ASSESSING SUBURBAN BICYCLE AINFRASTRUCTURE

FAIRFAX COUNTY, VA

Matt Dykstra
Penn State University
MGIS Program
November 2015

Contents

Abstract

As bicycling for transportation grows more popular in the United States, methods for measuring both adoption rates and the effectiveness of bicycle-related infrastructure need to be developed and implemented. The most widespread methodology uses data from the American Community Survey to assess bicycle commute rates; this data incompletely captures mode share and has extremely high margins of error. Multiple recent studies have determined a linear relationship between bicycle infrastructure and ridership rates; assessing infrastructure can both provide an estimate of relative ridership and grant insight into the reasons why people do or do not ride in given locations.

There have been numerous studies on individual locations within the United States that assess both ridership rates and aspects of infrastructure, but nearly all have been on cities rather than suburbs. This project uses Fairfax County, VA as a case study for assessing suburban bicycle infrastructure using a combination of commonly available data sources and a replicable methodology. Fairfax County is suitable for this study because it has a large population, covers a larger area than most cities, and has a nascent network of bicycle-related infrastructure that it plans to expand. The project provides an assessment of current infrastructure status and effectiveness, identifies deterrents to cycling, and offers recommendations on focus areas for improvement.

Background

The intention of this study is to assess the practical access granted to a bicyclist within Fairfax County, rather than to define the limits of bicycle infrastructure. However, some operating definition of what constitutes bicycle infrastructure is needed.

Bicycle infrastructure can include a wide range of on-road and off-road facilities intended for the use of bicyclists. These facilities can be intended solely for bicyclists, but often are shared spaces with other users, including automotive traffic or pedestrians. In some cases, the infrastructure can be as simple as markings on lanes shared with other vehicles, while in others there are lanes fully separated from traffic. Bicycle infrastructure can also include quiet neighborhood streets, even if not fully marked as such.

Sidewalks are not included in this study (or in most studies) as bicycle infrastructure. Bicyclist use of sidewalks is subject to varying laws in varying jurisdictions; in some cases, there is a blanket prohibition. However, on a more basic level, sidewalks were designed primarily for pedestrians and often are ill-suited for bicyclists, particularly adult bicyclists traveling at moderate to high speeds. There is high potential for conflicts with pedestrians on the sidewalk, and high potential for conflicts with automotive traffic at intersections or driveways, where drivers are unlikely to expect anyone on the sidewalk to be moving very quickly.

Objective

The primary objective of this study is to provide an assessment of the current cycling infrastructure and its ease of use in Fairfax County. The study also identifies some deterrents to cycling within Fairfax County and provides recommendations on focus areas for improvement.

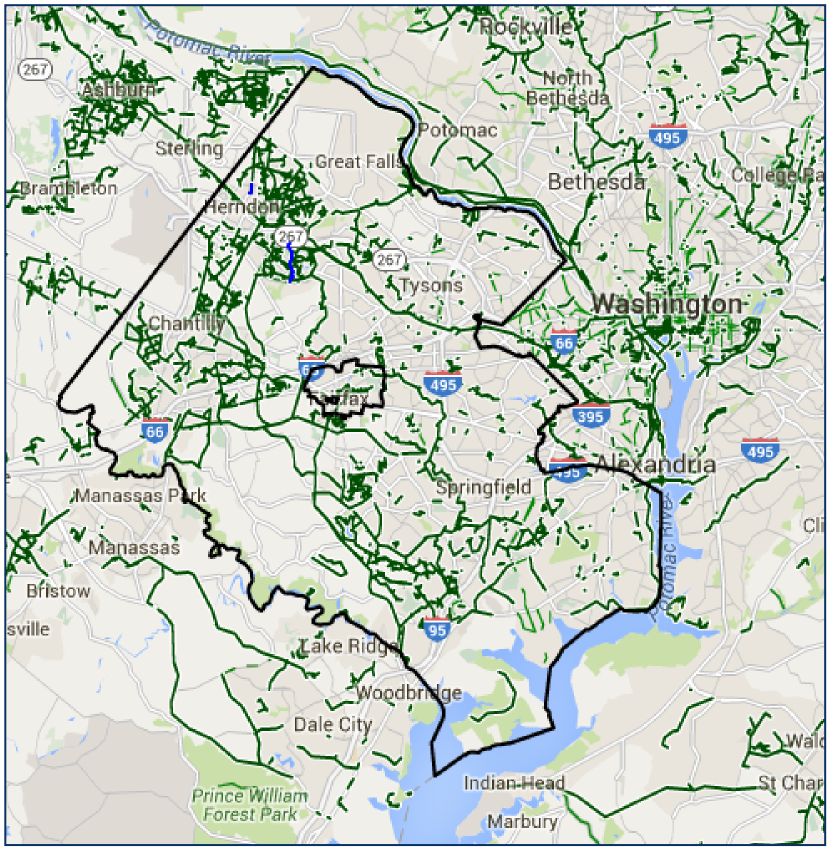

Figure 1. Bike Lanes and Trails in Fairfax (Fairfax County)

Existing Research

Most current studies of bicycling within the United States focus on large cities and in particular on the rates of bicycle commuting within those cities. While some of these draw on data from some method of physical counting (automated or manual) within the city, many use data provided through the American Community Survey (ACS), a product of the U.S. Census Bureau.

This approach, while often the best available for finding approximate rates of bicycling, suffers from several key issues. The first is that little research has focused on non-urban areas; this study attempts to partially rectify that.

The second is that the ACS survey asks for the most-used commuting mode within the last work week; this question by nature eliminates multi-modal commuting, bicycle commuters who only ride their bicycles 1-2 days per week, as well as bicyclists who do not ride to work but may ride to other destinations. According to information within the ACS survey results, ACS data for bicyclists also has high margin of error rates, over 100% in many cases.

Most critically, this method of approaching bicycle ridership divorces ridership rates from the physical infrastructure, and thus provides advocates and local authorities with minimal information on what factors within a given jurisdiction might be affecting ridership or ridership demographics.

Previous research efforts on bicycling have established a strong correlation between the amount of bicycle-related infrastructure present in a city and the number of bicycle commuters (Nelson and Allen 1997; Dill and Carr 2003; Parkin et al. 2007; Buehler and Pucher 2012). Numerous studies have also concluded that there is a difference between types of bicycle facilities, and that bicyclists are willing to go out of their way to use facilities that appear less dangerous or involve a less stressful journey (Buehler and Pucher 2012, Mekuria et al. 2012, Schoner and Levinson 2014). Some have additionally concluded that the number of lane-miles, while important, is a less important factor than the level of network connectivity and the overall network density (Mekuria et al. 2012; Schoner and Levinson 2014).

Schoner and Levinson (2012) note that discontinuities within the bicycle network may have three potential consequences: forcing the cyclist into mixed traffic, requiring lengthy detours to avoid mixed traffic, or discouraging cycling altogether. This last consequence is posited as the most common, and aligns with other work on types of bicycle riders.

A 2006 paper (updated in 2009) by Roger Geller, the bicycle coordinator for Portland, OR, proposed the categorization of bicyclists into four categories based on attitudes toward bicycling, and assigned rough proportions to each, which researchers and advocates continue to agree are generally correct (Dill and McNeil, 2013).

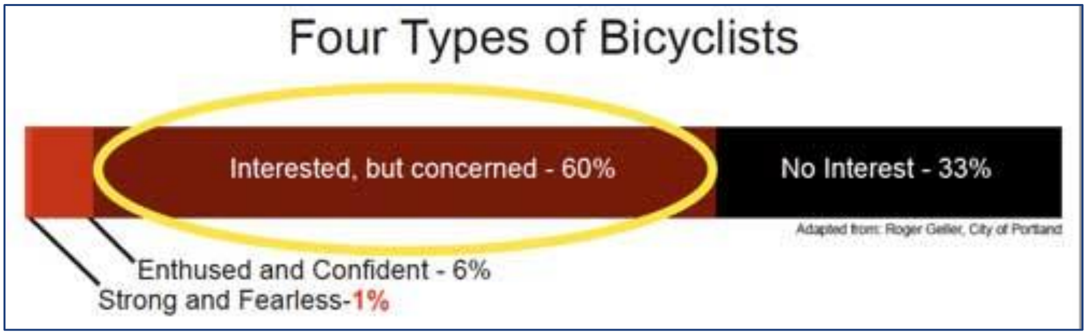

Figure 2. Four types of cyclists (Geller, 2006).

Most current cyclists fall into the “strong and fearless” or “enthused and confident” categories, which combined represent less than 10% of the population. On the other end, about a third of the population falls into the “no interest” group which will not ride regardless of conditions; this may be due to a variety of factors including physical unfitness or simple disinclination. However, the majority of the population falls into the “interested but concerned” category. If the concerns of this group can be met, the potential bicycling population in any given area can become significantly larger (over two thirds) and bicycling would no longer be a fringe transportation method.

Data

The study draws on the following data sources:

Virginia Geographic Information Network (VGIN):

- Virginia Most Recent Imagery (Lambert)
- Virginia Administrative Boundaries
- Roadway Centerlines

Fairfax County GIS:

- BikeFairfax/FCDOT Wikimapping project (bike lane locations)
- Bicycle Routes
- County Trails
- Non-County Trails

All data sources had been updated within the last year, and most since the beginning of 2015.

Methodology

A bicycling network can be defined as the marked bicycle-specific facilities available, or as those routes that cyclists are legally allowed to use. However, this does not necessarily lead to an accurate understanding of what is realistic for the "interested but concerned" group previously mentioned, as not all bike lanes feel safe and not all areas without bicycle markings feel unsafe.

This study therefore uses a definition first proposed in the Mineta Transportation Institute's 2012 report, "Low Stress Bicycling and Network Connectivity," which has since been referenced in several other articles and reports, and received significant attention from both bicycling advocates and transportation planners. A bicycle network by this definition is the infrastructure, with or without bicycle-specific markings, which bicyclists feel comfortable using (Mekuria, Furth, and Nizon 2012).

A measure called Level of Traffic Stress (LTS) was developed by these researchers to account for the varying levels of comfort with traffic that individual bicyclists might have; rather that categorizing the bicyclists themselves, LTS categorizes the road or trail to indicate how stressful the experience of riding there is likely to be given the provided data (numbers of lanes, speed limits, presence of bike lanes, whether or not there is a striped centerline, etc.).

Figure 3. Examples of levels of traffic stress within the greater Washington DC region.

The levels run from 1-4, with level one representing very low stress situations and level 4 representing infrastructure on which only the “strong and fearless” are comfortable, if it is even possible to bike there. The preceding images and following table show the types of facilities that fall within each level. Additional criteria taken from the Mineta Institute study are available in Appendix I. It is important to note that this methodology follows the “weakest link” approach: as an example, if any criteria on what would otherwise be an LTS 2 facility fall into the LTS 3 facility category, that facility is now categorized wholly as LTS 3. This ensures that the level captures any stressors or disincentives to ride in a given location.

Table 1. Levels of Traffic Stress (LTS)

LTS 1	Presenting little traffic stress and demanding little attention from cyclists, and attractive enough for a relaxing bike ride. Suitable for almost all cyclists, including children trained to safely cross intersections. On links, cyclists are either physically separated from traffic, or are in an exclusive bicycling zone next to a slow traffic stream with no more than one lane per direction, or are on a shared road where they interact with only occasional motor vehicles (as opposed to a stream of traffic) with a low speed differential. Where cyclists ride alongside a parking lane, they have ample operating space outside the zone into which car doors are opened. Intersections are easy to approach and cross.
LTS 2	Presenting little traffic stress and therefore suitable to most adult cyclists but demanding more attention than might be expected from children. On links, cyclists are either physically separated from traffic, or are in an exclusive bicycling zone next to a well-confined traffic stream with adequate clearance from a parking lane, or are on a shared road where they interact with only occasional motor vehicles (as opposed to a stream of traffic) with a low speed differential. Where a bike lane lies between a through lane and a right-turn lane, it is configured to give cyclists unambiguous priority where cars cross the bike lane and to keep car speed in the right-turn lane comparable to bicycling speeds. Crossings are not difficult for most adults.
LTS 3	More traffic stress than LTS 2, yet markedly less than the stress of integrating with multilane traffic, and therefore welcome to many people currently riding bikes in American cities. Offering cyclists either an exclusive riding zone (lane) next to moderate-speed traffic or shared lanes on streets that are not multilane and have moderately low speed. Crossings may be longer or across higher-speed roads than allowed by LTS 2, but are still considered acceptably safe to most adult pedestrians.
LTS 4	A level of stress beyond LTS3.

Figure 4. Level of traffic stress chart (Mekuria, Furth, and Nizon 2012).

This study categorizes all roads and trails within Fairfax County according to the Level of Traffic Stress (LTS) rating of each individual road or trail segment. The resultant networks were analyzed at various individual and combined levels to draw conclusions about the state of bicycling-appropriate infrastructure in Fairfax County.

In addition to examining the bicycle facility network by level of traffic stress, this study also provides information on the amount of identified bicycle-specific infrastructure within Fairfax County, expressed as a ratio of facility miles to county square miles. Numerous cities have been studied according to this metric, and it can furnish a rough idea of relative infrastructure maturity for the purposes of comparison. This data is not currently available for many counties; hence the comparison to cities.

To carry out the identification of trails and bike lanes, as well as assignment of LTS levels to the roads and trails within Fairfax County, several steps were taken, combining manual and programmed processes. ESRI ArcGIS software was used for all data manipulation.

Virginia road data comes packaged for the entire state; the first step was therefore to isolate Fairfax County, along with Falls Church and Fairfax City, two jurisdictions which fall within Fairfax County and therefore are important to consider when addressing network-related concerns. This approach does affect numeric calculations to some extent; however, both jurisdictions are very small (Falls Church is 2.2 mi^2 and Fairfax City is 6.3mi^2) compared to Fairfax County's 407 mi^2, and the effect of excluding them for network purposes would have created much more significant gaps in that analysis.

These areas were isolated within the Virginia Department of Transportation (VDOT) data using FIPS (Federal Information Processing Standard) codes that identify jurisdictions. This data was then exported to create a layer encompassing only the areas considered for analysis, and a field for LTS level was added.

The road data was then placed into a geodatabase to create a topology. A topology rule was created to isolate those roads that were dead ends or cul-de-sacs, and categorized those as LTS 1. All roads were then categorized by speed limit, and those with speed limits of 40 mph or higher were marked as LTS 4. On the other end, those with speeds of 25 or under and an Annual Average Daily Traffic (AADT) level below 2,000 vehicles were marked as LTS 1. An AADT of under 2,000 is considered by Dutch guidelines (which the Mineta study drew on) to be low-traffic and generally allow space for drivers of motor vehicles to easily and safely navigate around bicyclists. All roads categorized using these methods were later manually reviewed for accuracy, but these methods of sorting allowed for a reasonable starting point.

Using the above techniques, 90% of the roads (about 50,000 of 55,000 road segments) had been assigned an LTS value.

The remainder of the roads were sorted, and the already-assigned ones verified, using manual review. To do this systematically, the tax grid network (which uses a one square mile grid) was applied over the road network, which in turn was layered over satellite imagery. This allowed examination of each square mile individually, both to assign LTS 2 and 3 values and to check intersections for factors that could increase LTS. This manual examination also led to two rule exceptions early on, as follows:

- A road segment with lowered speed due to more dangerous conditions (e.g. sharp curves and significant elevation change) was assigned the higher value of those road segments surrounding it, rather than a lower value that did not take into consideration those hazards or the likely higher speed of vehicles through the smaller section.

- Errors in the VDOT data led to some neighborhood streets being mis-categorized; as speed limits of 35 or 45 are unlikely on short neighborhood streets, these were corrected to the standard 25 mph for neighborhood streets.

Discussion

Fairfax County has a total of approximately 205 miles of bicycle facilities (not including facilities added during mid-late 2015). The below table puts this in context: the county has approximately 25 times as many facilities for motor vehicles as it does for bicycles. When compared to large cities nationwide, Fairfax County has about a third the quantity of bicycle infrastructure as the large-city average when measured on a basis of miles of facility per square mile of area.

	Total miles	On-street	Off-street	Miles per mi^2
Bicycle Facilities	205	32*	173	0.5
Roads (all)	5017	5017	N/A	12.3
Large-city average (bicycle facilities) [1]	251	166	85	1.6

* – Does not include all lanes added in 2015

1 – Alliance for Biking and Walking, 2014

Despite this, an impressive 68% of the roads in Fairfax County are LTS 1; this significantly expands the number of facilities a bicyclist could reasonably use. However, these roads are rarely connected: most are boxed in by larger roads, as seen in Figures 5 and 6. In particular, the intersections with these larger roads represent critical barriers: in many cases, there are LTS 1-2 roads on both sides of a major road, but no safe way for a bicyclist (or a pedestrian) to cross.

Figure 5. An example of the barriers represented by LTS 3-4 roads (yellow and red); none of these neighborhoods can connect to one another.

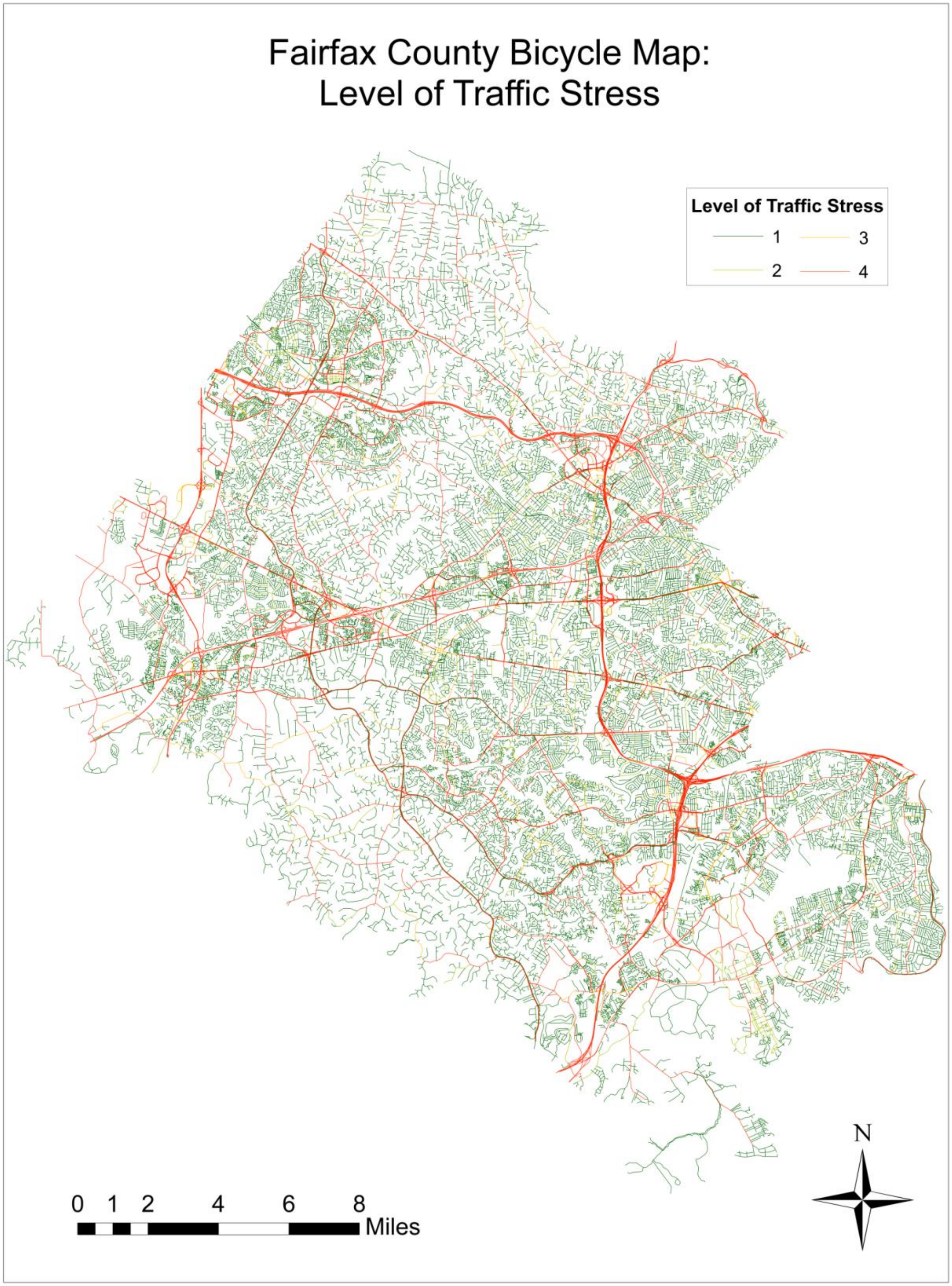

Figure 6. All LTS levels in Fairfax County.

Figure 7 demonstrates what occurs when only LTS 1 and 2 are displayed for major areas of the county; there is no reasonable transportation network when the LTS 3 and 4 roads, which most individuals will not want to use, are not included.

This disconnected nature is in large part a result of Fairfax County's construction: a full 25% of road sections are either dead ends or cul-de-sacs, which are of transportation value only to the small number of people living on each one.

Figure 7. Subsection of Fairfax County displaying LTS levels 1 and 2; in some cases, it is only possible to safely navigate a single section of road.

The two major paved trails in Fairfax County, the Washington and Old Dominion (W&OD) and Fairfax County Parkway Trails, are by themselves responsible for a significant portion of the LTS 1-2 networks present in Fairfax County. Figure 8 shows the single large network that is present by virtue of these trails and a few other key connectors. However, these do not service the vast majority of neighborhoods within the County, and therefore cannot serve as low-stress transportation routes for anyone except those living within the darker green areas displayed on the map. Many neighborhoods are cut off from this network by one or more major road intersections without adequate safe crossings for bicyclists.

Figure 9 includes the largest 4 networks of LTS 1-2 facilities in Fairfax County: this map is not very dissimilar from the previous one, as the second largest network, in southeastern Fairfax County, is only about 6 miles by 2 miles in extent. After the four largest networks, all networks fall to less than about a square mile in extent and are of minimal transportation value without including the higher-stress connectors, which again serve as key deterrents.

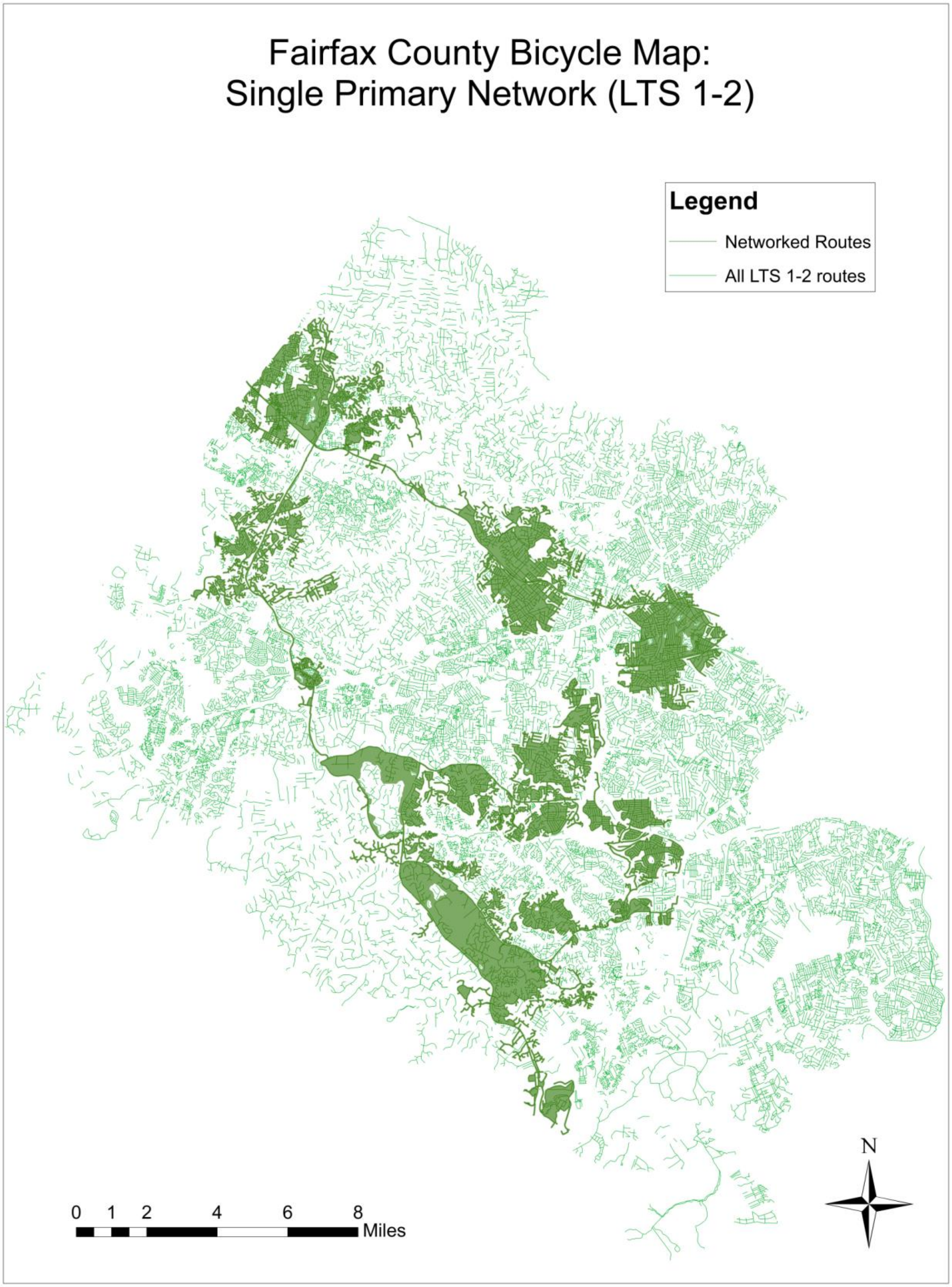

Figure 8. Single largest LTS 1-2 network.

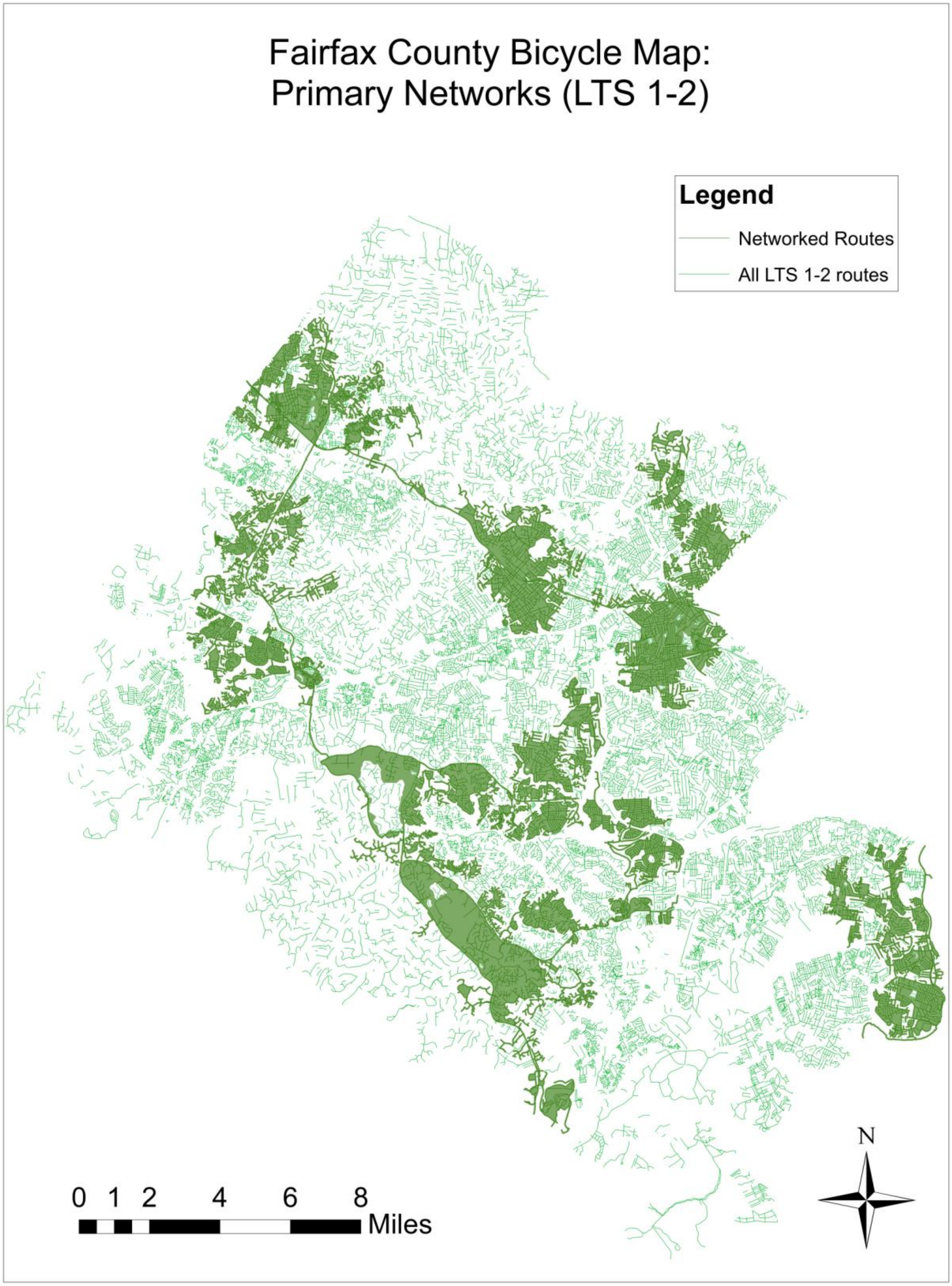

Figure 9. Largest 4 networks in Fairfax County.

Major highways also serve as a significant deterrent. A 16-mile stretch of route 66, a major east-west corridor in central Fairfax County, has only one LTS 1-2 crossing that connects to a major network, and a total of only 4 crossings that are LTS 1-2. Routes 495, 395, 267 (Dulles Toll Road), 28, and in some cases 1, 7, 29, and 50 all similarly serve as major barriers. Route 286 (Fairfax County Parkway) sometimes serves as a barrier, but the presence of the Fairfax County Parkway Trail partially mitigates its barrier effects.

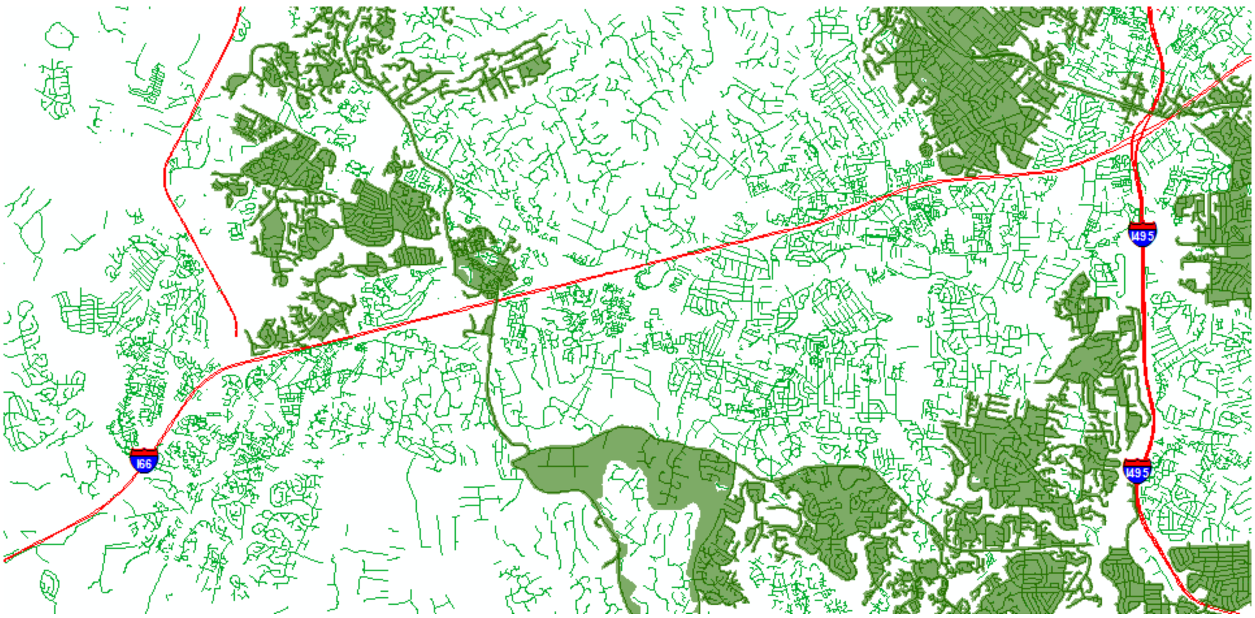

Figure 10. Only one crossing of I-66 ties into a major LTS 1-2 network.

Bike lanes in Fairfax County generally improve the LTS level by one; e.g. from LTS 4 to LTS 3. However, this does not always occur: the below screen shot from Google Maps shows a bike lane along a LTS 4 road; while this particular photo does not display heavy traffic, it does show the narrow bike lanes and lack of separation from vehicles traveling at over 40mph.

Figure 11. Dranesville Road near Herndon High School (40 mph, LTS 4): Google Earth.

Two thirds of the bike lanes examined were LTS 3, in most cases due to the higher traffic speeds on the roads which have bike lanes. Another quarter of bike lanes were LTS 4. Therefore, the vast majority (95%) of bike lanes were not included in the “interested but concerned” LTS 1-2 networks examined. While these bike lanes often make it more possible to bike on a given stretch of road, it is still frequently not a comfortable prospect. Based on these findings, it seems advisable when adding bike lanes to examine the potential effects on LTS for a given portion of roadway and seeking to bring the LTS down to 2 if at all possible, with 3 as a fallback goal. As many bike lanes are installed based on VDOT repaving schedules it may not be possible to prioritize installation of LTS 2 bike lanes, but a close examination of relevant factors and prioritization of facility structures that greatly decrease LTS may allow for installation of more LTS 2 facilities than might otherwise be implemented.

Significance and Limitations

This study demonstrates connectivity issues that cannot easily be seen via other methods, and is the first known study of a county using these recently developed methodologies. Gaps, deterrents, and inadequate infrastructure can all be clearly identified; likewise, routes that are not bicycle-specific but still viable can also be identified and incorporated into connectivity-based planning.

The study does have some limits: first, it is a single case study. Validation and applicability of these methods to other counties and suburban areas cannot be determined until the methods have been replicated. Likewise, it is difficult to compare Fairfax County to other counties or suburbs, even those in the greater Washington D.C. area, without first applying the methodology to those areas.

Additionally, the Level of Traffic Stress methodology itself does have some limits. Some roads with speed limits of 25mph may have low speed differentials between bicyclists and motorists, but nonetheless be quite stressful due to other factors such as narrow shoulders, continuous traffic, or even types of traffic (e.g. many large trucks). Additionally, some roads may be significantly more stressful at certain times of day or on certain days. It is extremely difficult, if not impossible, to accurately account for all of these factors. The LTS measurement, while useful, cannot be taken as a panacea and will not always convey the realities cyclists may face on a given stretch of road. It is a very good guideline, but still a guideline.

Finally, this study, while reviewed by others, has been primarily the work of a single individual applying a methodology originally developed for urban areas to a non-urban area. There is a potential for some small degree of human error in both the underlying data and in the application of LTS to that data. However, these limitations do not significantly detract from the overall value of the methodology or application of said methodology to Fairfax County.

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Appendix 1

The following tables from the 2012 Mineta Institute study show the various criteria for assigning Level of Traffic Stress. (Mekuria, Furth, and Nizon 2012)

Table 2. Criteria for Bike Lanes Alongside a Parking Lane

	LTS ≥ 1	LTS ≥ 2	LTS ≥ 3	LTS ≥ 4
Street width (through lanes per direction)	1	(no effect)	2 or more	(no effect)
Sum of bike lane and parking lane width (includes marked buffer and paved gutter)	15 ft. or more	14 or 14.5 ft.*	13.5 ft. or less	(no effect)
Speed limit or prevailing speed	25 mph or less	30 mph	35 mph	40 mph or more
Bike lane blockage (typically applies in commercial areas)	rare	(no effect)	frequent	(no effect)

Note: (no effect) = factor does not trigger an increase to this level of traffic stress.

* *If speed limit < 25 mph or Class = residential, then any width is acceptable for LTS 2.*

Table 3. Criteria for Bike Lanes Not Alongside a Parking Lane

	LTS ≥ 1	LTS ≥ 2	LTS ≥ 3	LTS ≥ 4
Street width (through lanes per direction)	1	2, if directions are separated by a raised median	more than 2, or 2 without a separating median	(no effect)
Bike lane width (includes marked buffer and paved gutter)	6 ft. or more	5.5 ft. or less	(no effect)	(no effect)
Speed limit or prevailing speed	30 mph or less	(no effect)	35 mph	40 mph or more
Bike lane blockage (may apply in commercial areas)	rare	(no effect)	frequent	(no effect)

Note: (no effect) = factor does not trigger an increase to this level of traffic stress.

Table 4. Criteria for Level of Traffic Stress in Mixed Traffic

Speed Limit	Street Width		
	2-3 lanes	4-5 lanes	6+ lanes
Up to 25 mph	LTS 1[a] or 2[a]	LTS 3	LTS 4
30 mph	LTS 2[a] or 3[a]	LTS 4	LTS 4
35+ mph	LTS 4	LTS 4	LTS 4

Note: [a] Use lower value for streets without marked centerlines or classified as residential and with fewer than 3 lanes; use higher value otherwise.

Table 7. Level of Traffic Stress Criteria for Unsignalized Crossings Without a Median Refuge

Speed Limit of Street Being Crossed	Width of Street Being Crossed		
	Up to 3 lanes	**4 - 5 lanes**	**6+ lanes**
Up to 25 mph	LTS 1	LTS 2	LTS 4
30 mph	LTS 1	LTS 2	LTS 4
35 mph	LTS 2	LTS 3	LTS 4
40+	LTS 3	LTS 4	LTS 4

Table 8. Level of Traffic Stress Criteria for Unsignalized Crossings With a Median Refuge at Least Six Feet Wide

Speed Limit of Street Being Crossed	Width of Street Being Crossed		
	Up to 3 lanes	**4 - 5 lanes**	**6+ lanes**
Up to 25 mph	LTS 1	LTS 1	LTS 2
30 mph	LTS 1	LTS 2	LTS 3
35 mph	LTS 2	LTS 3	LTS 4
40+	LTS 3	LTS 4	LTS 4