

Low-Density Transit: A Study of Sullivan County, NY

A thesis submitted by

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ABSTRACT

Sullivan County located in southern New York, was once home to the numerous resorts, hotels, and bungalow colonies that made up the Borscht Belt. After the decline of hospitality businesses in the area, Sullivan County has faced difficult times as the opioid crisis and lack of access to healthcare ravages the county. To pursue ways to close the gap in access to healthcare and treatment facilities, the county created MOVE Sullivan in 2019. This fixed-route transit system currently serves five of the fifteen towns in the county. Location Quotient analysis and ArcGIS Pro were used to explore a pattern between statistics determined to be indicators of transit-sensitive populations and total roads within a quarter-mile service area of the fixed routes compared to where the population is in the county. The results show that the current stops are in areas with the highest densities regarding roads and populations. This research indicates that the current network is in places that make sense. Future studies in Sullivan County and other regions interested in pursuing rural transit include different methods of providing transit to meet the unique needs of rural areas and incorporating analysis of the existing pedestrian environment.

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TABLE OF CONTENTS

ACKNOWLEDGMENTS.....	II
ABSTRACT	II
CHAPTER 1: INTRODUCTION	1
BACKGROUND	1
<i>The Borscht Belt</i>	<i>1</i>
<i>The County Today</i>	<i>4</i>
TRANSIT IN THE COUNTY	8
<i>History of Transit</i>	<i>8</i>
<i>Transit in the County Today.....</i>	<i>10</i>
BENEFITS OF RURAL TRANSIT NETWORKS	13
OVERVIEW	16
CHAPTER 2: METHODOLOGY	18
GIS METHODOLOGY.....	19
CHAPTER 3: LITERATURE REVIEW	24
DEFINING RURAL	24
CAR DEPENDENCY & RURAL TRANSIT TRENDS.....	27
ASSESSING THE FEASIBILITY OF RURAL TRANSIT ROUTES	28

TRANSIT FOR SENSITIVE AND VULNERABLE POPULATIONS	32
METHODS OF RURAL TRANSIT.....	34
<i>Paratransit and Flexible Transit Services</i>	34
<i>The Network Approach</i>	35
CHAPTER 4: RESULTS	36
LOCATION QUOTIENT.....	36
GIS RESULTS	40
COMPARING MAPS AND VARIABLES OF INTEREST.....	46
CHAPTER 5: DISCUSSION	48
LIMITATIONS	48
DISCUSSION	50
CHAPTER 6: CONCLUSION	53
APPENDIX	56
BIBLIOGRAPHY	62

CHAPTER 1: INTRODUCTION

When it comes to transit networks, rural communities are often overlooked due to their lack of population density and funds to create functional and profitable public transit systems. This thesis aims to examine the problems that Sullivan County, New York, faces in its transit network and present a series of recommendations to help the area ensure an equitable and efficient transit network that other counties and municipalities can use.

BACKGROUND

The Borscht Belt

It is impossible to talk about the history of the County without first talking about the Borscht Belt. The term was said to have been coined by Abel Green, an editor for *Variety* who nicknamed the area after the well-known Eastern European beet soup (Herrmann 2023). Other names for the area such as the "Jewish Alps" and "The Mountains" were also used to reference the area, the "Borscht Belt" is the name that continues to stay with the area.

With the increase of Eastern European immigrants at the turn of the 20th century, Jewish aid societies established programs to encourage them

to earn their livelihood through farming. In the case of New York, the area supported were Jewish communities in the Catskill region. Unfortunately, the area's rocky terrain is unsuitable for agriculture and those who relocated to the area adapted to taking in boarders during the summer to make ends meet (Herrmann 2023).

The Catskill Region was already popular when it became part of the vacation area along the Hudson River which was popular with middle-class tourists (Johnson 2009). However, many popular resorts did not open their doors to all customers. Most 19th-century resorts had strict anti-Jewish policies that were explicitly or implicitly enforced. This resulted in Jewish immigrants from New York City creating the Borsht Belt as a place to vacation and be Jewish without experiencing the rampant antisemitism of the many other establishments of the time.

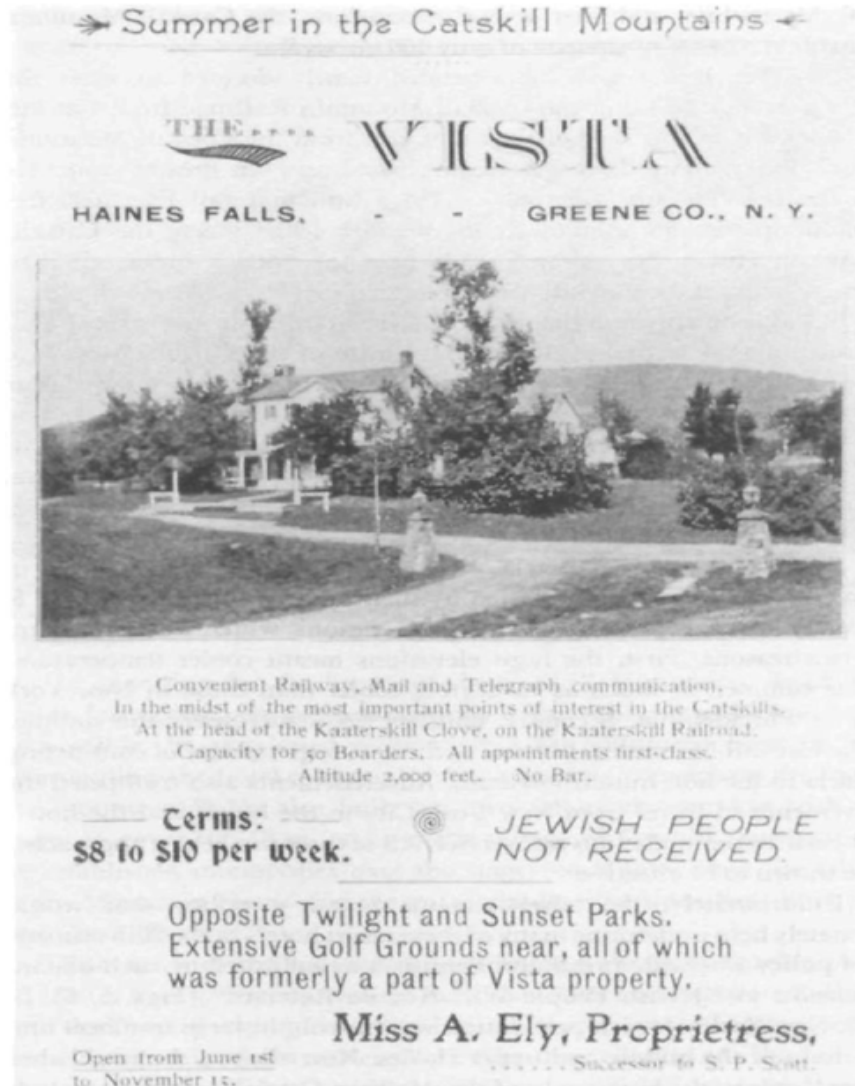


Figure 1: Advertisement for The Vista, a boarding house in Haines Falls in Greene County, NY (Johnson 2009)

The area's heyday was in the 1950s and 60's with at one point there being 509 hotels and boarding houses in Sullivan County alone (Brown 1996). The resorts that peppered the landscape were well-known for their lavish meals and the number of activities offered to visitors. The area was well known for its comedy and entertainment at its many nightclubs.



Figure 2: Highway signs along NY State Rt 17 showing advertisements for hotels along the route. (Herrmann 2023)

The decline was gradual as the area grew out of style for younger generations as they assimilated into American society. Additional factors such as the price of air travel became cheaper and more accessible to those in the middle class in addition to the development of more exotic vacation areas. By the 1980s just twelve large hotels survived (Brown 1996). Those that still visit the area today are the Ultra-Orthodox and Hasidim. However, many of the resorts and communities that relied on the income from these visitors are rundown or abandoned (Richman 2001).

The County Today

Today, the county is home to just under 80,000 people according to the U.S. Census Bureau. In 2022, the county was also one of the fastest-growing in the state with a 1.5% increase from 2020 (John Camera 2022).

The most populated towns within the county are Fallsburg, Liberty, Mamakating, and the Town of Thompson.

The median income for the county in 2021 was \$63,393 and the per capita income in 2021 was \$33,037 (US Census Bureau, n.d.). However, the county is on the front lines of the opioid crisis with the highest overdose deaths per capita outside of New York City (Josh Camera 2023). The below graph shows the overdose rate per 100,000 involving any opioid for Sullivan and its neighboring counties (NYS Department of Health 2020). As of July of 2023, Sullivan County was the only county in the Hudson Valley region not listed on the High-Intensity Drug Trafficking Areas (HIDTA) list. Now that it is, the area will see additional funding and mutual aid from other regions that share this designation (Randall 2023).

Overdose deaths involving any opioid, crude rate per 100,000 population

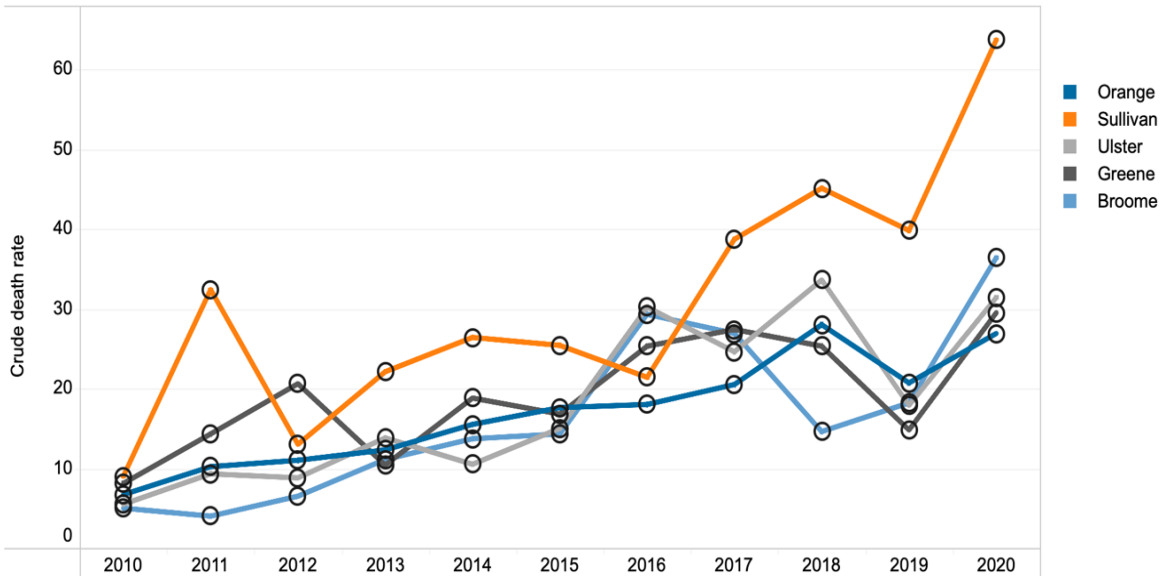


Figure 3: Overdose Death rate per 100,000 for Sullivan and its surrounding Counties (NYS Department of Health 2020)

The county is also home to two different private organizations that have communities that care for and foster independence in people that have intellectual, and developmental disabilities and those that are behaviorally complex. The first is The Center for Discovery. This non-profit is a research and specialty center that offers residential, medical, clinical, and special education programs. It provides many unique services such as music and creative arts therapy. According to their website, The Center serves 1,200 children and adults across New York State and beyond. It is also the largest private sector employer in Sullivan County. The second is the New Hope Community. Built on the 44-acre ground of the Green Acres Hotel, this

facility seeks to empower the lives of individuals with intellectual and developmental disabilities. New Hope is home to thirty-eight residential homes, day programs, and a holistic approach to service, and support, intending to enrich and empower lives.

The county is also home to numerous alcohol and drug rehab centers. These rehabs provide treatment for thirty days, sixty days, ninety days, and one-year long-term rehabilitation. They additionally give residential and in-patient drug and alcohol addiction treatment. These centers include New Hope Manor, Monticello Op, Monticello Smart SL, Monticello MSW IP, Monticello Day Rehabilitation Program, Dynamic Youth Community Inc., and the county's Department of Community Services Alcohol and Drug Abuse Services.

Sullivan County is also one of the areas served by Fearless. Fearless is the only private, non-profit agency in the county dedicated to assisting survivors of domestic violence, teen dating violence, and human trafficking. It provides these individuals with free and confidential services, and shelter as well as educating communities about such acts of interpersonal violence. As of the end of 2022, Fearless has answered 11,821 hotline calls, provided 9,716 nights of safety, provided 27,710 advocacy services, and served 7,488 adults and children (Fearless 2022).

TRANSIT IN THE COUNTY

History of Transit

From 1868 to 1957 the New York & Western Railway (O&W) connected the New York rural towns from Oswego on the shores of Lake Ontario to New York City (Sullivan O&W Rail Trail, n.d.). Its routes were mainly used for transporting people, coal, and dairy across the state into New York City's metropolitan area. Sullivan County had two separate branches: one to Monticello, and the other was the main line that continued towards Oswego to the northeast (Sullivan O&W Rail Trail, n.d.). The location of the railroad in the county can be found in the highlighted portions of the map below. The O&W fell on hard times due to its reliance on the coal industry and the populations in the area moved from rural to more urban environments. The railroad filed for bankruptcy and liquidated its assets in 1957; it was the first Class I railroad to become fully abandoned (Sullivan O&W Rail Trail, n.d.). Much of the railbeds have been converted to rails to trails.

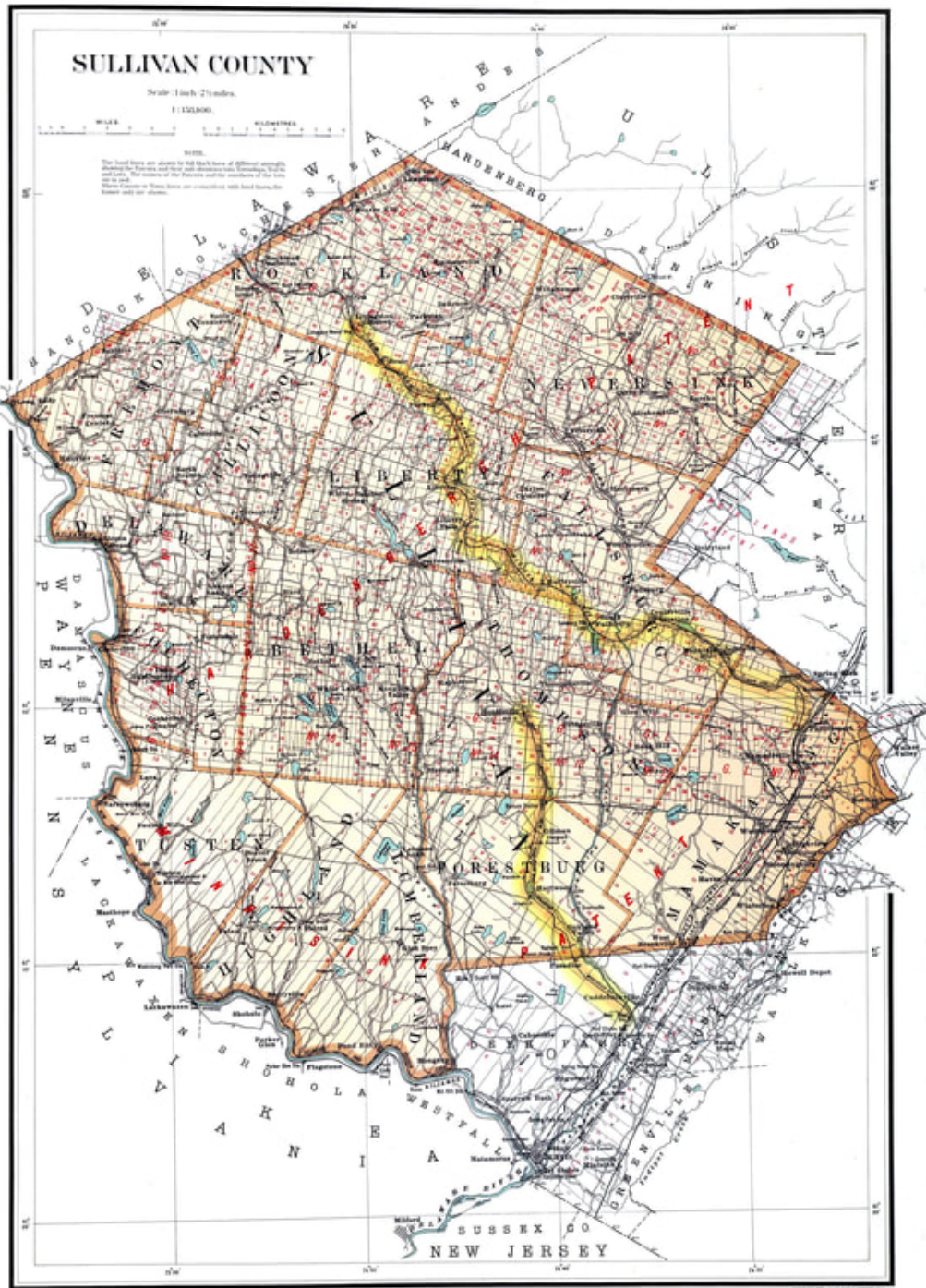


Figure 4: A map of Sullivan County with the O&W route highlighted. (Sullivan O&W Rail Trail, n.d.)

Transit in the County Today

The options for transit today in the county include Coach Buses, taxi companies, a MOVE Sullivan bus, and private transportation. MOVE Sullivan is an initiative to connect the different communities in the county through a bus service. This service began serving the County in August 2019 with free fare until the end of the year (Robayo 2019). The goal of this service is to serve areas with the largest concentrations of people to provide better access to health care and exercise opportunities. This came after the county was rated second unhealthiest in the state (Robayo 2019). The initial cost to the County was \$400,000 with funding from the Legislature and the Federal Transit Authority via a New York State Department of Transportation Grant (Robayo 2019). 18 new stops in 8 communities were added to the 24 stops in 10 locations in September of 2022. Fares were made free until January 1st 2023 (Abraham 2022).

The County additionally offers a door-to-door shopping bus that must be reserved by noon the day prior. The bus is free for riders over sixty with a suggested contribution of \$3 per round trip for others. The bus does follow a schedule which can be found below in Figure 5 (MOVE Sullivan 2022).

- **MONDAYS:**
 - Town of Bethel - Smallwood, Cochection, Bethel Senior Housing and White Lake
 - Town of Neversink - Neversink, Grahamsville, Foxcroft Village
- **TUESDAYS:**
 - Town of Fallsburg - Woodridge, Mountaindale & South Fallsburg
 - Town of Rockland - Livingston Manor & Roscoe.
- **WEDNESDAYS:**
 - Town of Liberty – Liberty, Golden Park, Barkley Gardens & White Sulphur Springs
 - Town of Mamakating - Summitville, Wurtsboro & Bloomingburg
- **THURSDAYS:**
 - Towns of Tusten, Highland and Lumberland - Narrowsburg, Eldred, Barryville, Glen Spey, and surrounding areas
 - Town of Thompson - Monticello, Mongaup Valley
- **FRIDAYS:**
 - Towns of Delaware, Fremont and Callicoon – Fremont Center, Callicoon, Hankins, Jeffersonville, etc.
 - Liberty Village & Town of Fallsburg- Liberty Village Apts., Hurleyville, Loch Sheldrake & Kiamesha Lake

Figure 5: Shopping Bus Schedule for the different towns in Sullivan County (MOVE Sullivan 2022)

The bus brings people to Monticello only to shop at Walmart, ShopRite, or Aldis and allows people to make bank runs or other quick errands if they are not out of the way. This MOVE Sullivan campaign is the focus of this analysis for this thesis. The fixed route transit map can be found below.

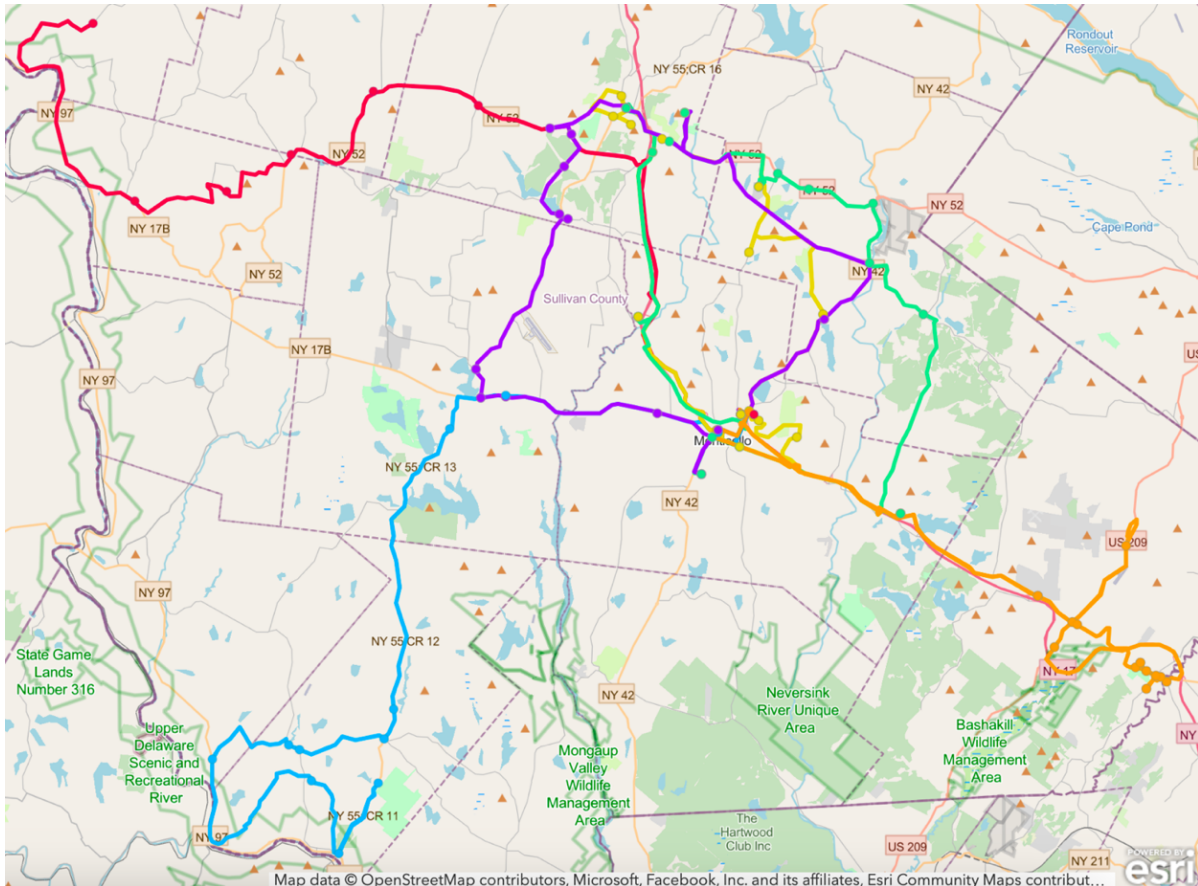


Figure 6: Transit routes of the MOVE Sullivan Bus run by Sullivan County. Each color represents a different route with blue being the Highland Township Line, Route A represented by the purple line, Route B in yellow, Route C in green, Route D in orange, and red being the Delaware Area Township Route. (MOVE Sullivan 2022)

Paratransit options available within the county include Medical Answering Services (MAS) and BeST Transit. MAS, advertised on the County website is a Medicaid transit service and requires 3 days' notice for transit along with prior approval from the County with proof of Medicaid eligibility ("Medicaid Transportation | Sullivan County NY," n.d.). BeST Transit serves Bradford, Sullivan, and Tioga Counties and serves any person under 65 within a ¾ mile of the area's network. As for cost "Federal law allows BEST Transit to charge twice the fixed route fare for persons who use the ADA Paratransit Service" ((BeST Transit, n.d.). Riders are required to fill out an application for the service and additionally require a minimum of one business day to reserve a ride. Personal Care Attendants are allowed to ride along with riders as long as they board and disembark with the rider and a note to have such an attendant may be required (BeST Transit, n.d.).

BENEFITS OF RURAL TRANSIT NETWORKS

Transportation does not exist in a vacuum. As with any ecosystem, adding a factor that increases the efficiency of the population has a butterfly effect on the rest of the system. Adding a transit system to a rural area has net positive effects on the residents served and the economy in the area. The benefits fall into the categories of health, social, and economic.

According to a survey conducted in 2017, it's estimated that 5.8 million people in the US have delayed medical care because of a lack of

transportation (Mattson and Quayson 2023). This number has increased from 4.8 million individuals in 1997 to 5.8 million in the 2017 survey (Wolfe et al. 2020). Providing transportation to healthcare services to those who don't have easy access increases the use of such services. This results in improved healthcare outcomes, well-being, and cost-saving benefits (Mattson and Quayson 2023). Ensuring that people don't miss their initial appointments, prevents more costly visits down the road. This means a reduction in healthcare costs.

Aside from physical health benefits, there are also mental health benefits associated with transit in rural areas. Public transit makes it easier for people to meet others with it being a place for people to interact on their way to destinations. This is particularly true for the elderly population where the use of public transit can improve mental health and result in a decrease of suicides (Mattson and Quayson 2023).

By definition, using public transportation involves interaction with the public. Within the literature, social capital is used to explore the interactions between people, the transit they use, and how they interact with the space around them. It describes the advantage individuals and communities can gain from social participation, mutual assistance, and trust (Currie and Stanley 2008). This social capital can be present in real-life and online spaces since it is the product of a group rather than the individual. The

measurement of social capital has been done through the number of community groups in the area and how well-attended their meetings are. The addition of the public eliminates the question of transit from the equation of barriers to attending these meetings. However, further research is needed due to how new this concept is, and no quantitative studies have been done as of this thesis.

Perhaps the most important for rural communities is the economic benefits that public transit can provide. Adding a transit system allows the centralization of services. These services could be medical care, industries, services, and goods (Laird and Mackie 2014). In addition, transit provides a means for the hiring pool to expand because people have a broader range of movement accessible to them. Some economic benefits that are more difficult to measure, but can be associated with the addition of a transit system are increased business to local businesses in addition to regional economic growth (Southworth et al. 2005).

The assessment of further benefits of rural transit systems requires further empirical studies, however, Southworth et al. laid out a way to measure such benefits in their 2003 report and created the following assessment tree (Southworth et al. 2003). It was noted in the previously cited report that the benefits that are perhaps the most relevant for rural

transit use are the regional economic benefits and mobility-based accessibility benefits (Southworth et al. 2005).

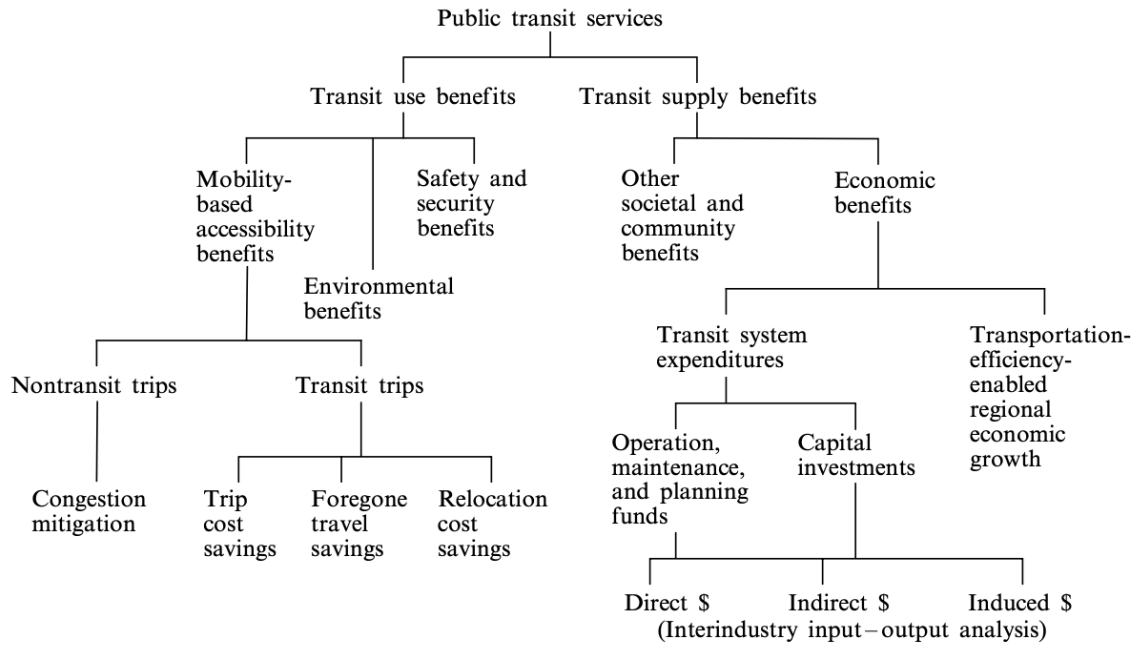


Figure 7: Assessment tree of rural benefits as determined by Southworth et al.

OVERVIEW

This thesis aims to examine what factors influence the creation of rural transit systems, the linkage between service and people, and identifying populations that would benefit from access to transit through the lens of Sullivan County’s MOVE Sullivan system. This will be done first through maps of the area looking at population density and how many miles of roads fall within a specified distance of a stop. The methods for such mapping are

laid out in Chapter 2. A literature review, found in Chapter 3 will be used to explore what is involved in establishing a rural network and the considerations that are made when transporting the general population in addition to those who require specialized transit to suit their need. Finally, the results, discussion, and recommendations will follow in chapters 4 through 6. These sections will cover the results of the analysis and the next steps that can be taken to improve the existing network.

CHAPTER 2: METHODOLOGY

To create a full context of what rural transit is, the transit needs of the county, and create a series of targeted recommendations that can be taken up by counties or municipalities facing similar issues, different methods will be used to address the research questions seen below:

- *What is the relationship between the people who need transit and the total distance of roads within a ¼ mile service area in a transit network?*
- *What determines if a rural transit network is feasible?*
- *What are the different approaches that transit agencies use to meet the needs of the population they serve?*
- *How do different populations of different abilities and needs interact with public transit?*

First, will be a review of the current literature on rural transit. This will involve looking at how rural is defined, the process to assess the feasibility of rural networks, how disabled populations interact with transit, and the benefits that rural networks bring to the areas they serve.

To assess the county's distribution of populations that may be transit-disadvantaged, location quotient (LQ) ratios will be calculated. LQ is an analytical statistic that can measure a statistic in a region relative to a larger

geographic unit. For the case of this thesis, towns will be compared to the larger geographical unit of the county. The purpose is to identify towns having a higher portion of their population that may struggle with transit. This will serve to target municipalities for an expansion of the service. The statistics that will be looked at for this are chosen from a 2015 paper by Shay et al. The indicators are low income, disability, youth (non-driving age), seniors (over age 62), ethnic minority, and low English proficiency (Elizabeth Shay et al. 2016). The data for this analysis will come from the US Census. The following equation will be used for the calculation (Minnesota Department of Employment and Economic Development 2022):

$$LQ = \frac{\% \text{ of population in a town with selected statistic}}{\% \text{ of population in the county with statistic}}$$

Figure 8: Location Quotient equation

GIS METHODOLOGY

To analyze if there is a pattern between accessible roads and population centers, ArcGIS Pro will be used. What will be done is a visual analysis of created maps. First, to visualize the amount of road network covered, a quarter-mile buffer will be added around each bus stop. Then, the total distance of roads within the buffer will be added and normalized for the total amount of roads within the town. For this thesis, accessible will be defined as the degree to which something is “get-at-able” or has an “ease of

reaching” (Currie and Stanley 2008). To discern where populations are located, zonal statistics will be calculated for a grid where each side of a square is a quarter mile. Finally, a visual analysis will be done by comparing service areas relative to where populations are on the county and town levels as well as t

The methodology for creating the buffers for this comparison is based on the procedure laid out by Foda and Osman in their 2010 paper assessing the stop accessibility of a bus network in Egypt. The below flow chart lays out the methodology modified from this paper (Foda and Osman 2010).

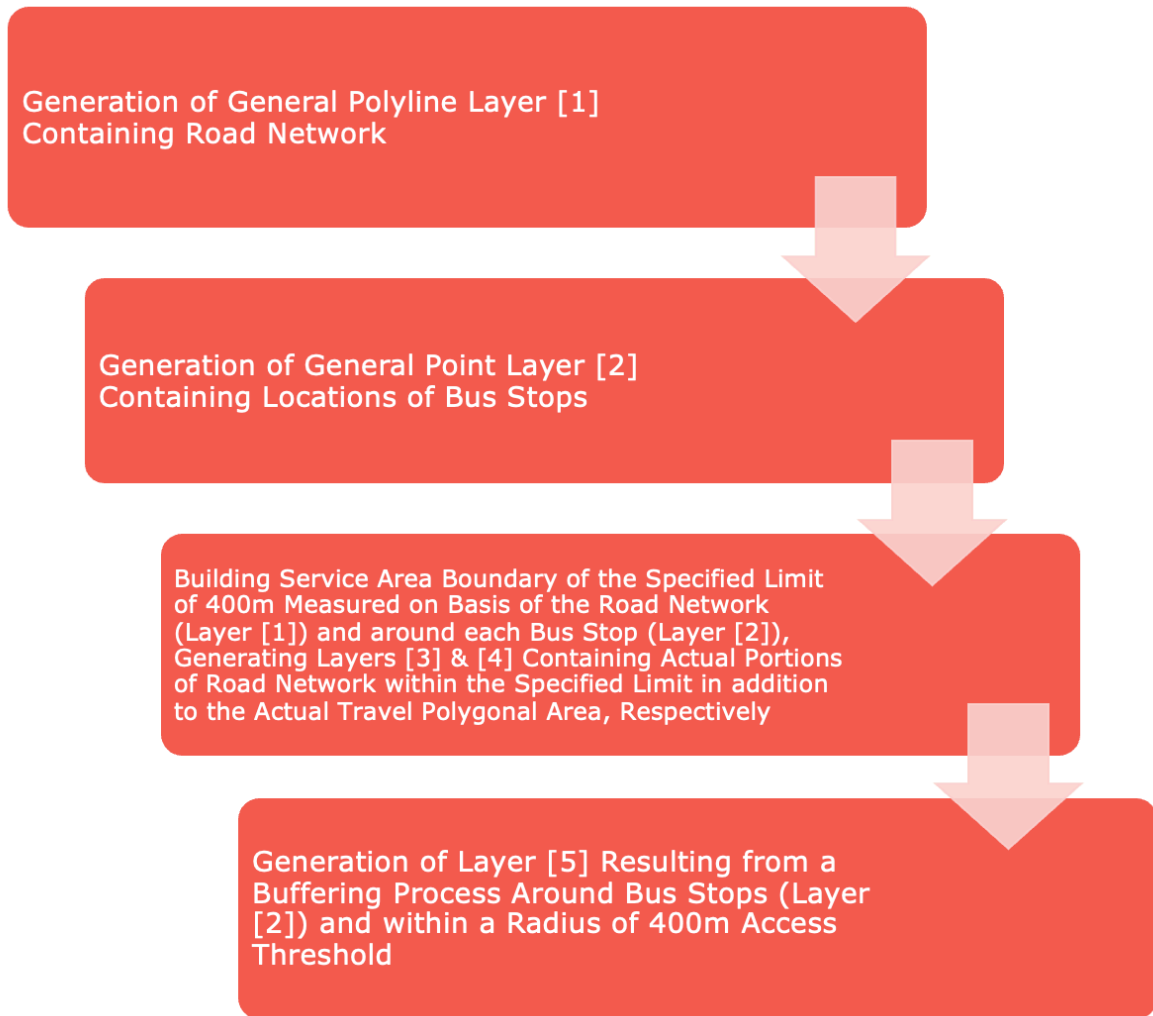


Figure 9: Flow chart of GIS methodology modeled after the analysis in [Foda and Osman's 2010 paper](#).

The reason for using such an analysis is to exclude roads not directly connected to the same road as the stop is located. Therefore, only roads directly connected to the road network are counted as accessible. Roads that require crossing property lines to reach the stop or roads not open to

pedestrian traffic such as highways are excluded. What this means for the mapping is illustrated below.



Figure 10: Illustration of the result of the GIS methodology mentioned above.

To compare how close populations are to stops, a grid will be overlaid onto Census Block Group data from the 2020 US Census. Using the fishnet tool, a grid will be created with squares a quarter mile in length. Next, the Census Block Group shapefile will be spatially joined to the fishnet data. The number of squares within a census block will be counted through a join count. Values of squares will be calculated by dividing the population in each polygon by the number of grid cells. The interpretation will be by

visualizing the population within each cell. Through a visual comparison of the created maps, the question of where stops are located relative to people can be answered.

The final step is to compare the results of the GIS and LQ analysis. This will be done by looking at how many variables of interest are above 1.2 compared to the percentage of roads in an accessible range to the bus stops. Finally, the location of bus stops and population density in the county will be compared to the service areas to identify where people are relative to the stops. This will answer the question of comparing the populations needing transit to what is accessible.

CHAPTER 3: LITERATURE REVIEW

This literature review explores the different factors considered when creating a rural transit network, but also what defines “rural”. Additionally, this section will examine the ideas of car dependency, and what makes a transit network or agency able to move people of varying needs and ages. Finally, this chapter closes with different approaches transit agencies use to create networks.

DEFINING RURAL

For the 2020 Census, the Census Bureau classified urban areas as having at least 2,000 housing units or having a population of at least 5,000. The definition of a rural area is all those that do not meet those conditions (US Census Bureau 2020). This classification of rural areas has seen adjustments over time as the United States has experienced urban growth in its suburbs around large cities. Additionally, the Bureau updates the definition every ten years to match the different geographical contexts in the country. Deciding where to draw the line between the ends of urban areas and the beginnings of rural areas is based on population density and land-use characteristics. This classification system groups densely settled small towns and housing divisions on the fringes of urban areas and the sparsely populated remote areas (Ratcliffe et al. 2016).

This definition of rural, however, is not consistent throughout government agencies or academia. For example, the Office of Management and Budget (OMB) uses census designations to define Metropolitan and Micropolitan Statistical Areas at the county level, then units are classified as metropolitan or micropolitan depending on whether they are centered in an urbanized area or an urbanized cluster of more than 10,000 residents respectively. Perhaps the most interesting piece is that the OMB released guidance that these standards do not produce an urban-rural classification. Many government agencies and federal research programs use them as such anyway (Bennett et al. 2019). The Department of Agriculture's Economic Research Service (ERS) is one example of taking the OMB standards and expanding them into Rural-Urban Continuum Codes. These codes, last updated in 2013, are categorized by population size and adjacency. The difference is that the ERS uses census tracts to provide a more precise and nuanced range of categories. Such categories include Frontier and Remote Area codes that are zip code-based and therefore specific to rural places (Bennett et al. 2019).

When defining "rural" for academic and policy reasons, they have a wide range of definitions. This leads to studies having different delineations of urban and rural areas based on two differing challenges. One is choosing the appropriate urban boundary based on three concepts: administrative (municipal or jurisdictional boundaries), land use, and economics. The

second is the population threshold which is akin to the Census Bureau's methodology. The choice of definition that results is one based on the purpose of the study (Cromartie and Bucholtz 2008). A study done in 2008 found that the existing classification systems did not adequately delineate differences among geographic areas as they relate to personal mobility needs and the availability of transportation services on the definitional boundary between urban, small urban, and rural areas. Instead, they found that classifying urban areas by total population and rural areas by their population density was better. This is based on looking at the type of transit provided in the county (fixed-route, demand-response, and intercity bus service) and establishing a statistical relationship between urban population and rural density in the Upper Great Plains region. They created a two-part system of five classes with the first number representing the urban nature of the county based on the US Census Bureau's definition of urban and rural. The second letter represents the rural nature of the county based on the density. The classification system can be found in the tables below. It should be noted that while there is a high level of association with transportation services provided, service data is primarily classified by agency, not services provided. With the added issue of old data, analysis is difficult and calls into question the accuracy of the results (Ripplinger, Beck, and Hough 2008).

*Urban Population-Numeric Classification and Corresponding
Population Breaks (persons per square mile)*

<i>Class</i>	Lower Bound	Upper Bound
1	200,000	+
2	50,000	199,999
3	10,000	49,999
4	2,500	9,999
5	No urban areas	

*Rural Density-Alphabetic Classification and Corresponding Density
Breaks (persons per square mile)*

<i>Class</i>	Lower Bound	Upper Bound
A	No Rural Areas	
B	50	1,000
C	25	49
D	10	24
E	0	10

Figure 11: Tables of values used to assess rural and urban area designation based on population density.

CAR DEPENDENCY & RURAL TRANSIT TRENDS

Car dependency has only become a recent topic of conversation in literature. Thus, creating confusion as to how to define it. A survey done in the UK found that the phrase “car dependency” is a recent addition to the literature and has in the past been defined as some degree of reliance with

dependency seen as the most extreme reliance. The reasons for this reliance were sectioned into two categories: structural constraints and situational. Structural constraints are those that are 'hard-wired' into the system. This includes areas with land use that don't lend itself well to public transit. Situational barriers are those that are person or trip-specific (Blumenberg et al. 2011)

On average, rural residents make fewer trips but travel a farther distance compared to their urban counterparts. The Federal Transit Association offers funds for rural areas to provide capital, planning, and operating to states that support public transportation in rural areas with populations less than 50,000 (Federal Transit Association 2023). As of 2020, 1,286 rural agencies received funding to provide service. 1,136 rural operators provided a demand-response service and 464 provided fixed-route service in 2020, including deviated fixed-route service. Eighty-three percent of counties had some level of rural transit service. Counties not included are urban counties served by urban transit agencies or those that may have some other type of service not supported by this funding (Mattson and Mistry 2022).

ASSESSING THE FEASIBILITY OF RURAL TRANSIT ROUTES

Before a route is created, a feasibility study should be done first to assess the needs of the area. Due to the low population density of rural

areas, they present unique challenges when creating a mass transit system. The planning of these systems can be broken down into a comprehensive cycle shown in the flow chart below. The first step is the acknowledgment of a transit issue in the area, the next step is defining the problem in context and searching for alternatives and what, and where, the transit issues are. The third step is to conduct a needs and feasibility study and seek support economically and politically for the system. The system is then planned out, implemented, and evaluated to see if it is solving the perceived problem identified at the beginning of the process. If it is not, the cycle begins again and necessary changes are made to the system (Saltzman 1976).

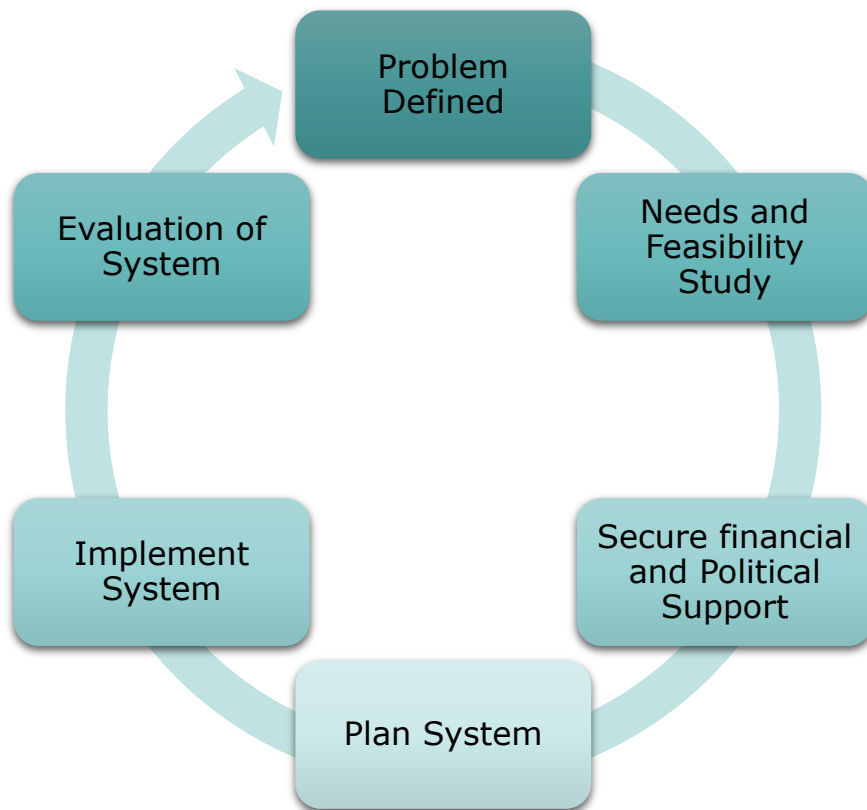


Figure 12: Cycle of feasibility assessment for rural transit networks

Going through a needs and feasibility study is like the feasibility process but includes the context of the area the system needs to serve. The below flow chart maps out the considerations that planners take to determine whether a transit system should be used. The importance of this process is to make it as simple as possible so that the scope of such a project is not out of reach for a rural planner or local manager and to make it as customizable as possible to mold it into the needs of a geographic area or community (Saltzman 1976).

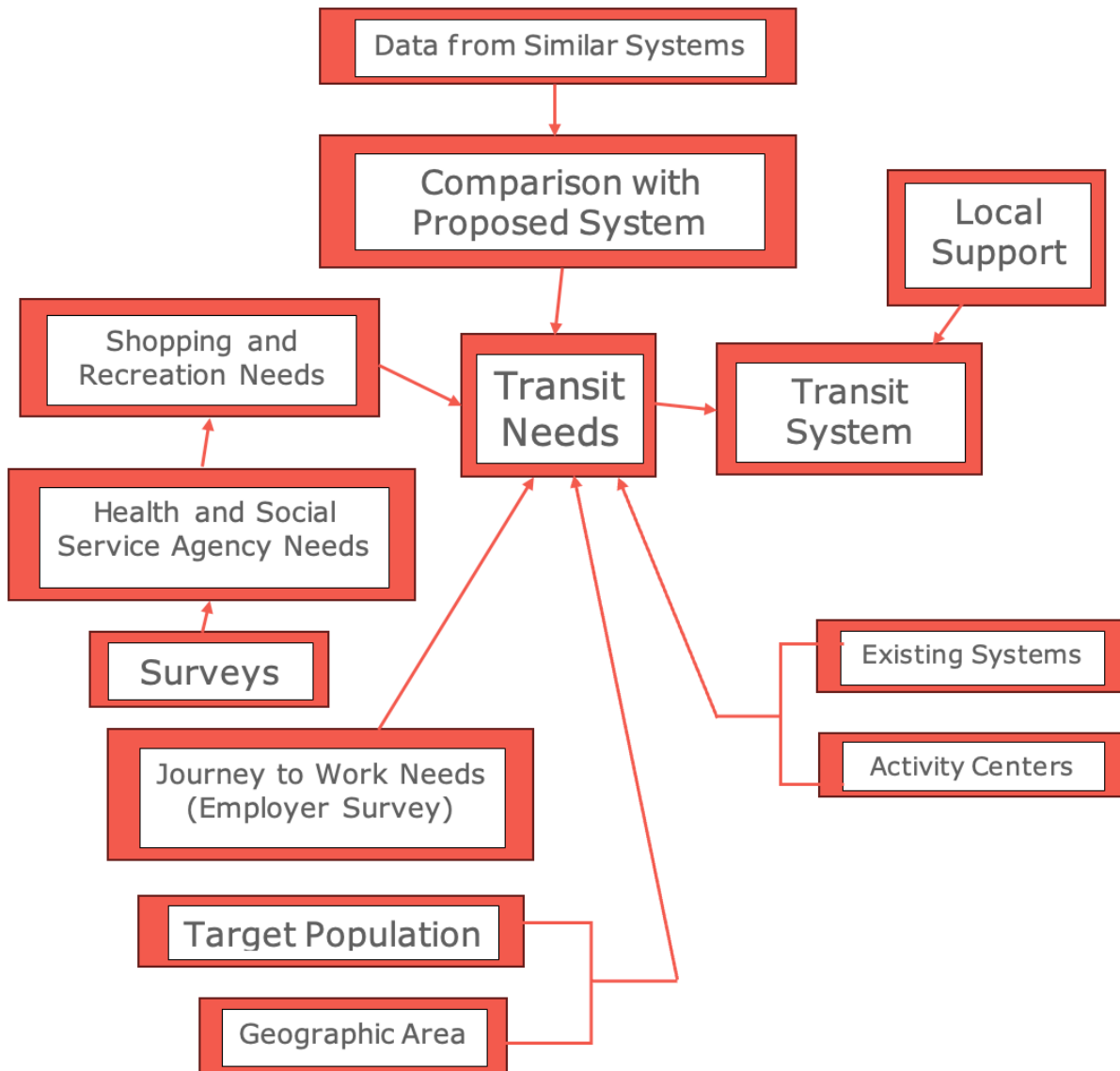


Figure 13: Factors that planners consider when planning a transit network.

TRANSIT FOR SENSITIVE AND VULNERABLE POPULATIONS

According to the CDC, in 2023 up to 27 percent of adults have some disability. 12.1 percent of those have serious difficulty walking or climbing stairs, 12.8 percent have cognition issues, 7.2 percent have difficulty doing errands alone, 6.1 percent are deaf or have serious difficulty in hearing, 4.8 percent have blindness or serious difficulty seeing, and 3.6 percent have difficulty dressing or bathing (CDC 2023). Locally, the breakdown of those reporting disabilities within Sullivan County is shown below (US Census Bureau 2022).

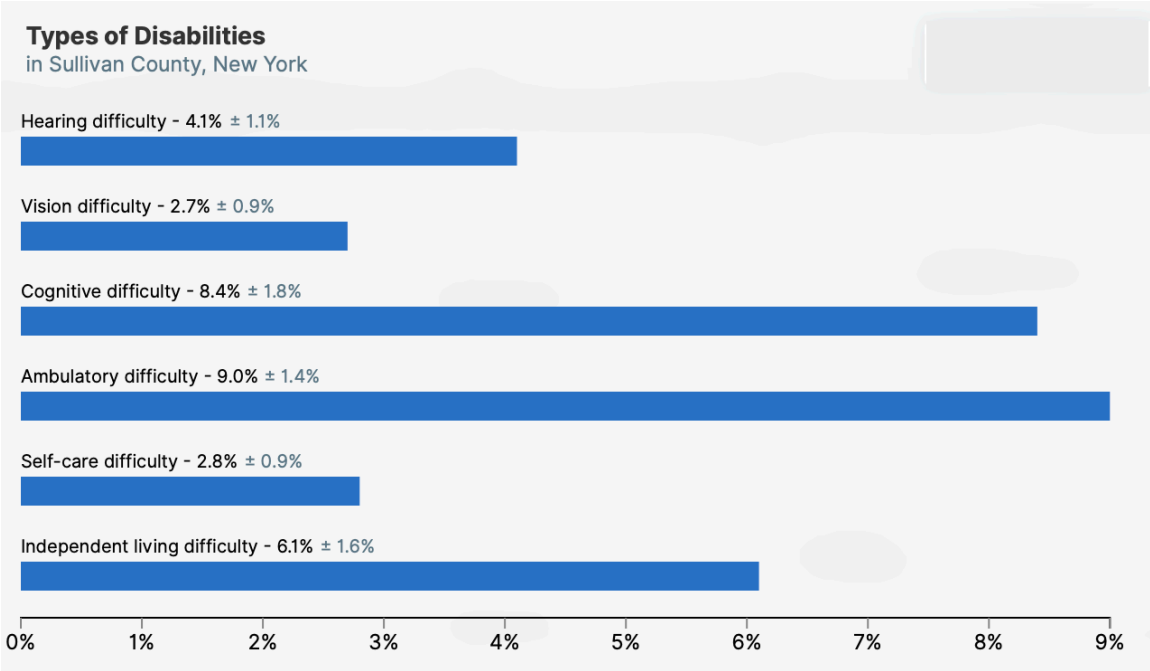


Figure 14: Percent breakdown of disabilities in the population of Sullivan County (US Census Bureau 2022)

According to the 2017 National Household Travel Survey, regardless of age, people with disabilities made fewer trips per day on average than people without disabilities. The ability to travel is often essential to employment and people with disabilities that limit their ability to travel are less likely to have jobs. Only 20.2 percent of individuals aged 18 to 64 work full or part-time if they reported having disabilities. This contrasts with the 76.6 of those who don't report having disabilities in the same age bracket (Brumbaugh 2018).

A supplemental survey to the National Health Interview Survey in 1994 aimed to gather information about transportation needs and barriers from those with self-reported disabilities and impairments. It found that two-thirds of respondents under 65 with one or more disabling conditions drove a car every day or occasionally. Of respondents who reported never driving, roughly forty-five said they didn't and listed their impairment or health problem as the reason. Those who did drive, even infrequently, reported using a special vehicle or special equipment on their car to allow them to drive. In terms of using public transit, the survey found that of those who had access to transit of some kind for people with disabilities only ten percent reported using them in the last 12 months and respondents were almost twice as likely to use a regular taxi at full fare price instead of a subsidized transportation option. The most common reason for not using these resources was the pedestrian environment (Field et al. 2007).

METHODS OF RURAL TRANSIT

Paratransit and Flexible Transit Services

Basic paratransit, also called “many-to-many”, is the product of altering the basic service of static transit routes to offer a user-specified origin to a user-specified destination at a user-specified time. In practice, these systems cover two areas, paratransit required to comply with the Americans with Disabilities Act and other paratransit that involves other demand-responsive services (Lave and Mathias 2000). Due to the topographic and complex road networks in rural areas, providing consistent service is often difficult. Travel demand is often low in these areas, and residents have many destinations. An option for these governments is the Dial-a-Ride (DAR) system (Saeed and Kurauchi 2015).

An example of such a system has been carried out in Fort Erie. Fort Erie, Ontario has recently restructured their public transit system in 2021 to be on-demand services rather than fixed-route transit. This was done by replacing its community bus route with a fleet of six minivans. The bus routes consisted of four buses with three routes, each following a roughly one-hour, one-way, loop. The new service uses six minivans, two of them with retrofitted wheelchair-accessible ramps.

The new system uses a software app handling routing, payment, driver dispatching, and real-time scheduling. This was put together by a Toronto-

based software company Pantonium and a local company, Regional Limousine, to meet the requirements for changing to an on-demand service. This resulted in a similar system that Uber and Lyft use to manage their services. The system may require a passenger requesting a standard van to walk up to 400 meters to their pickup location to optimize vehicle routing while providing origin-to-destination service (Powell et al. 2023).

The Network Approach

A network planning approach in rural areas involves creating a grid of frequent public transport routes for easy transfers. This conveniently links a higher proportion of passenger's origins and destinations than isolated transport corridors. However, services in rural areas are low frequency and must be timed well to create the same effect. A solution to this is to have "pulses" of transit. Similar methods are used at airports when planes arrive at a central point simultaneously to allow passengers to transfer in all directions. Examples of places that include pulse timetables include Edmonton, Sacramento, and Portland (Petersen 2016).

CHAPTER 4: RESULTS

This chapter is split into two parts. The first is the Location Quotient (LQ) which will identify how relevant a statistic is to determine if an area needs transit and what populations to target. The second is the GIS analysis of the ratio of total roads to the sum of roads within a quarter-mile radius of a MOVE Sullivan bus stop. The created values are then compared to one another to analyze the pattern of the ratio of roads accessible to the number of statistics with a value higher than one.

LOCATION QUOTIENT

The calculation of the LQ was done for five different statistics that are indicators of populations in need of public transit that potentially have issues with transit currently. This was done for all fifteen towns that make up Sullivan County. What is a value of interest is anything over 1.2. Below is a table listing the towns, the relevant statistics, and the calculated LQ.

Percent Population with Variable of Interest

Variable of Interest (% of Population)	Bethel	Callicoon	Cochecton	Delaware	Fallsburg	Forestburg	Fremont	Highland
Disability	13.2	10	14.5	15	15.4	13.9	16.6	22.2
Different Language Home	8.3	5	6	10	24.4	12.9	8.2	15.5
Poverty Rate	14.2	10.5	7.2	20.4	18.4	5.4	8.8	7.4
Over 65	28.8	26.1	26.2	22.2	13.9	31.9	28.5	27.6
Under 15	16.7	14	10.1	12.3	18.1	8.3	13.8	8.3

Variable of Interest (% of Population)	Liberty	Lumberland	Mamakating	Neversink	Rockland	Thompson	Tusten	County
Disability	19.5	8.1	13.1	17.2	18.2	17.9	16.4	1.091
Different Language Home	27.2	10.6	18	10.8	11.8	26.8	7.9	3.392
Poverty Rate	15.5	8.7	13.6	9.6	11.8	18.4	11.2	1.643
Over 65	14.6	15.8	14.7	16	29.9	20.5	21.1	0.972
Under 15	24.1	14.4	19	14.7	14.1	17.2	12.4	1.387

Figure 15: Table created using data from the US Census displaying percentages of populations classified within the variables of interest.

Location Quotient of Variables of Interest

Variable of Interest (% of population)	Bethel	Callicoon	Cochecton	Delaware	Fallsburg	Forestburg	Fremont	Highland
Disability	0.759	0.575	0.833	0.862	0.885	0.799	0.954	1.276
Different Language at Home	0.382	0.230	0.276	0.461	1.124	0.594	0.378	0.714
Poverty Rate	0.866	0.640	0.439	1.244	1.122	0.329	0.537	0.451
Over 65	1.492	1.352	1.358	1.150	0.720	1.653	1.477	1.430
Under 15	0.879	0.737	0.532	0.647	0.953	0.437	0.726	0.437

Variable of Interest (% of Population)	Liberty	Lumberland	Mamakating	Neversink	Rockland	Thompson	Tusten
Disability	1.121	0.466	0.753	0.989	1.046	1.029	0.943
Different Language Home	1.253	0.488	0.829	0.498	0.544	1.235	0.364
Poverty Rate	0.945	0.530	0.829	0.585	0.720	1.122	0.683
Over 65	0.756	0.819	0.762	0.829	1.549	1.062	1.093
Under 15	1.268	0.758	1.000	0.774	0.742	0.905	0.653

Figure 16: Table Created by calculating LQ values for each town in Sullivan County. Values of interest are bolded.

Overall, the variable above 1.2 most consistently was the percentage of the population over 65 with eight occurrences. The second most common was language spoken at home with two instances. It should be noted, however, that many of the variables had values close to 1.2 but were just off.

The towns with the most LQs above 1.2 were the towns of Liberty and Highland with two variables being over 1.2. For Liberty, the two were the percentage of the population who speak a different language at home and the percentage of the population under 15 years old. Highland's statistics of interest were percentages of the population with disabilities and those over 65 years old.

Towns that had no values over 1.2 were Lumberland, Mamakating, Neversink, and Tusten. These towns mostly had values less than 1, with Mamakating and Tusten only having one value at or slightly above 1.

Looking at towns with fixed-transit options, out of the five with transit stops, three have values above 1.2. These towns are Liberty, Bethel, and Thompson. Each of these towns only has one variable of interest above 1.2 and each is a different variable meaning there is no pattern across towns with transit concerning variables of interest. This suggests that a fixed-transit system is not meeting the needs of those who need transit and a supplemental service could be added to meet their needs.

GIS RESULTS

At the time of this thesis, only five of the fifteen towns host stops for the MOVE Sullivan program. Those towns are Bethel, Liberty, Thompson, Mamakating, and Fallsburg. The system is made up of a total of 47 stops: Liberty and Thompson having the most amount of stops at fourteen, Mamakating with ten, Fallsburg having nine, and Bethel three.

Below is the result of the fishnet analysis at the county level in Figure 17. The populations are centered in the towns located along the State Route 17 corridor that runs northeast through the county and the State Route 209 that runs about north-south through the southernmost town of Mamakating.

On the town level, the towns follow the same pattern with populations centered around main roads and in areas of denser roads. Service areas for transit stops are also centered in areas of denser road networks. It's in these areas that have the most distance of roads covered. Below are the results of the maps and analysis for the towns of Liberty and Thompson due to their number of stops. The rest of the results can be found in the appendix.

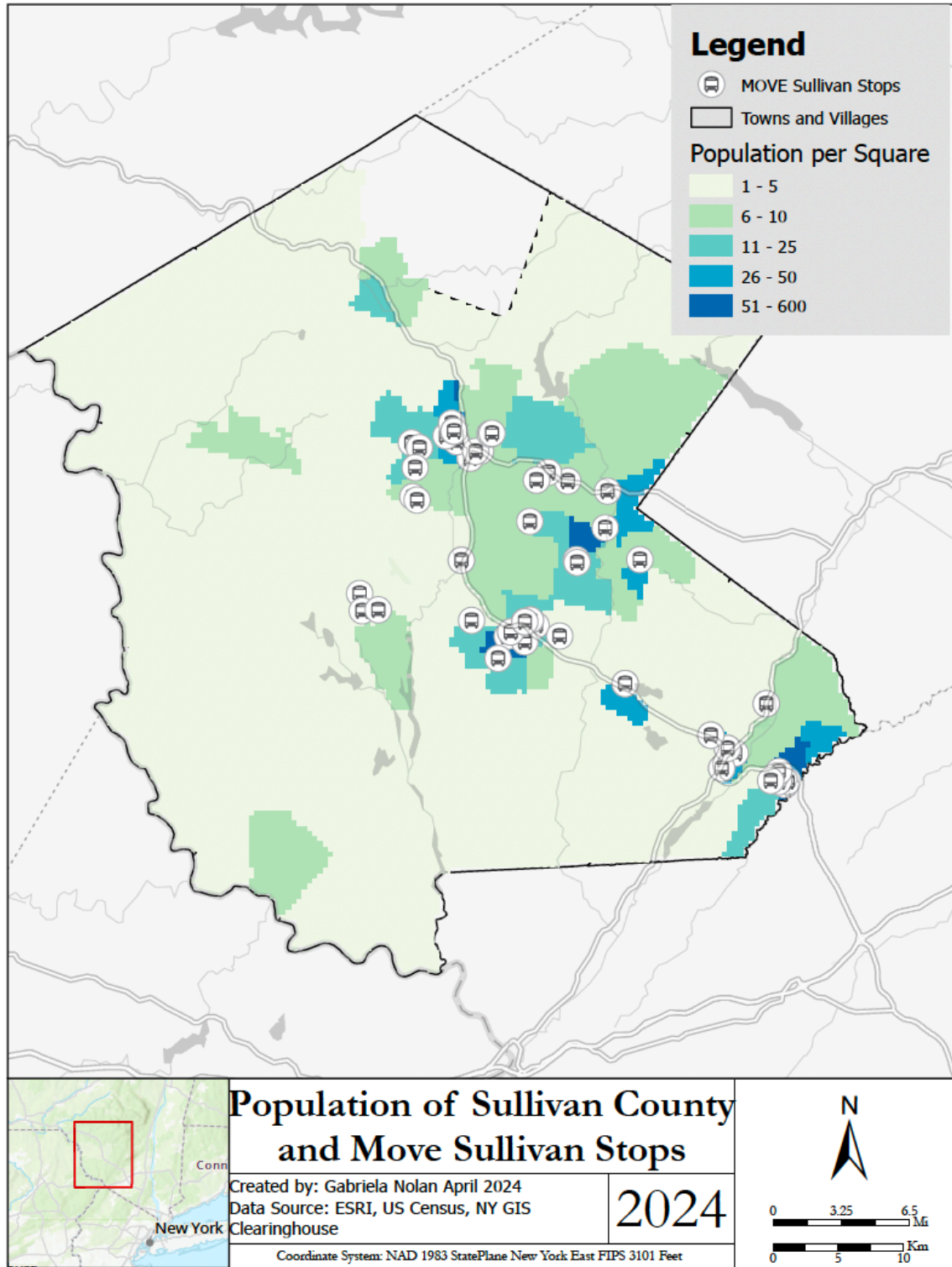


Figure 17: Map of the fishnet analysis of Sullivan County using 2020 US Census Data.

Town of Liberty

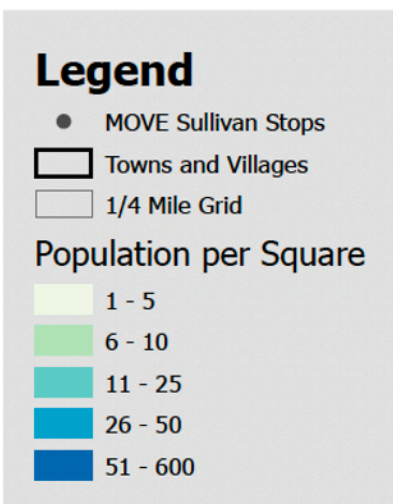
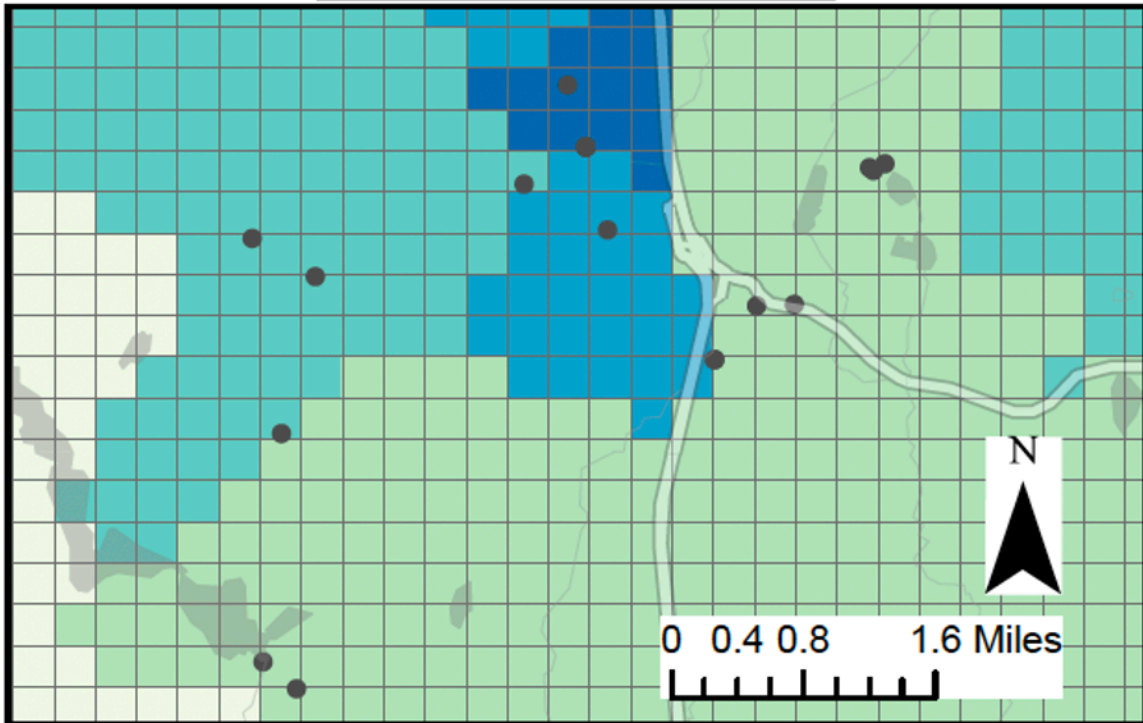
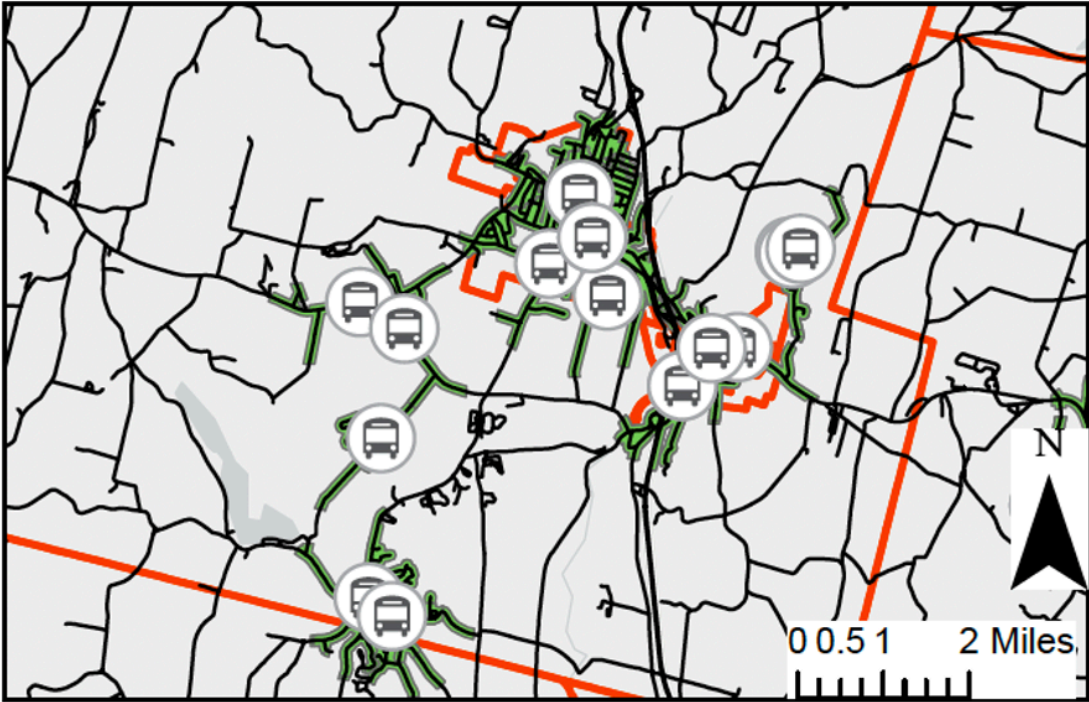


Figure 18: Map of the result of fishnet analysis for the Town of Liberty using data from the 2020 US Census.

Town of Liberty



Legend





-  Facilities
-  Streets
-  MOVE Sullivan Service Area
-  Towns and Villages

Figure 19: Map and legend showing the service areas of bus stops for the MOVE Sullivan network in the Town of Liberty.

Town of Thompson

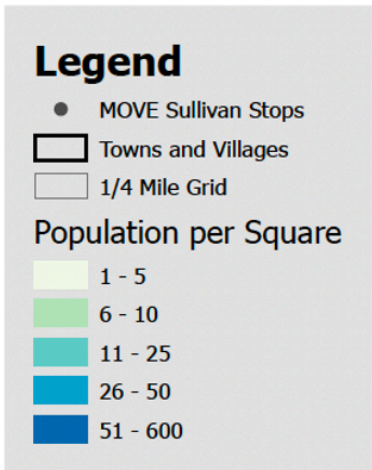
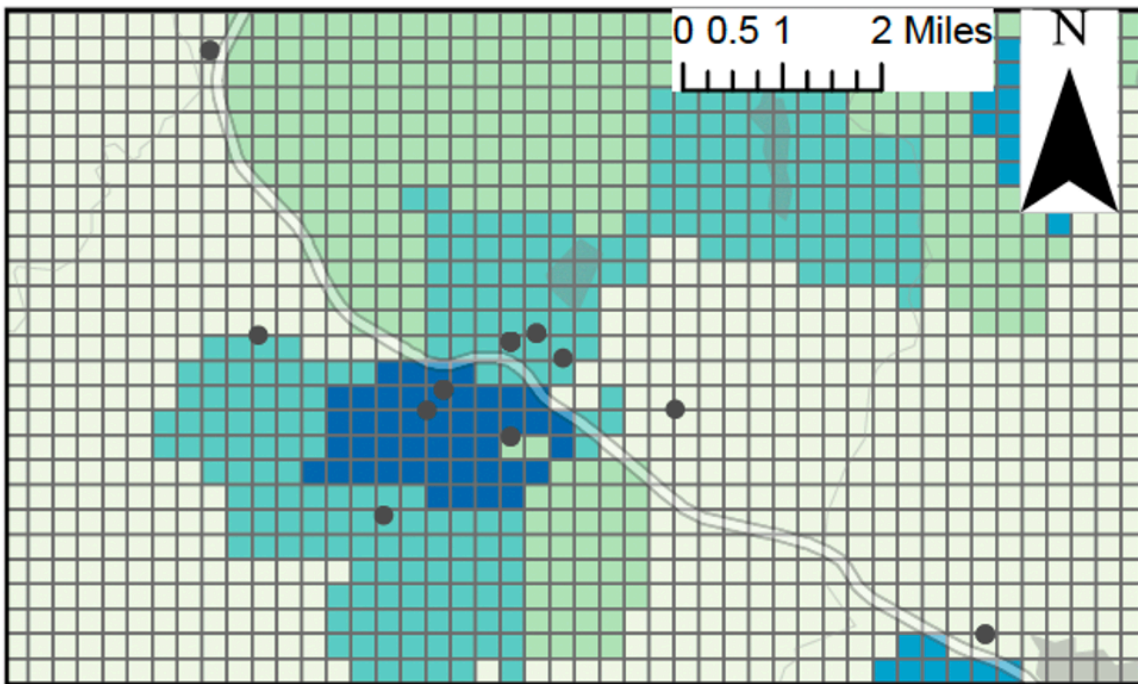
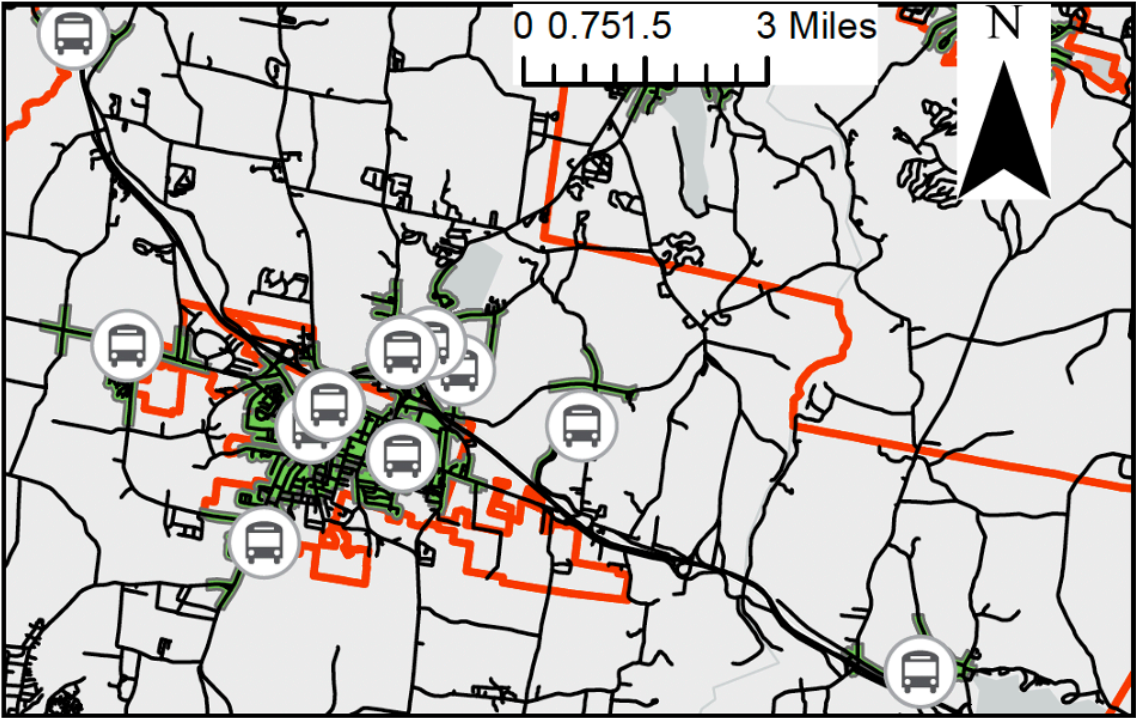


Figure 20: Map of the result of fishnet analysis for the Town of Thompson using data from the 2020 US Census.

Town of Thompson



Legend





-  Facilities
-  Streets
-  MOVE Sullivan Service Area
-  Towns and Villages

Figure 21: Map and legend showing the service areas of bus stops for the MOVE Sullivan network in the Town of Thompson.

For the town of Liberty, three stops are in areas with a population of 301-642 persons, five stops in 643 to 900 persons, and 6 in the 901-1390 persons. This shows that the stops in Liberty follow a pattern of being in more populated areas. As for the service area of the stops, the service area of stops covers most of the roads within the boundaries of the Village of Liberty. This aligns with the higher population areas seen in the fishnet map.

The Town of Thompson follows a similar pattern to Liberty, with most of its stops being in areas of higher populations with some in areas of lesser populations. It also follows the pattern of stops at a village, in this case, the Village of Monticello. However, the town of Thompson has all its stops clustered around the village while Liberty's are more spread out.

COMPARING MAPS AND VARIABLES OF INTEREST

Below is the table created from the sum function of roads within each town having MOVE Sullivan stops and the sum of roads within a quarter-mile radius of stops. The municipalities of Thompson and Liberty have the highest percentages of roads within the service area as seen in Figure 22. This aligns with Liberty's number of significant variables and the statistics that Thompson has close to being over 1.2.

Town	Total Distance of Roads (mi)	Total Distance of Roads within 1/4 Mile of a Stop (mi)	% Miles Roads Accessible to transit
Bethel	98.94	11.44	11.52
Fallsburg	127.5	35.62	27.94
Liberty	108.5	71.11	65.54
Mamakating	109.7	48.55	44.26
Thompson	138.3	85.34	61.71

Figure 22: Table of length of roads for each town that has MOVE Sullivan stops and calculated percentage of accessible roads.

Looking at the comparison between where the population density is relative to the road network and the service areas, the stop placement in the five towns is in denser road networks or in such a way that stops are connected to create as complete a coverage area as possible in denser population areas.

CHAPTER 5: DISCUSSION

LIMITATIONS

When it comes to the study of rural transit systems, much of the research is relatively new and lends itself easily to limitations. However, these holes in studies such as this one and others present a chance for targeted future studies and research to understand rural transit better as interest in this area increases.

To begin with the location quotient analysis, the population of Sullivan County is small leading to a potential large margin of error. Since the data used was taken from an American Community Survey with a large margin of error, there is a high margin of error possible for the above-calculated Location Quotient. The second method is finding the total sum of roads within a quarter-mile service area of a bus stop compared to the total number of roads within a town. This method was used to explore the pattern of service and statistics that had been determined to be indicators of transit needs based on a literature review. The error of using this method is that it does not consider the local knowledge in the area and what populations need transit thus resulting in a loss of accuracy in this analysis. In addition to this, the 1/4-mile service area may not be an accurate depiction of the

accessibility due to the lack of sidewalks. This challenges the idea that the ¼ mile buffer represents a zone that is actually transit accessible.

GIS itself is also a source of error and limitations. For example, the resolution of the population data. Since this is a large area with a lesser population density, it is possible that the shapefile used for the Census Block Group data is not able to accurately visualize the population in the grid. For the network analysis, some roads included were on-ramps to highways and therefore cannot be used by pedestrians. Finally, there could have been miscommunication on the accuracy of numbers used to calculate the length of roads within the towns.

Areas that should be pursued for future areas of study include those having varying populations during the year requiring demand-responsive transit and using collaborative methods of public transportation. These studies should be based on the local knowledge of needs in the area through interviews or surveys that include people who have used public transit in the area, those inclined to use the transit but don't, and those who don't use the transit at all but maybe could be convinced otherwise with alterations of the system. Additionally, future research could examine the locations of sidewalks within the service areas to study pedestrian accessibility around current or future stops. This would require creating a data set by ground-truthing existing infrastructure through Google Street View or site visits.

DISCUSSION

Sullivan County and its surrounding Catskill Park is a cultural, biological, and geological area of interest. Host to the infamous Woodstock Festival, home to the Bashakill Wildlife Management area which provides refuge for a myriad of migratory birds and other mammal species, and home of numerous valleys carved by glaciers and the site of a suspected impact crater; Sullivan County is more than just an abandoned vacationland from a time before cars.

The county has a steep hill to climb to meet the needs of its residents. The MOVE Sullivan program was created as a stepping stone to meet these needs. MOVE Sullivan should be seen as such; a stepping stone that can connect residents to services and goods without a car. Of course, this service will not be able to replace car use in rural areas as some trips will not be able to be replaced by transit. The county should seek to expand this service informed by residents and their needs in a way that collaborates with public and private interests in the area.

This thesis explores the existing rural transit networks in the area with research questions focusing on the relationship between people who need transit and the total distance of roads within a service area, what makes a rural network feasible, the different approaches used in designing rural networks, and how different populations of variable abilities and needs

interact with public transit systems. What was found is for the fixed route transit system that exists, for the most part, it is in areas that have higher populations along with relevant LQ results. Therefore, showing the area has a higher concentration of those that may need transit. The LQ also highlights areas without transit that can be targeted for future expansions. The feasibility of a rural transit network is based on the area's needs and therefore each network is unique to the area it serves. This can mean a variety of different approaches can be used. For example, there's the fixed route currently in use in the county, the pulse system that focuses on connections between transit routes to allow for the maximum connectivity of these routes, and a demand response system that operates in a specified area on a demand basis. The demand-style transit system is often used to meet the needs of those with disabilities. This is called paratransit and is generally how those with different needs interact with a transit system. These findings imply that the placement of the current stops makes sense with where the populations are in the county and presents a case for expanding the existing service. The results of the location quotient analysis highlight the different ways service can be added outside of fixed route transit options. Rural transit does not have to be a static network or something that is the responsibility of the county government alone. Rural systems often benefit from cooperation with private interests in the area,

whether from large employers or tourist attractions. Sullivan County hosts many organizations that could also benefit from coordinating transit options.

A final note to be made purely as an aside is the interest in expanding State Route 17, the main highway that runs through the county, that connects Interstate 81 to the North and 86, 84, and 90 to the South. There is a vested interest in the area to convert the State Route completely to Interstate 86 to receive federal funds to maintain and expand the highway to three lanes for much of its length. The explanation for this is the volume of traffic in the summer coming to and from New York City. Instead of doing such an expansion, interest should be vested in maintaining the roads and a larger public transit system to meet travel needs in the summer.

CHAPTER 6: CONCLUSION

The recommendations for improvements to this system fall into four categories. Those are the expansion or alteration of the system based on resident and user surveys, the evaluation of the existing system, the coordination of transit and services, and the accessibility of information about the program.

When creating a transit system intended to link communities, it is important to make sure that it is made to meet their needs. This is done using surveys and focus groups. In the study done by Shay et al., which was mentioned in the Methods section, the importance of a mixed approach of qualitative and GIS mapping was found to be a key feature in enriching transit planning in rural areas (Elizabeth Shay et al. 2016). This allows for informed decisions when expanding or evaluating how well the system meets the needs of the communities and those that are transit disadvantaged.

After identifying what is important to residents when using public transit, it is essential to create meaningful methods of evaluation. Examples are a success plan that includes a mission statement, vision statement, values, and a scorecard incorporating unique performance metrics (Monast and Stanfield 2019). The creation of consistent evaluation metrics results in

more targeted funding to meet the area's needs and interests. For example, a study on the performance of rural transit systems in North Carolina found that using a more collaborative approach with state and federal parties led to a significantly positive effect on rural transit systems' performance (Monast and Stanfield 2019).

As mentioned in the benefits of rural transit section, introducing public transit to a rural area provides opportunities and advantages to the residents it serves. The next step after this is the coordination of services. In communities such as Sullivan County, many public and private agencies provide transit services to meet differing needs. This results in service issues and money being spread thin across several programs. Coordination between the public and private sectors has been found to have increased economic benefits, decreased the cost of providing transit, and increased productivity of these services (Burkhardt 2004). In the case of Sullivan County, this may look like coordination between services for Medicaid clients, the private entities of the Center for Discovery and New Hope, and expanded services to parks, community events, and other places of interest.

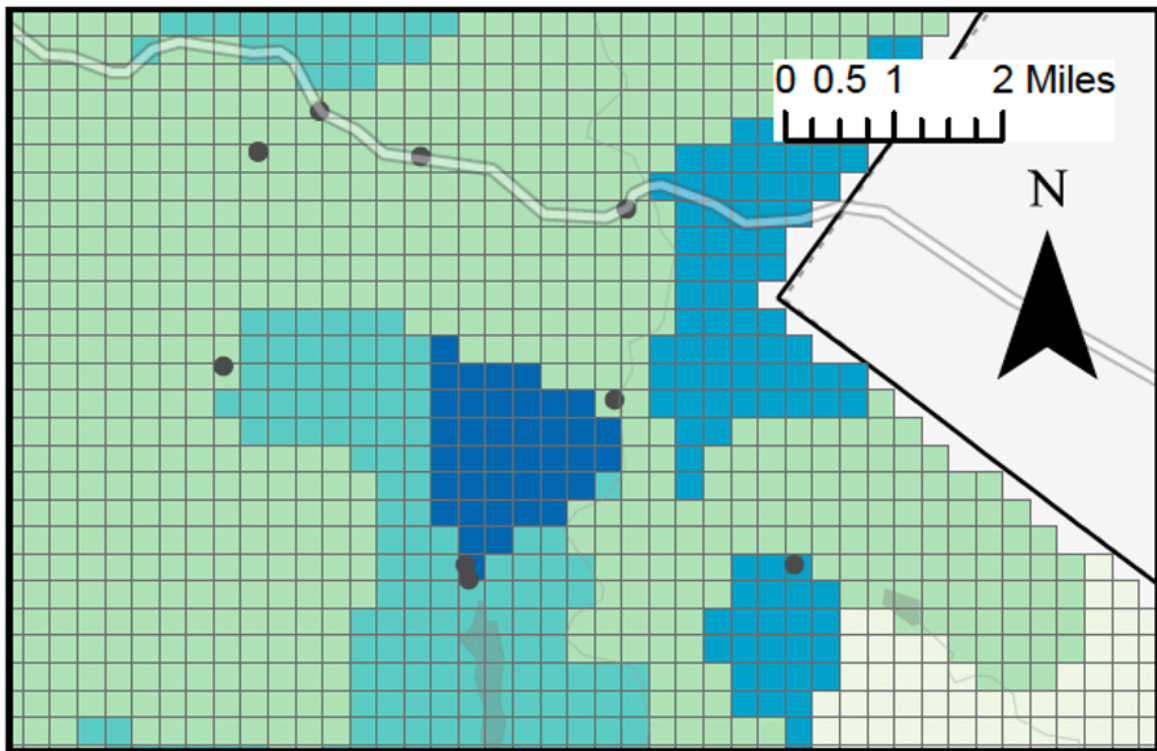
When researching data for this thesis, finding the exact locations of stops or any county documents regarding the creation of the system was difficult to find. It may be helpful to show residents how the service is being used through access to a data portal to highlight how the service is useful to

residents. Additionally, the exact addresses for stops are not listed, just the names of the stops based on what is around them. To make the stops easier to locate for those not familiar with the area, the county should include addresses of stops on the website and post signage at stops so people can ensure they are waiting at the correct spots for the buses. Another measure that should be taken is putting the stop locations on Apple and Google Maps. While some of the stops are searchable on these apps, the stops are usually not in the correct spot.

In conclusion, while this method is good for recognizing existing patterns of roads within a service area and the potential populations that would benefit from service in the area, it does not consider local knowledge of the area or what statistics are relevant to the area. However, this method does provide a stepping-stone for towns and municipalities doing a basic analysis of existing systems. This thesis highlights the need for municipalities to work with residents to build a system to meet their needs while also improving the economic health, social health, physical health, and accessibility of the area. Providing such transit does not have to be just in the form of fixed-route transit. Demand-responsive transit and pulse-style transit options have also been used in rural areas. There is also the opportunity for communities to find their unique solution by transporting residents through collaboration with public and private parties to ensure that money is spent most efficiently.

APPENDIX

Town of Fallsburg

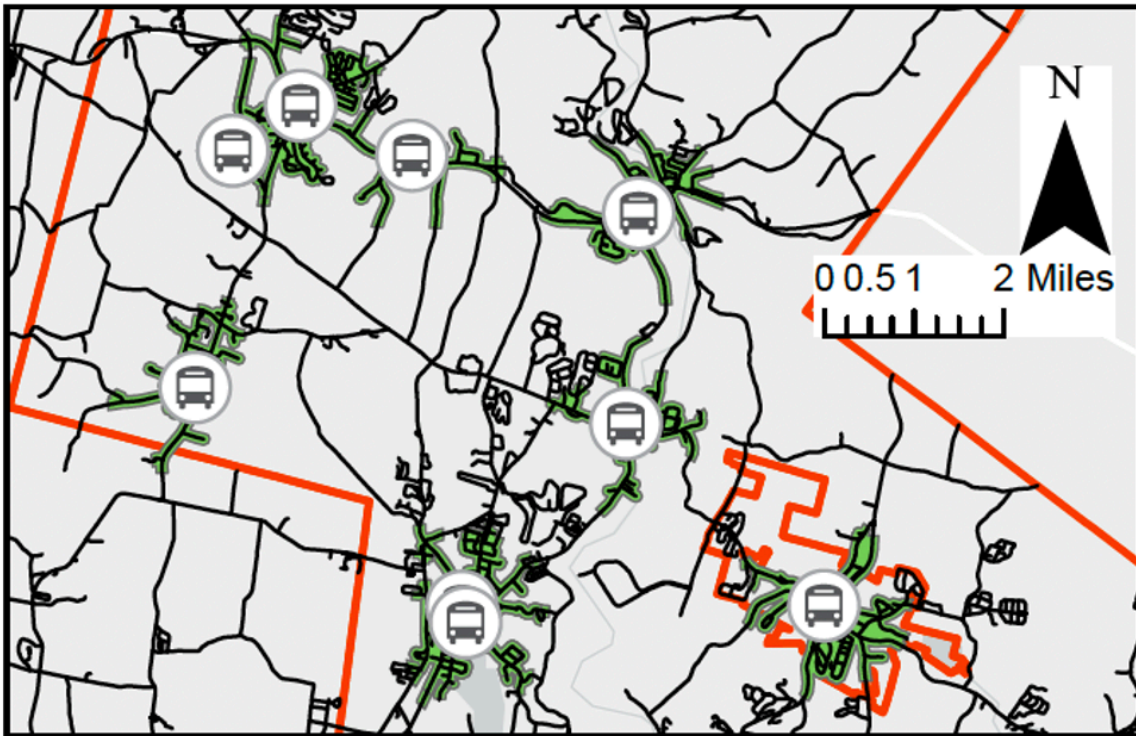


Legend

- MOVE Sullivan Stops
- ▭ Towns and Villages
- ▭ 1/4 Mile Grid
- Population per Square
 - 1 - 5
 - 6 - 10
 - 11 - 25
 - 26 - 50
 - 51 - 600

Figure 23: Map of the result of fishnet analysis for the Town of Fallsburg using data from the 2020 US Census.

Town of Fallsburg



Legend





-  Facilities
-  Streets
-  MOVE Sullivan Service Area
-  Towns and Villages

Figure 24: Map and legend showing the service areas of bus stops for the MOVE Sullivan network in the Town of Fallsburg.

Town of Bethel

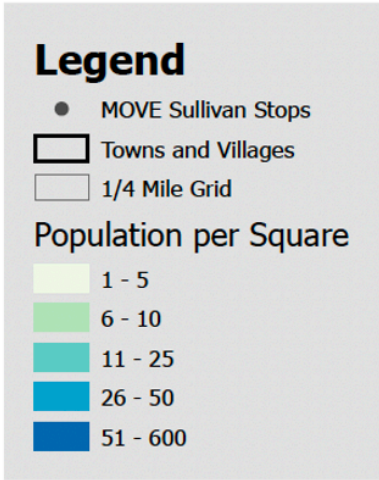
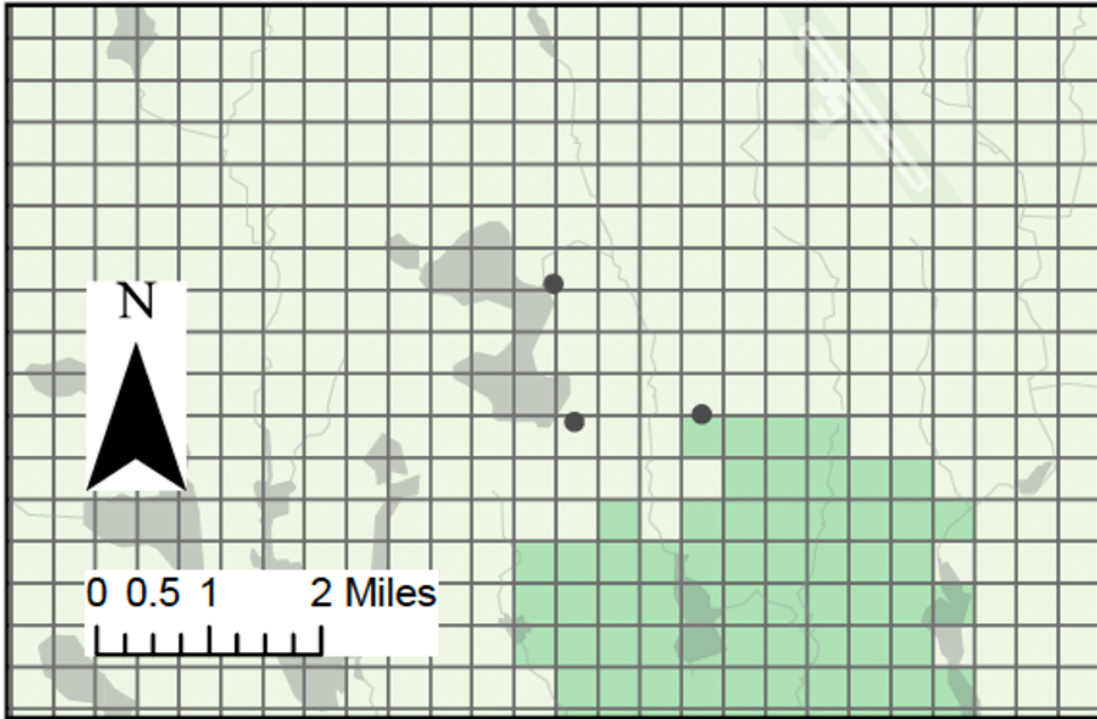


Figure 25: Map of the result of fishnet analysis for the Town of Bethel using data from the 2020 US Census.

Town of Bethel

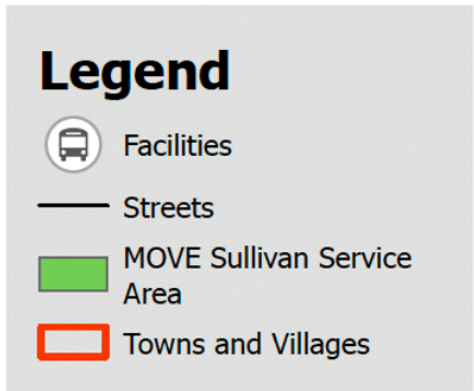
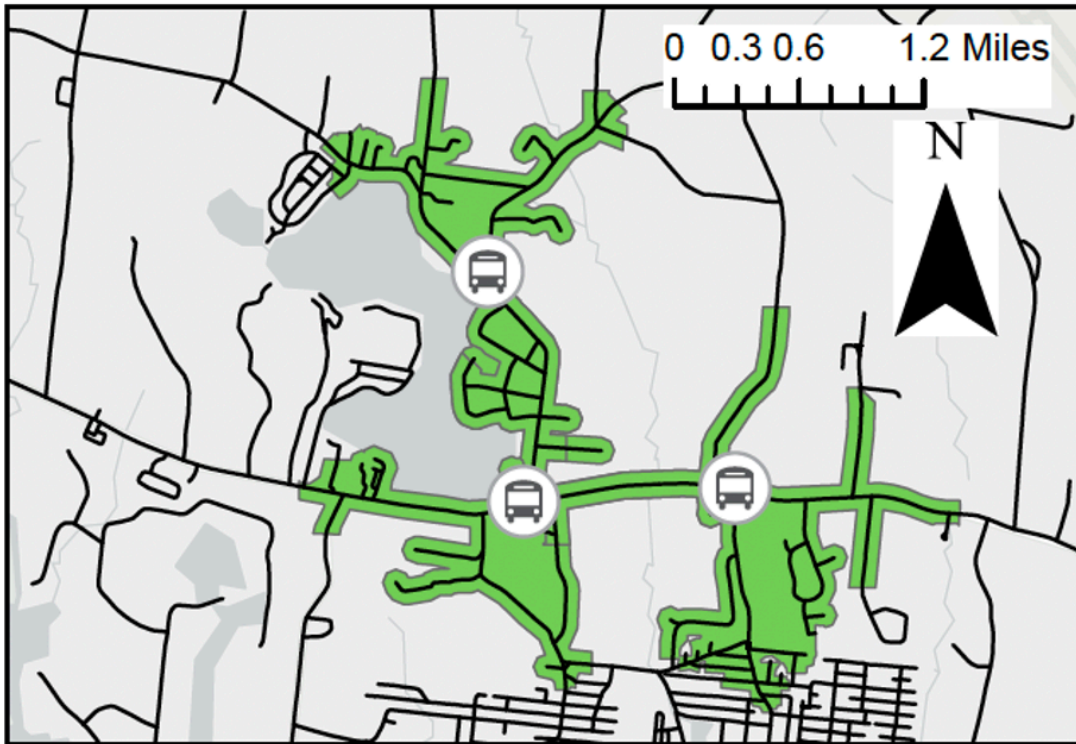


Figure 26: Map and legend showing the service areas of bus stops for the MOVE Sullivan network in the Town of Bethel.

Town of Mamakating

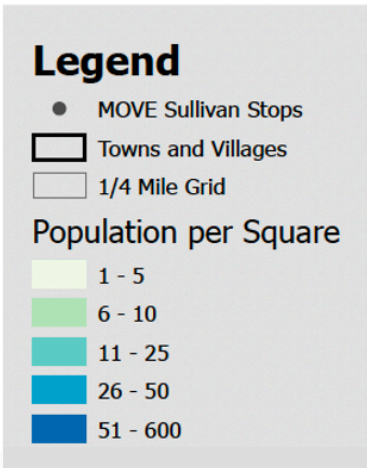
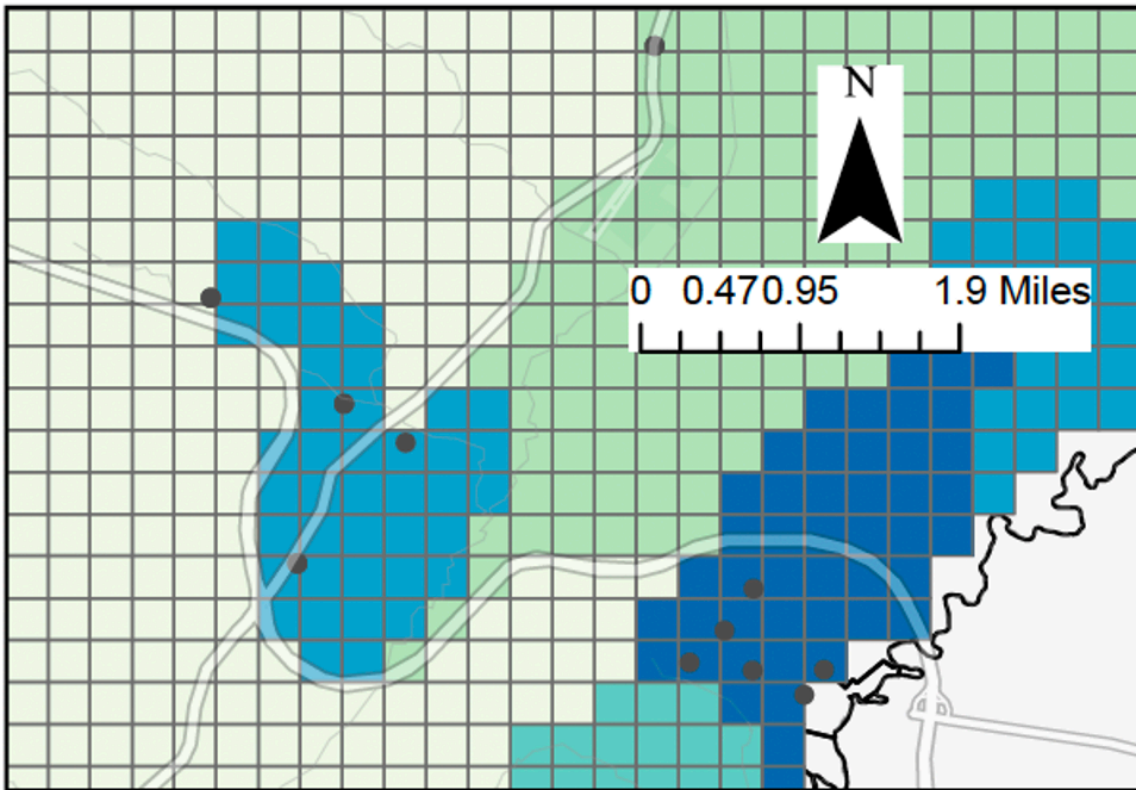


Figure 27: Map of the result of fishnet analysis for the Town of Mamakating using data from the 2020 US Census.

Town of Mamakating

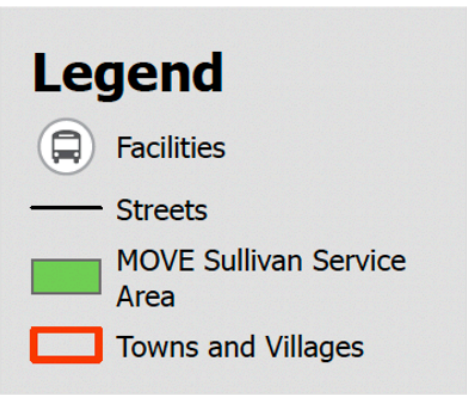
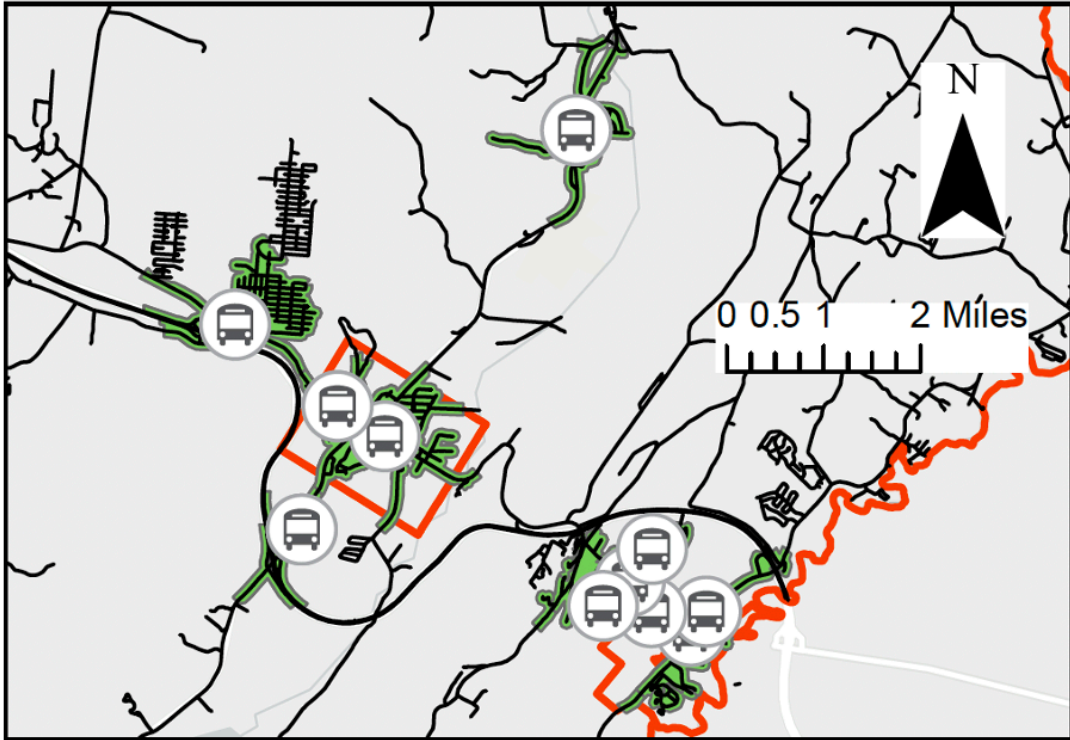


Figure 28: Map and legend showing the service areas of bus stops for the MOVE Sullivan network in the Town of Mamakating.

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