5, the rural sign densities of Wake and Durham counties were found to be significantly higher than those of the other 5 counties. These two counties are more urban in nature the other counties in the study and have significantly higher population densities. It was therefore inferred that the higher population densities resulted in an increased need for rural traffic control signage as motorists flowed in and out of large municipalities. This increased flow of traffic was thought to result in higher rural sign densities. It was therefore necessary to estimate signs in counties with high population densities separate from counties with low or average population densities.

Using the findings of North Carolina's 2000 census figures [Census 2000], the 100 counties of North Carolina were divided into 2 categories, termed *Type I* and *Type II* counties. Type I counties have low population densities of less than 525 persons per square mile. Type II counties have high population densities, greater than 525 persons per square mile. Type II counties are typically dominated by a large municipality, and therefore are similar to both Durham and Wake counties. Table 3.6 lists all of North Carolina's counties and their respective classification. There are a total of 93 Type I counties and 7 Type II counties.

| Type I Counties | | | | Type II Counties |
|---|---|---|---|---|
| Alamance | Craven | Jones | Richmond | Durham |
| Alexander | Cumberland | Lee | Roberson | Forsyth |
| Alleghany | Currituck | Lenoir | Rockingham | Gaston |
| Anson | Dare | Lincoln | Rowan | Guilford |
| Ashe | Davidson | Macon | Rutherford | Mecklenburg |
| Avery | Davie | Madison | Sampson | New Hanover |
| Beaufort | Duplin | Martin | Scotland | Wake |
| Bertie | Edgecombe | Mcdowell | Stanly | |
| Bladen | Franklin | Mitchell | Stokes | |
| Brunswick | Gates | Montgomery | Surry | |
| Buncombe | Graham | Moore | Swain | |
| Burke | Granville | Nash | Transylvania | |
| Cabarrus | Greene | Northampton | Tyrrell | |
| Caldwell | Halifax | Onslow | Union | |
| Camden | Harnett | Orange | Vance | |
| Carteret | Haywood | Pamlico | Warren | |
| Caswell | Henderson | Pasquotank | Washington | |
| Catawba | Hertford | Pender | Watauga | |
| Chatham | Hoke | Perquimans | Wayne | |
| Cherokee | Hyde | Person | Wilkes | |
| Chowan | Iredell | Pitt | Wilson | |
| Clay | Jackson | Polk | Yadkin | |
| Cleveland | Johnston | Randolph | Yancey | |
| Columbus | | | | |

Table 3.6 County Classifications

The two-way rural sign density of Type I counties was estimated to be 7.33 signs per mile (Appendix A). This figure was found by dividing the total number of signs counted in Type I counties (3314) by the total number of miles driven in Type I counties (906.4). This number (3.66) was then multiplied by 2 to arrive at a two-way sign density of 7.33 signs per mile. Rural sign totals in Type II counties were estimated using the same method, and the two-way Type II rural sign density was found to be 14.36. Even though urban data was taken from only Wake and

Durham counties, this was used to estimate all of North Carolina's urban secondary route signs. Although Wake and Durham are dominated by the large municipalities of Raleigh and Durham respectively, several of the smaller municipalities in these counties were also sampled. Urban routes were also driven in Cary, Holly Springs, and Fuquay-Varina. It was felt that this provided enough variation in municipality size to reasonably estimate the number of signs on North Carolina's urban secondary routes. Using the same method as described for rural routes, total urban signs counted (2058) was divided by the total number of urban miles driven (121.0) and multiplied by 2 to derive a two-way urban sign density of 34.01 signs per mile. This number was applied to urban miles in both Type I and Type II counties.

### 3.2.1 Total Number of Signs

Using the computed sign densities (7.33, 14.36, and 34.01) the total number of signs on both rural and urban secondary routes was estimated. Table 3.7 shows these estimates. Type I counties are listed in the 1st row and Type II counties are listed in the 2nd row. The 3rd row lists the sign totals for the entire state in both rural and urban areas. The 4th row tallies both the rural and urban totals to arrive at 616,436 secondary route signs in the state of North Carolina. Appendix E shows the calculation of these figures, along with an estimate for the number of signs in each individual county.

| Summary Table Type I & II Counties | | | | | | |
|---|---|---|---|---|---|---|
| County Type | Rural | | | Urban | | |
| | Miles | Sign Density Estimate | Signs | Miles | Sign Density Estimate | Signs |
| Type I | 53,972.14 | 7.33 | 395,616 | 2909.76 | 34.01 | 98,961 |
| Type II | 5,196.04 | 14.36 | 74,615 | 1389.12 | 34.01 | 47,244 |
| Totals | 59,168.18 | -NA- | 470,231 | 4298.88 | -NA- | 146,205 |
| **Statewide Estimation** | | | | | | **616,436 Signs** |

Table 3.7 Statewide Secondary Road Estimate of Total Number of Signs

### 3.2.2 Number of Signs by Color

Table 3.8 shows the estimate of total number of secondary route signs by background color. The data shows the estimated number of signs by each color for Type I rural, Type II rural, and urban

roadways. These three rows are then summed to find a statewide sign total estimate. The data in Table 3.8 was computed in Appendix F.

| Statewide Color Estimate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Roadway Classification | Sign Color | | | | | | | |
| | Blue | Brown | Green | Orange | Red | White | Yellow | Stop |
| Type I Rural | 3,238 | 1,619 | 20,509 | 4,318 | 1,619 | 107,405 | 213,190 | 43,717 |
| Type II Rural | 1,403 | 104 | 1,143 | 935 | 883 | 30,709 | 33,722 | 5,716 |
| Urban | 7,695 | 1,204 | 6,233 | 4,772 | 3,611 | 82,410 | 38,647 | 1,634 |
| Statewide Estimate | 12,336 | 2,927 | 27,885 | 10,025 | 6,113 | 220,524 | 285,559 | 51,067 |

Table 3.8 Statewide Secondary Road Sign Estimate by Color

A color sign density for the secondary route totals was calculated and is shown in Table 3.9. These figures are computed in a fashion similar to a typical sign density. For example 3,238 blue signs were counted while driving 906.4 miles of rural Type I roadway. The number of blue signs (3,238) was divided by the number of miles (906.4) and this figure (0.03) was multiplied by 2 to arrive at an estimate of 0.06 blue signs per mile of Type I rural secondary roadway. This same calculation was performed for each sign color along each road type. It is important to recognize that Table 3.8 shows totals of signs by color, while Table 3.9 shows frequency of sign colors. The column on the far right of the table sums the individual color sign density to show the total sign density for each route type.

| Road Type | Sign Color | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Blue | Brown | Green | Orange | Red | White | Yellow | Stop | Total |
| Type I Rural | 0.06 | 0.03 | 0.38 | 0.08 | 0.03 | 1.99 | 3.95 | 0.81 | 7.33 |
| Type II Rural | 0.27 | 0.02 | 0.22 | 0.18 | 0.17 | 5.91 | 6.49 | 1.10 | 14.36 |
| Urban | 1.79 | 0.28 | 1.45 | 1.11 | 0.84 | 19.17 | 8.99 | 0.38 | 34.01 |

Table 3.9 Color Sign Densities for Secondary Routes

## 3.3 Count Totals of Both Studies

The following Tables summarize the final results of both this and the Kirtley Study. These data tables give the estimated total number of signs in the state of North Carolina by background

color. The statewide estimate is approximately 970,000 NCDOT maintained signs, and is detailed in Table 3.10.

Several aspects of this table may be confusing to the reader. The 1st row in Table 3.10 titled "I,US,NC" is the final estimate provide in the Kirtley primary route study. This row estimates the total number of signs along North Carolina Interstate (I), NC Routes (NC), and US Routes (US). The "RAs, VCs, and WC" row in Table 3.10 estimates the total number of signs located in rest areas (RAs), visitor centers (VCs), and welcome centers (WCs). This data can also be found in Table 3.2 of this report. The "Truck Weigh Station" row simply lists the findings of the truck weigh station estimate presented in Table 3.4 of this report.

| | Blue | Brown | Green | Orange | Red | White | Yellow | Stop | Totals |
|---|---|---|---|---|---|---|---|---|---|
| I, US, NC (Kirtley) | 26,702 | 3,523 | 39,247 | 10,405 | 19,746 | 161,735 | 88,233 | 1,548 | 351,139 |
| RAs,VCs,and WCs | 294 | 0 | 21 | 0 | 378 | 970 | 50 | 23 | 1,736 |
| Truck Weigh Stations | 32 | 0 | 96 | 0 | 58 | 292 | 76 | 40 | 594 |
| Primary Total | 27,028 | 3,523 | 39,364 | 10,405 | 20,182 | 162,997 | 88,359 | 1,611 | 353,469 |
| Secondary Total | 12,336 | 2927 | 27,885 | 10,025 | 6,113 | 220,524 | 285,559 | 51,067 | 616,436 |
| All Total | 39,364 | 6,450 | 67,249 | 20,430 | 26,295 | 383,521 | 373,918 | 52,678 | 969,905 |

Table 3.10: Total Number of Signs in North Carolina

Table 3.11 details the number of signs on North Carolina's Interstates. The 1st row of this table shows the findings of the Kirtley study's Interstate counts. The Kirtley study did not include estimates for signs in rest areas or truck weigh stations along Interstates. These estimates were performed as part of this study and are shown in the 2nd and 3rd rows, respectively. The 4th row is a summation of rows 1, 2, and 3; showing the total number of signs along North Carolina's Interstates.

| | Blue | Brown | Green | Orange | Red | White | Yellow | Stop | Totals |
|---|---|---|---|---|---|---|---|---|---|
| Interstate (Kirtley) | 5,271 | 164 | 8,982 | 1,673 | 2,370 | 6,574 | 2,936 | 694 | 28,664 |
| RAs and WCs | 230 | 0 | 0 | 0 | 290 | 770 | 50 | 0 | 1,340 |
| Truck Weigh Stations | 32 | 0 | 96 | 0 | 56 | 288 | 76 | 40 | 588 |
| Interstate Total | 5,533 | 164 | 9,078 | 1,673 | 2,716 | 7,632 | 3,062 | 734 | 30,592 |

Table 3.11: Total Number of Interstate Signs in North Carolina

Table 3.12 details the number of signs on North Carolina's US Routes. Similar in format to Table 3.11, the 2nd row lists totals for rest areas, and the 3rd row lists totals for truck weigh stations. These were performed as an improvement to the Kirtley study. The 4th row is a

summation of rows 1, 2, and 3; giving an estimate for the total number of signs along North Carolina's US Routes.

| | Blue | Brown | Green | Orange | Red | White | Yellow | Stop | Totals |
|---|---|---|---|---|---|---|---|---|---|
| US Route (Kirtley) | 11,160 | 1,488 | 17,833 | 3,631 | 14,138 | 101,116 | 31,252 | 31 | 180,649 |
| RAs and VCs | 63 | 0 | 21 | 0 | 84 | 189 | 0 | 21 | 378 |
| Truck Weigh Stations | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 6 |
| US Route Total | 11,223 | 1,488 | 17,854 | 3,631 | 14,224 | 101,309 | 31,252 | 52 | 181,033 |

Table 3.12: Total Number of US Route Signs in North Carolina

Table 3.13 details the number of signs on North Carolina's NC Routes. There are no truck weigh stations on NC Routes, and the only extension to the Kirtley study was the addition of rest area totals, presented in the 2nd row.

| | Blue | Brown | Green | Orange | Red | White | Yellow | Stop | Totals |
|---|---|---|---|---|---|---|---|---|---|
| NC Route (Kirtley) | 10,271 | 1,871 | 12,432 | 5,101 | 3,238 | 54,045 | 54,045 | 823 | 141,826 |
| RAs | 1 | 0 | 0 | 0 | 4 | 11 | 0 | 2 | 18 |
| NC Route Total | 10,272 | 1,871 | 12,432 | 5,101 | 3,242 | 54,056 | 54,045 | 825 | 141,844 |

Table 3.13: Total Number of NC Route Signs in North Carolina

Table 3.14 details the number of signs on North Carolina's secondary routes. This data table is the primary contribution of this paper, and a more detailed summary of secondary route totals can be found in Section 3.2.

| | Blue | Brown | Green | Orange | Red | White | Yellow | Stop | Totals |
|---|---|---|---|---|---|---|---|---|---|
| Secondary Total | 12,336 | 2,927 | 27,885 | 10,025 | 6,113 | 220,524 | 285,559 | 51,067 | 616,436 |

Table 3.14: Total Number of Secondary Road Signs in North Carolina

Table 3.15 shows the composition of primary, secondary, and statewide totals based upon background color. This table will tell the reader, for example, that blue signs account for 7.6% of primary route signs, 2.0% of secondary route signs, and 4.1% of statewide sign totals.

| Route Type | Blue | Brown | Green | Orange | Red | White | Yellow | Stop | Total |
|---|---|---|---|---|---|---|---|---|---|
| Primary Route | 7.6 | 1.0 | 11.1 | 2.9 | 5.7 | 46.1 | 25.0 | 0.5 | 100.0 |
| Secondary Route | 2.0 | 0.5 | 4.5 | 1.6 | 1.0 | 35.8 | 46.3 | 8.3 | 100.0 |
| Total | 4.1 | 0.7 | 6.9 | 2.1 | 2.7 | 39.5 | 38.6 | 5.4 | 100.0 |

Table 3.15: Composition of Primary and Secondary Routes (%)

Table 3.16 shows how much each route accounts for a background color's total. For example, 68.7 % of blue signs are on primary routes, whereas the remaining 31.3% are on secondary routes.

| Route Type | Blue | Brown | Green | Orange | Red | White | Yellow | Stop |
|---|---|---|---|---|---|---|---|---|
| Primary Route | 68.7 | 54.6 | 58.6 | 50.9 | 76.8 | 42.5 | 23.6 | 3.1 |
| Secondary Route | 31.3 | 45.4 | 41.4 | 49.1 | 23.2 | 57.5 | 76.4 | 96.9 |

Table 3.11: Percentage of Background Color Totals on Primary and Secondary Routes (%)

Table 3.17 shows the frequency of each sign type on both primary and secondary routes. For example, there are 1.85 blue signs for every mile of primary route, and 0.19 blue signs for every mile of secondary route. The total column on the far right shows the average sign density for each route type.

| Route Type | Blue | Brown | Green | Orange | Red | White | Yellow | Stop | Total |
|---|---|---|---|---|---|---|---|---|---|
| Primary Route | 1.85 | 0.24 | 2.69 | 0.71 | 1.38 | 11.15 | 6.05 | 0.11 | 24.2 |
| Secondary Route | 0.19 | 0.05 | 0.44 | 0.16 | 0.10 | 3.47 | 4.50 | 0.80 | 9.7 |

Table 3.17: Average Color Sign Densities for Primary and Secondary Routes (signs/mile)

# 4.0 CONCLUSIONS

By combining the results from the Kirtley primary route study and the primary route improvements and secondary route totals of this study, the total number of NCDOT maintained signs could be reasonably estimated at 969,905. Roughly one-third (353,469) of these signs are on primary routes and the remaining two-thirds (616,436) are on secondary routes. The vast majority of these 970,000 signs are either white (39.5%) or yellow (38.5%). Together these total approximately 760,000 signs, accounting for 78% of the statewide total. The remaining six color classifications are relatively small in number. There are some notable differences between the characteristics of signs on secondary and primary routes.

## 4.1 Comparison of Primary and Secondary Totals

In general, signs are denser on primary routes than secondary routes. Primary route signs have an average density of 24.2 signs per mile, while signs on secondary routes have an average sign density of 9.7 signs per mile (Table 3.17). In addition, all of the sign color classifications occur more frequently on primary routes except for stop signs. Stop signs are more frequent on secondary routes (0.80 stop signs per mile) than on primary routes (0.11 stop signs per mile).

Even though primary routes have a higher average sign density, secondary routes contain more signs because of the vast number of secondary roadways. As previously noted, there are approximately 616,000 signs are located on 63,467.06 miles of secondary roadway, accounting for two-thirds of the statewide total. The remaining 354,000 signs are located along 14616.32 miles of primary highway. In terms of color, the majority of white, yellow, and stop signs are on secondary roadways, whereas the majority of blue, brown, green, orange, and red signs are on primary routes. The most notable of these differences are that secondary routes contain 97% of all stop and 76.4% of all yellow signs. Alternatively, while primary routes contain 68.7% of all blue and 76.8% of all red signs. Brown, green, orange, and white signs are more equally distributed between the two road types.

## 4.2 Primary Route Improvements

The primary route improvements of this study add an estimated 2,330 number of signs to the Kirtley primary route study. Of these, 1,736 are in rest areas and 594 are in truck weigh stations.

While these are a large number of signs, and make the primary route estimates more complete, they are relatively insignificant when compared to the estimated statewide total of 353,469 NCDOT primary route maintained signs. Thus, although we enhanced the results of the previous study the results themselves did not significantly change.

## 4.3 Secondary Route Extensions

The secondary route extensions of this report show a total of 616436 signs along North Carolina secondary route systems. Of these signs, roughly three-quarters (470,231 signs) are on rural secondary roadways, while the remaining one-quarter (146,205 signs) are on urban secondary routes. Signs on urban routes (34.0) had a much higher density than signs on rural routes (9.7). Furthermore, counties with high population densities had higher rural sign densities than counties with low population densities. This is further discussed below.

Secondary routes essentially only have four types of signs on them: green (4.5%), stop (8.3%), white (35.8%), and yellow (46.3%). These four signs combine to account for 95% of all secondary route signs. There are, therefore, virtually no blue, brown, orange, or red signs on secondary routes.

### 4.3.1 Comparison of Rural and Urban Secondary Routes

It is important to note that urban secondary routes are actually very different from rural secondary routes. In actuality, an urban secondary route is very similar to a primary route. Urban secondary routes have a fair share of blue, brown, and red signs and have very few stop signs. This likens them to primary routes, as primary routes also have many blue, brown, and red signs and very few stop signs. Furthermore, the overall urban secondary sign density (34.01 signs per mile) is also closer to the primary route average (24.2 signs per mile) than to the average rural secondary sign density (9.7 signs per mile). In terms of signage, it could therefore be said that a secondary urban route has more in common with a primary route than with a rural secondary route.

Taking this trend further, one can see that most secondary stop signs are on rural roadways. Type I and Type II rural secondary roads (See Section 4.3.2) have stop sign densities of 0.81 and 1.10 stop signs per mile respectively. Urban secondary routes, on the other hand, have a stop sign density of 0.38. The reason for this is that an urban secondary route is likely to be a main thoroughfare, and its intersections typically have stoplights instead of stop signs. There is,

therefore, a low density of stop signs. Alternatively, a rural secondary route intersection is typically controlled by stop signs, hence the difference in stop sign frequency. As previously noted, 97% (51,067) of all stop signs are on secondary routes. Of these 96% (43,717) of all secondary route stop signs are on rural secondary routes. This means the approximately 94% of all statewide stop signs are on rural secondary roadways!

### 4.3.2 Comparison of Type I Rural and Type II Rural Routes

Type I Rural and Type II Rural routes are actually very similar, except the Type II rural routes have a greater overall sign density (Type I – 7.33 signs per mile, Type II – 14.36 signs per mile). Remember that Type I rural secondary routes are located in counties with population densities less than 525 persons per square mile, and Type II rural secondary routes are located in counties with population densities greater than 525 persons per square mile. It appears that the reason for the 7.03 (7.03=14.36 - 7.33) difference between the two sign densities can mainly be attributed to an increase in the number of white and yellow signs. Type II rural routes have a total of 6.46 more white and yellow signs per mile. This figure (6.46 signs per mile) represents 92% of the total 7.03 sign per mile difference in sign density. The primary difference in a Type I and Type II rural route is therefore and increase in white and yellow signs. That is, in high population density counties (Type II) there are many more white and yellow signs.

## 4.4 Sign Reflectivity Implications

Since this study was performed, in part, to assist the NCDOT in determining a sound strategy for complying with the new federal sign reflectivity standards, it is important to specifically address reflectivity implications. Stop, red, orange, and yellow signs were thought to be the most essential signs when addressing sign reflectivity, and each are addressed individually below.

**Stop**

Stop signs are essentially all located on rural secondary routes. This study estimates there to be a total of 52,686 stop signs in the state of North Carolina. Of this total, 97% (51,067 stop signs) are on secondary routes. Of the 51,607 stop signs on secondary roadways, 96% (49,433 stop signs) are located on rural secondary routes. Urban secondary routes only account for 1,634 stop signs. There is a stop sign for every 1.2 miles of rural secondary roadway.

**Red**

Red signs are mainly on primary routes. There are an estimated 26,334 red signs in North Carolina. Of these, 77% (20,221 red signs) are located on primary routes. There is a red sign for every 0.72 miles of primary routes, and only one for every 10 miles of secondary route.

**Orange**

Orange signs widely occur on both primary and secondary routes. Approximately 51% (10,405) of statewide orange signs are on primary routes, and 49% (10,025) are on secondary routes. On average, orange signs are denser on primary routes than secondary routes. There is an orange sign for every 1.4 miles of primary route and for every 6.25 miles of secondary route.

**Yellow**

Yellow signs occur frequently across the spectrum of all route types. There are an estimated statewide 373,930 yellow signs. Approximately 76.4% (285,559) of these occur on secondary routes. Yellow signs, however, actually have a higher sign density on primary routes (6.05 yellow signs per mile) than secondary routes (4.50 yellow signs per mile). Secondary routes therefore have more total yellow signs because there are 63,467 miles of secondary roadway and only 14,616 miles of primary roadway.

From the above discussion, it can be seen that different road types have different types of signs. Stop signs are primarily are almost exclusively on rural secondary routes (94% of statewide total). Red signs are mainly on primary routes. Orange and Yellow signs are strongly represented on all route types.

### 4.4.1 Other Observations

It is important to remember that urban secondary routes comprise only 6.7% (4,299 miles) of the total secondary system (33,467 miles), and therefore do not significantly impact the secondary route totals. Reflectivity properties of urban secondary route can therefore be easily missed when looking at the system-wide totals. Urban secondary routes, unlike rural secondary routes, have a high frequency of red, orange, and yellow signs, but have very few stop signs. The reflectivity implications of urban secondary roadways are more akin to that of a primary route.

## 4.5 Summary

From these comparisons and implications, the reader can discern several clear and important points. First of all, signs on primary routes are more frequent than on secondary routes. The lone exception is the 4,300 miles of secondary urban routes, which have an estimated sign density of 34.01. Even though signs are more dense on primary routes, there are more total signs on secondary routes because the secondary route system is much more extensive than the primary route system.

Next, most NCDOT maintained signs are either white or yellow. These widely occur on both primary and secondary routes. There are relatively few of the other color classifications. Of the sign colors that are low in frequency and number, blue, brown, and red signs are mainly on primary routes. Green and orange signs are roughly equally represented on both primary and secondary routes. Stop signs almost exclusively exist on secondary routes.

## 4.6 Bullet Points

The following list of bullets is a reiteration of the key findings of this report:

- Estimated total of 970,000 NCDOT maintained signs
- Roughly 2/3rds of all NCDOT maintained signs are on secondary routes, the remaining 1/3 is on primary routes
- In general, primary routes have higher sign densities than secondary routes
- Urban secondary routes are more similar to primary routes in terms of sign density and types of signs found than rural secondary routes
- Counties with high population densities also tend to have higher rural secondary route sign densities than counties with low or average population densities
- 78% of all signs are either white or yellow, and occur frequently along all route types
- Stop signs are almost exclusively on rural secondary routes, urban secondary and primary routes have virtually no stop signs
- Red, Brown, and Blue signs are mainly on primary routes
- Green, Orange, White, and Yellow signs are widely found on all route types

# 5.0 RECOMMENDATIONS

## 5.1 An Alternate Sampling Approach

An alternate method of sampling is suggested to check the validity of this study's data. In this study, roads were driven that covered portions of the entire targeted counties. This was done to achieve equal and roughly balanced representation from all sections of the county. Roads were selected based upon geography, length, and structure (unpaved vs. paved). The selection process was done in a manner to attempt to develop a sample set that would fairly represent the make-up of the entire county. As a further check of the check the success of this process, an alternate method is suggested for consideration.

In Figure 5.1 a map of the Durham area is shown. In the current method a balanced but somewhat arbitrary selection of roads would be driven across the target area. The alternate method involves selecting a fixed, bounded area of a county, and then driving every secondary road within the boundaries of the selected area. The box, in this instance, is a located in the southwest quadrant of the map.

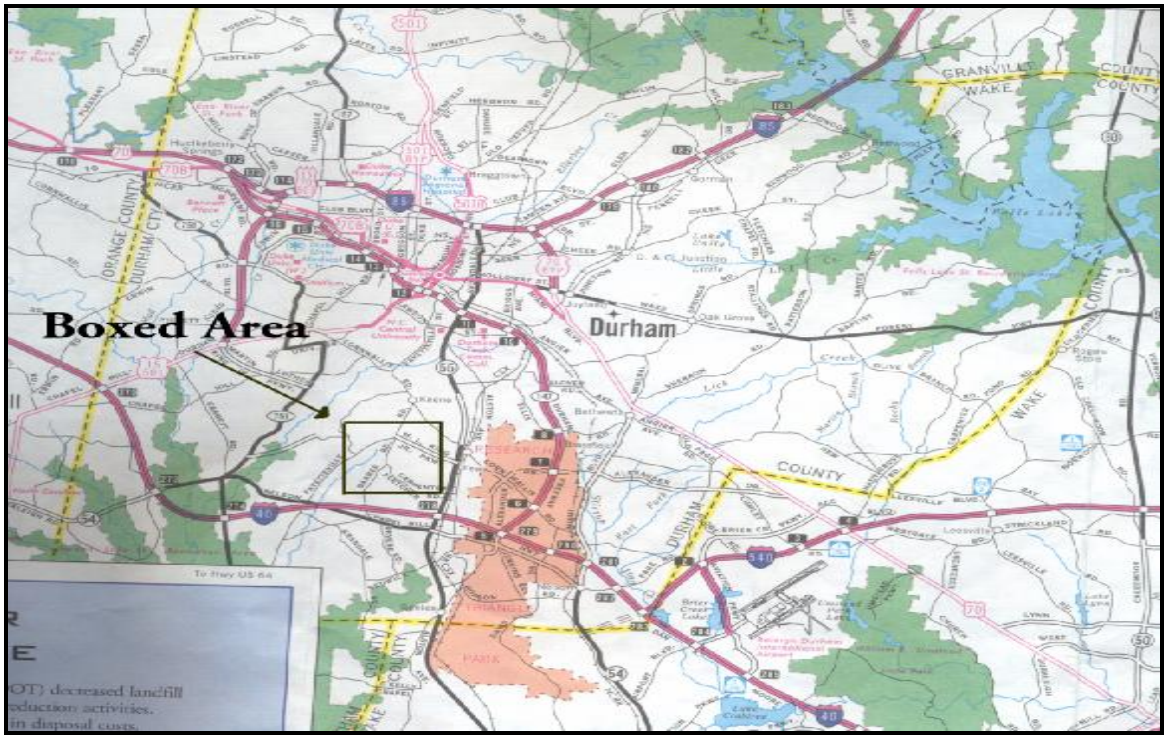

Figure 5.1: Map of Durham Area with a Sample Boxed Area

Every road within this boxed area would be driven. Sign densities for the study would be based on the information from this area only. If an adequate percentage of roads were driven in the current study, the sign density of the boxed area should match the current findings. Clearly, a large enough box would need to be selected. But benchmark sizes could be evaluated to determine an optimal size. Upon doing so this size could be used at any further time in other counties or benchmark checks on the results.

## 5.2 Determining a Representative Sample Size

Due to the vast number of secondary road miles in North Carolina, only a small percentage of them were actually driven. It was uncertain if the number of miles driven in the vicinity of Wake County were sufficiently large enough to accurately represent the entire state. This study drove a total of 2 percent of all secondary routes. That is, is the triangle area representative of other areas in the state? We believe so, but additional studies could find this out. See Section 5.3 below for a further discussion of this topic.

In the alternative approach, exactly how large and by what size a boxed area should be selected is uncertain. In the approach used, exactly how many miles to drive is uncertain. If a relatively small sample area is found to be adequate to replicate this study's data, the boxed area method may prove to be a more efficient method to sample signs densities by reducing the overall number of miles to drive and their dispersion. Therefore, a key question is how many miles are needed totally?

It is difficult to answer these questions at the present time. We recommend a limited further study. The recommendation is to use the alternative sampling approach described above for a number of additional areas across the state. Sampling is recommended because there is no other practical way to derive a complete count. We recommend the following sample specifications:

- Contain all road types (I, US, NC Secondary)
- Contain at least 100 miles of secondary roads

## 5.3 Geographic Coverage

It is important to recognize that in the initial secondary road study, samples were taken only from Wake and surrounding counties. In fact, sign densities in the costal and mountain regions may

differ from those in the piedmont area. There is a need to determine whether or not such a difference truly does exist. It is therefore recommended that a different geographical regional sampling to be undertaken using the alternative sampling approach and the sample specifications noted in the previous section.

At least two costal (Eastern) and two mountain (Western) samples are recommended. These would be rural samples. Additionally, Charlotte, Ashville, and Wilmington should also be targeted for urban samples. These seven sample studies should then be compared with each other and with the results we have compiled so far in this study. Based on such a comparison, further recommendations should emerge.

## 5.4 Further Extensions

It is recommended that one additional extension study be done. Not for the purpose of the NCDOT, but for the purposes of North Carolina as a whole. It is important to determine the number of signs located within the cities of North Carolina. Due to the low number of "stop" signs on urban secondary roads, with virtually zero on primary routes, it would be good to know how much burden will be placed on the cities and towns by the new retroreflectivity criteria. The absence of stop signs on primary routes begs the question of where all the stop signs really are. Clearly, with about 51,000 on secondary roads we have identified where the state maintained stop signs are located. However, the authors believe that there are many more on city roads and streets. Reflectivity standards, therefore, will significantly impact these municipalities and are of potential concern.

# 6.0 REFERENCES

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# Appendix A

## County Secondary Road Summary Tables

The following appendix contains county secondary road summary tables for data contained in both appendices B and C. The first table shows the sign density calculated for each county. Rural and urban counts have been divided into two separate tables. The data from the seven counties has been compiled to find sign densities. Note that this table contains actual count and density data and does not contain any estimation data.

On the next page is a summary table with sign color totals for each county. This data has then been summed to find the total number of rural signs counted in all 7 counties, and the total number of urban signs in the two counties sampled. This data is a summary of the actual counts found in Appendix D, and represents sign totals in one direction only.

# Appendix B

## Secondary Road Sign Density Tabulation Tables

This appendix contains a cumulative sign density worksheet. It shows each individual count, and its respective one-way sign and mileage totals. The first column shows the count #. More detailed information for each individual count # can be found in Appendix D. The second and third columns show the respective one-way sign totals, and mileage totals for each count. The fourth column shows a one-way sign density for each count #. The fifth column shows a running tally of the cumulative number of miles counted. Likewise, the sixth column shows the cumulative number of signs counted. The last column calculates a cumulative one-way sign density based upon the number of miles and signs.

# Appendix C

## Secondary Road Sign Count Tabulation Tables

This appendix contains a summary of the amount of total signs and miles in each count. The count number is shown in the first column, and respective mileage and sign data is shown to the right. Columns 2 – 8 show the number of signs by color for each respective count. The number of miles and total signs for each count are shown in the last two columns. It is important to remember that these count represent totals on one direction only. Each county has its own separate sheet. Counties with both urban and rural counts, have been further separated into two separate counts.

# Appendix D

## Secondary Road Individual Sign Count Tables

This appendix contains a summary for each individual count. Each count has been given a reference number, which is shown in the upper-left hand corner of the table. Beneath the count reference number is listed the pertinent information for each sample count. This includes the date the sample was taken, the road name, road type (Rural vs. Urban), Road Location (County), sample length (in miles), and the total number of signs counted. To the right of the count # is listed a more detailed description of where the sample was taken. It typically lists the intersections at which the road sampler was begun and ended. At the bottom of the form the exact color of each sign in the sample is listed.

# Appendix E

## County and Statewide Secondary Road Number of Total Signs Estimate

This appendix contains the statewide estimate for the total number of secondary route signs. This appendix has three parts: a summary table, a Type I county estimate, and a Type II county estimate. The summary table shows a statewide estimate of 616,436 NCDOT maintained secondary route signs. The summary table is also show in Section 3.2.1 of this report.

The summary table is a condensed listing of the information shown in the second and third part of this appendix. It shows the total number of estimated signs in Type I and Type II counties. Recall that Type I counties have population densities less than 525 persons per square mile and Type II counties have population densities greater than 525 persons per square mile. Each county type has been separated into rural and urban sections. The total number of rural and urban miles for each county type is shown, along with their respective sign density estimates. These sign density estimates come from Appendix A. These two numbers were then multiplied to estimate the total number of signs for that respective classification. These numbers were then summed to a total of 470,231 rural signs and 146,205 urban signs, for a total of 616,436 statewide secondary signs.

The second and third parts of this appendix are estimates of the total number of secondary route signs by county. Counties are listed by name under their respective classification (Type I or Type II). The total number of signs in each county was estimated using the same methodology as described in the previous paragraph, except for each individual county. The total number of signs in each county classification were then added and listed on the last row of each data set. These totals were then transferred to the summary table.

# Appendix F

## Statewide Sign Color Estimates

This appendix contains the statewide color estimates for secondary routes. This Appendix has four separate charts, a statewide estimate, a Type I rural estimate, a Type II rural estimate, and an urban estimate. The summary table is also shown in Section 3.2.2 of this report.

The summary table lists each secondary route classification (Type I rural, Type II rural, and Urban), and their respective sign color estimates. These three rows were then summed to provide a statewide color estimate at the bottom of the chart. The summary row if also duplicated in Table 3.9 of this report.

The Type I rural, Type II rural, and Urban route color estimates have all been set-up in a similar manner. The individual county sample totals are shown in the first few rows of each chart. These figures represent one-way totals, and can also be seen in Appendix A. For example, the Type I rural estimate shows the sign color count totals for each of the five Type I counties sampled. These sign totals are then summed to arrive at a total for each classification. This row shows the total number of each sign color actual counted. Beneath this row is listed the total number of miles driven in each respective classification. For example, the Type I rural estimate shows a total of 906.4 miles of Type I rural roadway sampled. The total number of each color type is then divided by the total number of miles driven, and multiplied by two to obtain a two-way color density. This tells the reader how many signs of each color for each mile of roadway. For example the Type I rural estimate shows 0.06 blue signs for every mile of Type I rural roadway. Beneath this row is a listing of the statewide number of miles for each classification. For example, there a 53972.1 miles of Type I rural roadway in the state of North Carolina. By multiplying the two-way color density with the statewide number of miles, a statewide estimate for the total number of signs in each color classification can be shown. So by taking the 0.06 blue signs per mile of Type I rural roadway, and multiplying this by 53,972.1 Type I rural miles, 3238 statewide Type I rural blue signs in calculated.