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IMPACTS OF SHARED USE PATHS

A study of the economic, health, transportation, environmental, safety, and accessibility impacts of four shared use paths in Massachusetts.

Acknowledgments

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EXECUTIVE SUMMARY

Shared use paths serve as vital parts of the regional transportation system, and the benefits of shared use paths are enjoyed by many people, businesses, communities, and organizations. MassTrails commissioned Kittelson & Associates, Inc. ("the project team") to explore, measure, and analyze the impacts of shared use paths in respect to health, social well-being, the environment, transportation, safety, and the economy. This project studied four shared use paths in Massachusetts. Key findings for this study are outlined in the following sections.

ECONOMIC

All four of the shared use paths studied were associated with increased spending in the community, which generated increased economic output into the community, jobs, and tax revenue. The team determined the economic impact to the communities based on path count data, intercept survey data, and an economic impact modeling tool, IMPLAN. The Cape Cod Rail Trail generated the greatest economic output mostly due to high volumes of bicycle tourism. The Minuteman Commuter Bikeway generated the second greatest economic output. Although spending per person on the Minuteman Commuter Bikeway was lower than the Mass Central Rail Trail (MCRT) - Norwottuck, the total economic output was higher due to a higher number of path users. The total number of jobs, the total economic output to the communities, and the total taxes generated (federal, state, and local) are presented in **Table 1**.

Table 1 Summary of Estimated Economic Impacts

	Minuteman	Northern Strand	MCRT-Norwottuck	Cape Cod
JOBS CREATED OR SUSTAINED	26	4	20	99
TOTAL ECONOMIC IMPACT	$2.6M	$378K	$1.8M	$9.2M
STATE/ LOCAL TAXES COLLECTED	$363K	$49K	$250K	$1.5M

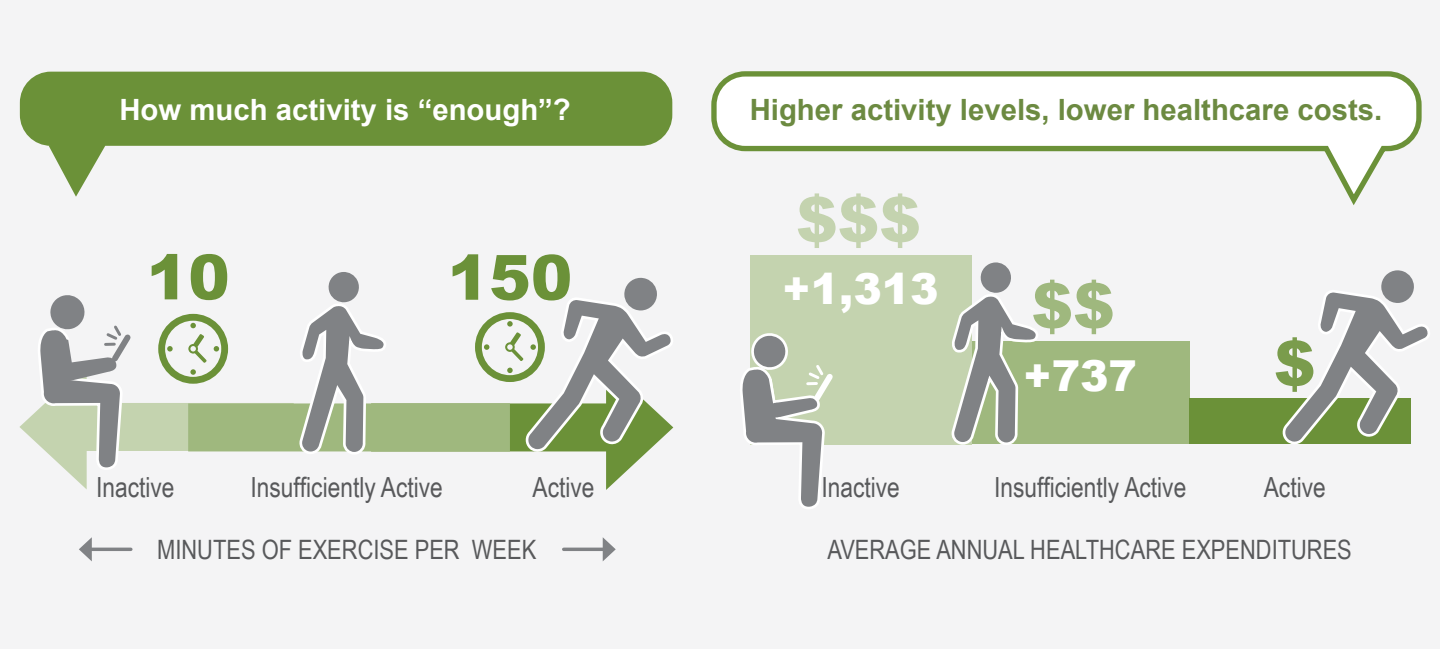
Numbers based on surveys from one city along each trail.

HEALTH

Individual health and well-being derive from a multitude of factors that are often complicated to quantify and analyze. The project team sought to measure physical activity and determine how the presence of shared use paths contribute to an individual's likelihood of exercising. This analysis aims to understand and measure health impacts of the four study paths within their communities and to determine how the increased physical activity impacts medical costs. The project team combined path count data, intercept survey data, physical activity, health guidelines, and healthcare expenditures provided by the Center for Disease Control and Prevention (CDC).

All four of the shared use paths had an impact on encouraging users to increase their levels of physical activity. As a result of increased physical activity, path users that have had a significant increase in their physical activity due to the path were estimated to save between $700 and $1,300 annually, based on their level of physical activity. Based on the survey results and the total path counts from July through October 2019, the four studied paths were estimated to save over $2.8 million dollars on annual health care expenditures. The Minuteman Commuter Bikeway contributed the most significant annual healthcare savings ($1.4 million), followed by the Northern Strand Community Trail ($660 thousand).

Figure 1 Recommended Levels of Physical Activity and Associated Reduced Healthcare Expenditures



Source: Centers for Disease Control and Prevention

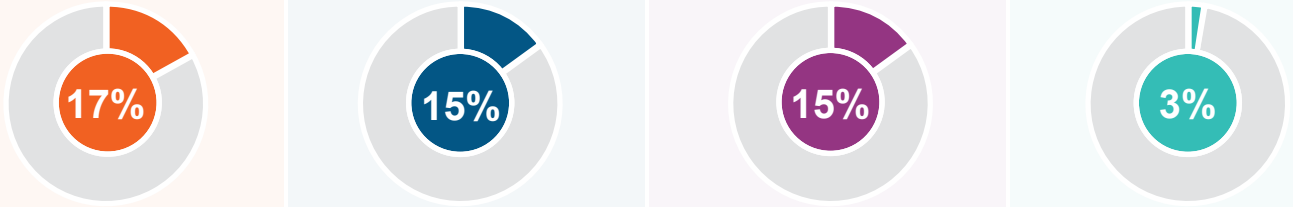
TRANSPORTATION

In addition to providing an outlet for exercising, the four shared use paths provide users with a safe and protected facility for traveling to and from destinations throughout Massachusetts. The project team utilized path count data, intercept survey data, geographic analysis, and Census commute behavior data. This section evaluated the direct impact shared use paths have on encouraging new active transportation commute trips. The evaluation determined the number of commuters that switched from commuting by vehicle to an active mode as a direct result of the path's presence.

All shared use paths contributed to a reduction in single occupancy vehicle trips and reduced single occupancy vehicle miles traveled (VMT). The Minuteman Commuter Bikeway had the most substantial impact on reducing vehicle trips and miles traveled. The Cape Cod Rail Trail attracted mostly recreational trips, whereas the Minuteman Commuter Bikeway, Northern Strand, and MCRT Norwottuck attracted larger numbers of commute trips. This reduction in VMT and in total vehicle trips ultimately reduces vehicular congestion and eliminates tons of greenhouse gases (GHG) and other noxious chemicals that would otherwise contribute to polluting the atmosphere.

Table 2 **Transportation Impact Summary**

An average of **13%** of total commuters in the path areas (half mile buffer) commute by active mode.



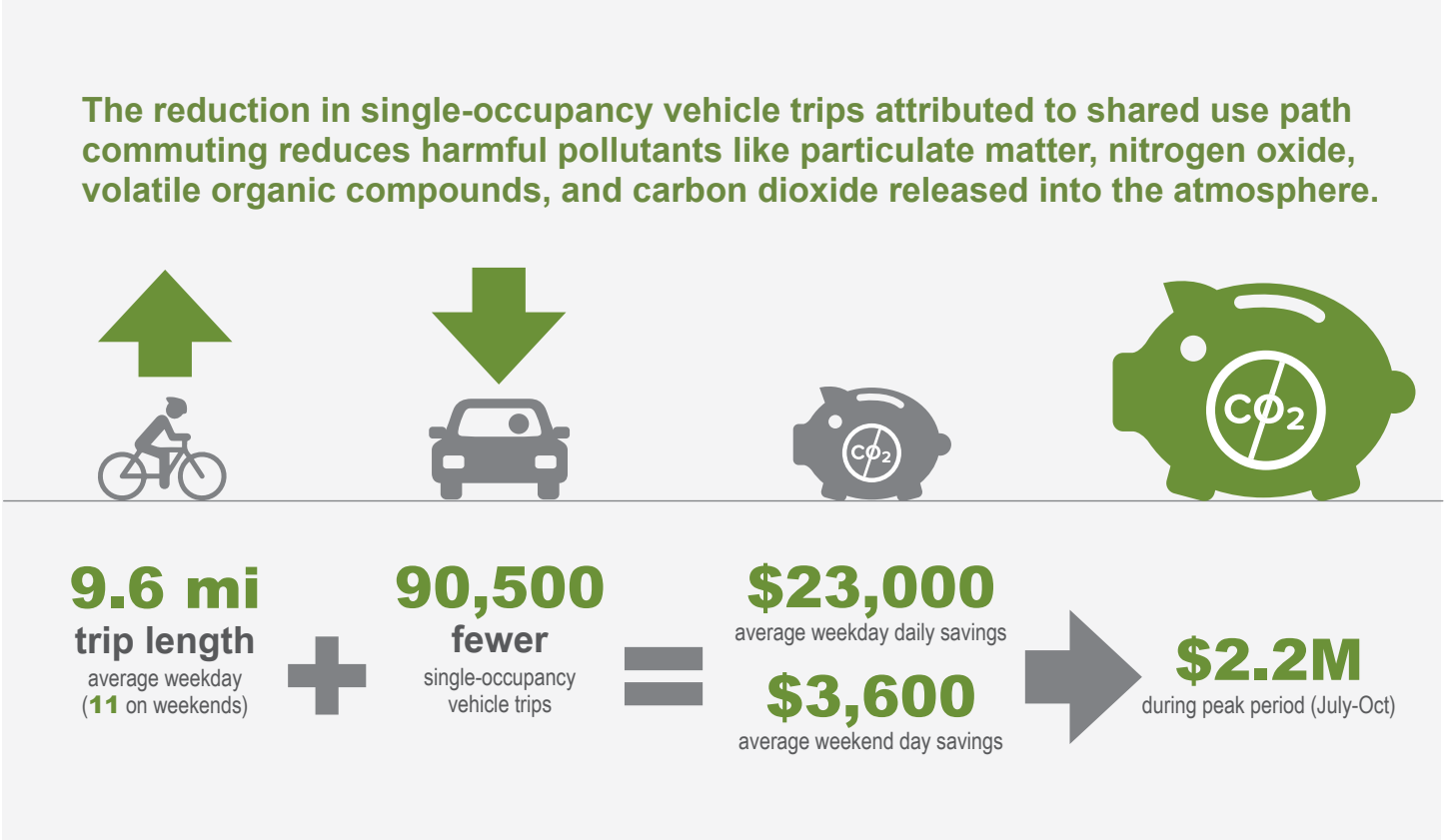
Minuteman Commuter Bikeway	Northern Strand Community Trail	MCRT-Norwottuck	Cape Cod Rail Trail
Path users substituted **90,509** one-way motor vehicle commuter trips with active transportation trips from July-October 2019.			
-50,291	**-18,054**	**-18,162**	**-4,002**
Which equates to **170,638** fewer vehicle miles traveled.			
-74,834	**-20,879**	**-59,420**	**-15,506**

ENVIRONMENT

Shared use paths may contribute many environmental impacts over their lifespan. These may include ecological impacts, natural habitat and biodiversity impacts, stormwater management impacts, and carbon sequestration, among others. This study focuses on environmental impacts by quantifying and evaluating the direct environmental impact of reduced vehicle trips and reduced vehicle miles traveled that result from commute trips on the shared use paths. The evaluation utilizes path count data, intercept survey data, and the Federal Highway Administration's Congestion Mitigation and Air Quality Improvement (CMAQ) Program tool, which assesses the impacts that reduced vehicle miles have on reducing greenhouse gas emissions and air pollution. The project team then quantified the economic impacts of reduced greenhouse gas emissions and air pollution.

The shared use paths contributed substantially to reducing commuter-based GHG emissions and air pollution. Based solely on path use from July to October 2019, reduced GHG emissions and air pollution translated to approximately $23,000 in cost savings on an average weekday and approximately $3,600 on a weekend day. From July - October, active commuters were estimated to contribute over $2 million dollars in environmental savings.

Figure 2 Environmental Impact Summary



SAFETY

The safety investigation included in this study contains two parts: an analysis of crash reduction due to separation of facilities for people walking, bicycling, and driving, as well as an analysis of the perception of general crime in the areas surrounding the shared use path.

By assuming that path users would otherwise be commuting on the adjacent roadways studied, the results of the crash analysis show that the reduction in vehicular trips resulting from people choosing to travel on the shared use paths results in a lower crash rate on the roadways directly adjacent to them.

In addition to reviewing crash impacts, the study evaluated perceived crime near the paths. Survey inquiry shows that generally speaking, pathway users perceive the presence of the shared use path in their community to not affect or reduce the amount of crime in their area.

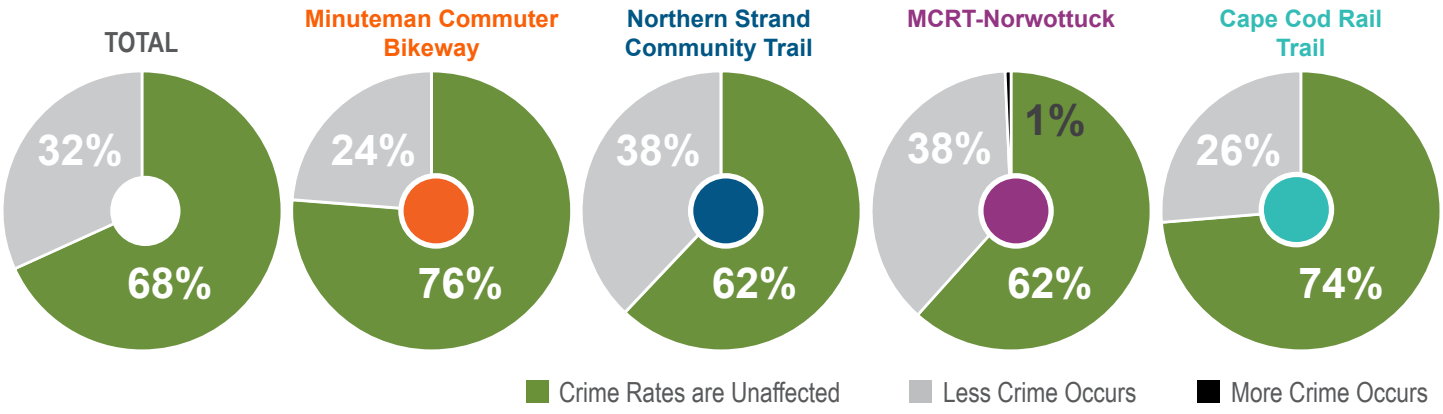
ACCESSIBILITY & EQUITY

Shared use paths play an important role in providing a safe, healthy, and accessible route for people to walk, roll, and bike for all trip purposes. Using geospatial analysis techniques, this investigation was performed to understand and quantify the types of destinations served by shared use paths, as well as the different groups of people who are able to access both the paths and the places they connect.

- **By walking 15 minutes**, about 4,100 people in minority groups, 2,200 people aged 65+, 3,700 people aged 19-, 1,600 people with a disability, 3,400 people experiencing poverty, 1,200 households without a car, and 1,000 households with limited English-speaking ability can access one of the studied shared use paths using sidewalks or very low speed and volume roadways.
- **By bicycling 15 minutes**, about 1,300 people in minority groups, 600 people aged 65+, 1,100 people aged 19-, 400 people with a disability, 900 people experiencing poverty, 400 households without access to a car and 400 households with limited English speaking ability can access one of the studied shared use paths using bicycle facilities or very low speed and volume roadways.
- **By walking 15 minutes** from the shared use path in their communities, people can access 8 libraries, 3 community health centers, 2 schools, 36 institutes of higher education, and 6 town halls.
- **By bicycling 15 minutes** from the shared use path in their communities, people can access 12 libraries, 10 community health centers, 3 schools, 75 institutes of higher education, and 9 town halls.

Figure 3 Summary of Path User Safety Perception

"Do you think the path has affected crime rates in the area?"



Conclusions

Shared use paths provide exercise and transportation opportunities for those bicycling, walking, scooting, skating, and using other active modes, on a facility separated from motor vehicles. These opportunities impact the path users and communities near the paths in a variety of ways. An increase in exercise opportunities provides physical health benefits, mental health and wellbeing benefits, in addition to reducing healthcare costs. Paths can also create transportation opportunities for active modes by connecting with other active transportation facilities and connecting to destinations like schools, workplaces, or transit. Pathway users who walk, bike, or roll instead of driving a vehicle reduce both vehicle miles traveled and subsequently, GHG emissions and crashes. Not only do reduced vehicle trips contribute to a reduction in GHG emissions and overall improvement in local and global environmental conditions, but they also reduce congestion, reduce air and noise pollution, enhance natural habitats and ecosystems, encourage healthy lifestyles, and generate revenue, benefitting the economy.

While this study focused on the peak usage period of July-October 2019 for the count and survey-based analyses, future studies may consider a full year of counts, which should be available through the permanent counters installed through this study. Future studies may also apply the same or a similar methodology as performed in this study to other paths to create a more comprehensive understanding of path impacts across the state of Massachusetts. Additionally, for the access and equity analysis, future studies may be able to access more refined datasets to understand where within block groups residential parcels exist, to have a more refined analysis of the number of people with access to the paths. Accurate residential parcel data with adequate detail to understand the number of residential units was not available for this study.

Adobe Stock

PROJECT OVERVIEW

Thousands of miles of shared use paths, also known as greenways, paths, or trails, intertwine throughout the state of Massachusetts. These paths are shared and enjoyed by locals and visitors pursuing a range of activities. Separated from vehicles, paths are protected facilities for people who bike, walk, and roll and are used for recreation, commuting, exercise, and local travel. Paths can vary in length and may be connected to other pedestrian and bicycle facilities and popular destinations, such as schools, parks, colleges, employment centers, and commercial areas[1].

A well-planned and designed network of paths can help achieve the goals outlined in the MassDOT Bicycle Plan and MassDOT Pedestrian Plan:

- **To eliminate pedestrian and bicyclist fatalities and serious injuries**
- **To increase the percentage of short trips made by walking and bicycling**

To better understand and quantify the impacts of shared use paths on communities in Massachusetts, MassDOT and the Mass Trails Team commissioned Kittelson & Associates, Inc. to conduct a review of other methodologies and shared use path research and determine an appropriate method for evaluating the impacts of shared use paths in the state of Massachusetts. The project team ultimately selected a representative sample of four shared use paths across the state. The results of this study may be used to inform future planning, funding, design, construction, and maintenance of paths.

As MassDOT continues to plan for and construct paths, it becomes increasingly important to understand the impacts these paths have on communities, the economy, homeowners, and businesses. Paths may benefit communities by encouraging active transportation, recreation, and outdoor activity, but until now, there were few studies that measured and traced their impacts in Massachusetts. Quantifying impacts and developing evaluation metrics will better equip shared use path and other active transportation projects to compete for transportation funding.

A literature review was conducted to review the methodology and findings of other jurisdictions in Massachusetts and across the country. The findings of the literature review can be found in Appendix A. Best practices informed the selection of the four representative paths as well as this study's methodology. The data collection process involved surveying path users, businesses, and property owners located near the paths, and collecting one year of continuous path usage data. The methodology incorporates the survey and path usage data to understand the impacts of paths in the following areas:

- **Economy**
- **Environment**
- **Health**
- **Safety**
- **Transportation**
- **Accessibility & Equity**

1 MassHighway Shared Use Paths and Greenways (2006).

PROJECT SCOPE/STUDY AREAS

Massachusetts has an extensive network of paths and trails, which renders the evaluation of each individual facility impractical. To focus the project scope, the project team selected four paths to evaluate in detail.

Path Selection

The selection criteria for the four trails focused on finding a balanced group of different types of paths based on geographic location, land uses, user characteristics, and connectivity. The project team brainstormed a list of paths in Massachusetts and determined study candidates based on the aforementioned criteria. The selected and studied paths are delineated in **Table 3**.

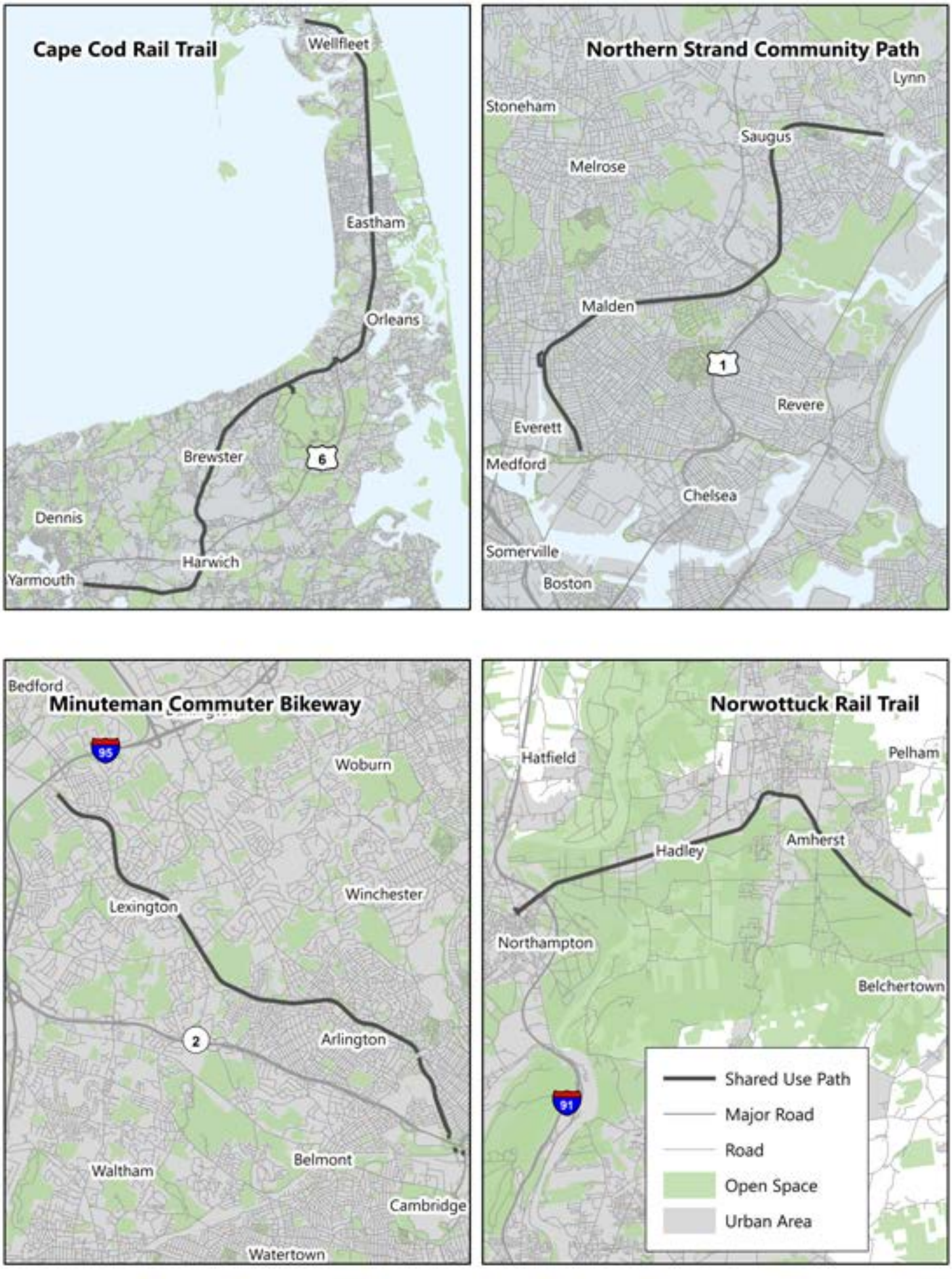
The selected paths are displayed in **Figure 4**. In the figure, 'Open Space' refers to both the Department of Conservation and Recreation's 1982 Landscape Inventory project report and the Bureau of Geographic Information's aggregated file that includes conservation land, recreation land, agricultural land, aquifer protection land, watershed protection land, forest land, town forests, parkways, and cemeteries. 'Urban Area' refers to the 2010 US Census Block Group aggregations that determined urbanized boundaries.

Table 3 Selected Study Paths

	GEOGRAPHY	STATE OR REGIONAL SIGNIFICANCE	USER TYPE	CONNECTIVITY	PREDOMINANT LAND USES
Minuteman Commuter Bikeway (Est. 1993[1])	Eastern Massachusetts: northwest of Boston	Well-established regional path that connects to rail/ train service and serves many commuter-based trips	Commuter and recreational 43% Daily Users 4% First Time Users	Connects to rail/ train service, regional recreation sites, other bike paths, restaurants and other local shops and destinations	Cities or Towns of Bedford, Lexington, Arlington, and Cambridge, outside of Boston
Northern Strand Community Trail (Est. 2012[2])	Eastern Massachusetts: north of Boston	Provides local connectivity within diverse areas of the greater Boston region	Commuter and recreational 14% Daily Users 2% First Time Users	Connects to bikeways and trails, residential areas, parks, commercial buildings, schools, and recreation facilities; future phases are expected to connect to the sea near Lynn Harbor	Cities or Towns of Everett, Malden, Revere, Saugus, and Lynn
Mass Central Rail Trail (MCRT) Norwottuck (Est. Early 1992[3])	Western Massachusetts	Well-established regional path that passes through various landscapes and provides local connectivity, including to the University of Massachusetts Amherst	Commuter and recreational 27% Daily Users 11% First Time Users	Connects to larger Mass Central Rail Trail Network, universities, recreational facilities	Traverses rural areas and connects the cities or towns of Northampton, Hadley, Amherst, Belchertown
Cape Cod Rail Trail (Est. 1978[4])	Southeastern Massachusetts: Cape Cod	Recently expanded regional path that serves mostly recreational trips and attracts tourism	Recreational 11% Daily Users 23% First Time Users	Connects parks, beaches, trails, and towns	Traverses though seven towns that experience high seasonal tourism, as well as indigenous landscapes and the Cape Cod National Seashore

1 MinutemanBikeway.org. Minuteman Commuter Bikeway America's Revolutionary Rail Trail. Accessed on May 18, 2020. http://minutemanbikeway.org/
2 Bike to the Sea. Accessed on May 18, 2020. https://biketothesea.org/about-us/
3 http://www.masspaths.org/bikeways/facguide/pioneerv.htm
4 Trail Link: Cape Cod Rail Trail. Accessed on May 18, 2020. https://www.traillink.com/trail/cape-cod-rail-trail/#trail-detail-about

Figure 4 Selected Paths



Path History & Community Details

MINUTEMAN COMMUTER BIKEWAY

Closely following the route that Paul Revere famously traversed in 1775, the Minuteman Commuter Bikeway was originally incorporated by the Lexington and West Cambridge Railroad in the mid-1860s for passenger rail service. The rail to trail conversion commenced in 1991, nearly 10 years after passenger and freight service along the line was discontinued in 1981. The path opened to the public the following year and has been heavily used for recreation and utilitarian trips since, spurring the addition of connecting paths and facilities in the community. This path was inducted into the national Rail-Trail Hall of Fame by the Rails-to-Trails Conservancy in 2008[2].

NORTHERN STRAND COMMUNITY TRAIL

Envisioned by the advocacy group Bike to the Sea in 1993, the Northern Strand Community Trail will be, upon its completion, a 12-mile shared use path connecting the Mystic River to the Lynn seashore. The first eight miles of the path have been constructed on the right-of-way of the former Saugus Branch Railroad, which ceased passenger operations in 1958. The remaining 1.5 miles of path will be an on-street facility, projected for completion in 2021. Once complete, the Northern Strand Community Trail will be a link in the 2,500-mile East Coast Greenway, which will span from Calais, Maine to Key West, Florida. Alternatively known as the Bike to Sea path, the Northern Strand Community Trail is the product of strong partnerships between the municipalities that host it, Bike to the Sea, Inc., The Lawrence & Lillian Solomon Foundation, the Massachusetts Executive Office of Environmental Affairs, the Massachusetts Department of Transportation, and the Massachusetts Bay Transportation Authority[3].

The communities of Everett, Revere, Saugus, Malden, and Lynn, which host the Northern Strand Community Trail, are north of Boston and are home to an ethnically and socioeconomically diverse population.

WELL-ESTABLISHED REGIONAL PATH

Minuteman Commuter Bikeway

- 10 miles in length
- Connects to rail/train service
- Fully paved surface
- Popular route often busy with users
- Many commuter-based trips
- Connects many origins and destinations

Photo by Ray Bernoff.

LOCAL PATH WITH REGIONAL EXTENSION IN PROGRESS

Northern Strand Community Trail

- 8-12 miles in length
- Mix of asphalt and stone
- Mostly local trips
- Connects to a larger network of bikeways and trails
- Connects five densely-populated urban communities totaling over 250,000 residents

Photo by Jeff Dietrich.

2 http://www.minutemanbikeway.org/Pages/HallofFame.html
3 https://en.wikipedia.org/wiki/Northern_Strand_Community_Trail

MASS CENTRAL RAIL TRAIL (MCRT) - NORWOTTUCK

As an 11-mile stretch of the proposed 104-mile Massachusetts Central Rail Trail (MCRT), the Norwottuck Branch is open year-round for hiking, bicycling, walking, roller-blading, and cross-country skiing. The Norwottuck Branch, purportedly named for the Native American tribe that once occupied the land, stretches from Northampton to Belchertown and is owned by the Massachusetts Department of Conservation and Recreation. Originally a passenger and freight rail line called the Central Massachusetts Railroad, the right-of-way for the Norwottuck Branch first opened in 1887 and was leased by the Boston and Maine Railroad Company. Passenger service ended in 1932, and freight service in 1974. The right-of-way was purchased by the State of Massachusetts in 1985, and the path opened in the early 1990s[4].

Since the Norwottuck Branch's recreation in the 1990s, there have been numerous efforts to connect the path with other multi-use trails in the surrounding area, such as the Northampton Bikeway, the Manahan Rail Trail, the Canalside Rail Trail, and the trails in the Connecticut River Greenway State Park. These efforts have been met with steady incremental success.

CAPE COD RAIL TRAIL

Prior to its life as a regional shared use path, the Cape Cod Rail Trail (CCRT) was an active railway. It provided freight service from the mid-1860s onwards and opened as a passenger rail line operated by New Haven Rail throughout the earlier part of the 20th century. Following the dismantling of service and a voter-approved eminent domain acquisition in the mid-1960s, the path opened for recreational use in September 1981[5]. Now the CCRT, one of many shared use paths along the Massachusetts Peninsula, is an important regional recreational asset in its community. In the nearly four decades since its inception, the CCRT has expanded from its original seven mile stretch to approximately 25 miles of paved surface for walking, bicycling, and rolling, with an additional 16 miles through connections with the Old Colony Rail Trail, the Yarmouth Trail, and trails within Nickerson State Park[6].

4 https://www.masscentralrailtrail.org/copy-of-the-big-picture

5 https://www.capecod.com/lifestyle/the-beginning-of-the-cape-cod-rail-trail/#:~:text=The%20Cape%20Cod%20Rail%20Trail%20follows%20an%20old%20railroad%20right,this%20point%20things%20get%20complicated.

6 https://www.mass.gov/locations/cape-cod-rail-trail

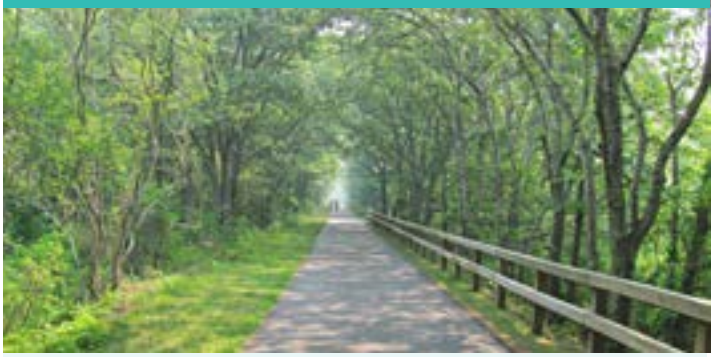
WELL-ESTABLISHED REGIONAL PATH

MCRT-Norwottuck

- 11 miles in length
- Fully paved surface
- Passes through various landscapes (rural farmland, residential neighborhoods, university campus)
- River and waterway overpass bridges
- Surrounded by nature (marshland, pine forests, corn fields)
- Connects to Town Centers

Photo by John Phelan - Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=9875755

RECENTLY EXPANDED REGIONAL PATH



Cape Cod Rail Trail

- 26 miles in length
- Fully paved surface
- Mostly recreational trips
- Connects to beach access and other bicycle routes
- Attracts tourism

By John Phelan - Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=10567938

METHODOLOGY AND RESULTS

The project team completed a comprehensive evaluation to understand and quantify the impacts of paths. The methodology aimed to deliver an accurate and replicable evaluation that accounts for the variations in path characteristics, user behavior, seasonal patterns, and other variables. The methodology outlined in the following section combines the best practices of path research from across the country with methods and applications tailored to the specific context of Massachusetts. The methodology is divided into two parts: data collection, which includes surveys, and data evaluation.

Data Collection

After selecting the analysis methodology, the team determined what data were needed for each analysis. Path user counts and intercept surveys were determined necessary for the study.

PATH COUNTS: METHODOLOGY

In June 2019, the team installed four automatic permanent bicycle and pedestrian counters on the study paths. The four counters are part of a pilot program to adopt permanent count stations for trails throughout the state. MassDOT regularly collects motor vehicle traffic counts on their roadways, but until now, bicycle and pedestrian counts have only been collected on a short-term basis through manual or temporary automatic counters.

Collecting volume data is imperative to understanding when infrastructure is being used, how many people are using it, and what modes they employ. These data were collected specifically to support the shared use path impacts study but may also be used in the future to foster a long-term understanding of path use.

PATH COUNTS: EVALUATION

The counter data showed that the Minuteman Commuter Bikeway had the highest number of total peak period path users as well as the highest average weekend and weekend day users, as shown in **Figure 5**.

Figure 5 Counts User Statistics

	Minuteman Commuter Bikeway	Northern Strand Community Trail	MCRT-Norwottuck	Cape Cod Rail Trail
AVG. WEEKEND DAY	3,023	735	1,397	1,330
AVG. WEEKDAY	2,466	776	887	885
BUSIEST DAY DURING PEAK PERIOD	4,305 July 7	1,161 October 19	2,315 August 11	2,751 September 1
TOTAL COUNTS	322,241	94,017	126,382	124,018

SURVEYS

The project team administered paper intercept surveys to users on each path near the location of the permanent path counters. Additionally, project team left paper surveys in mailboxes at homes within approximately a quarter mile of the paths. Project team administered business owner surveys by locating businesses near the paths and delivering paper copies to each business. A link to an online survey was also provided to path users, home occupants, and business owners. Online survey outreach was limited.

The team employed these intercept surveys to augment the data collected by the counters to collect more detailed information from path users, residents, and business owners. The survey questionnaires were developed to help answer the question, "How do paths impact communities?" The project team developed and administered online and paper surveys to collect data from a sample of users on each path. Separate surveys were created for nearby home occupants and business owners near the paths.

- The user surveys were designed to yield direct insight into user expenditures, path use, perceptions of the path, demographics, physical activity, and other inputs that help determine impacts. The home occupant surveys collected information on occupant demographics, approximate home distance from the paths, perception of property values, perception of crime, propensity to use the trail, correlated expenditures, and estimated path usage. The business owners survey included questions related to the location of businesses, type of business, proximity to the paths, and estimated revenue attributed directly to path users.

The first step in creating the survey questionnaire was to develop the methodology for studying the impacts of paths and determine the key inputs needed from the intercept surveys. Once these inputs were identified, the survey questionnaires were crafted to inform the analysis. The survey forms are provided in Appendix B.

The path user, home occupant, and business owner surveys were administered during the a.m. and p.m. peaks on a weekday (September 24, 2018) and midday on a weekend day (September 22, 2018). An additional round of path user paper surveys were collected on the Cape Cod Rail Trail on September 19 and 20, 2019 to supplement the previously collected data. July through October is considered the peak of path usage, due to summer schedules and climate. **Table 4** displays total survey responses collected and during several time periods in 2018 and 2019, as well as counts from July through October 2019.

Table 4 Path User Survey Responses and Path Counts

	NUMBER OF SURVEYS		DAILY COUNTS DURING SURVEY	
	WEEKEND (9/22/18)	WEEKDAY (9/24/18)	WEEKEND DAY (9/22/19)	WEEKDAY (9/24/19)
Minuteman Commuter Bikeway	54	54	3,328	2,925
Northern Strand Community Trail	28	12	772	896
MCRT-Norwottuck	115	68	1,625	831
Cape Cod Rail Trail[1]	32	84	845	309
Total	229	218	12,368	9,026

1 Cape Code Weekday Survey Sample data includes additional data collection completed on September 19th and 20th, 2019.

Although the survey data collection process involved both in-person and online surveys for path users, home occupants, and business owners, the project team chose to conduct the evaluation using survey results collected solely from paper surveys. The online surveys were not widely distributed by the project team and instead were voluntarily advertised by organizations that found an interest in the project purpose. The project team sought to survey an unbiased, representative sample of daily path users and deemed the online responses skewed in favor of promoting the paths. Because the online responses almost exclusively represented Friends of the Trail groups, they were not included in continued analysis. The intercept paper surveys were deemed a more representative and unbiased sample. **Table 5** shows the distribution of responses collected from path users, home occupants, and business owners.

Response rates were low for home occupants and businesses within approximately 0.25 mile of the path. Home occupant response rates were less than 15%, and business owner response rates were lower, less than 10%. Some business owners and homeowners reported being wary of reporting expenditures and revenue information, thus limiting response rates. As a result, home occupant and business owner responses were not ultimately used to evaluate path impacts.

PATH USER DEMOGRAPHICS

The survey included basic questions about user demographics, to help the project team gain perspective on user profiles for each of the four paths. **Table 6** and **Figure 6** summarize user demographics for each path.

Table 5 Survey Responses from Path Users, Home Occupants, and Business Owners

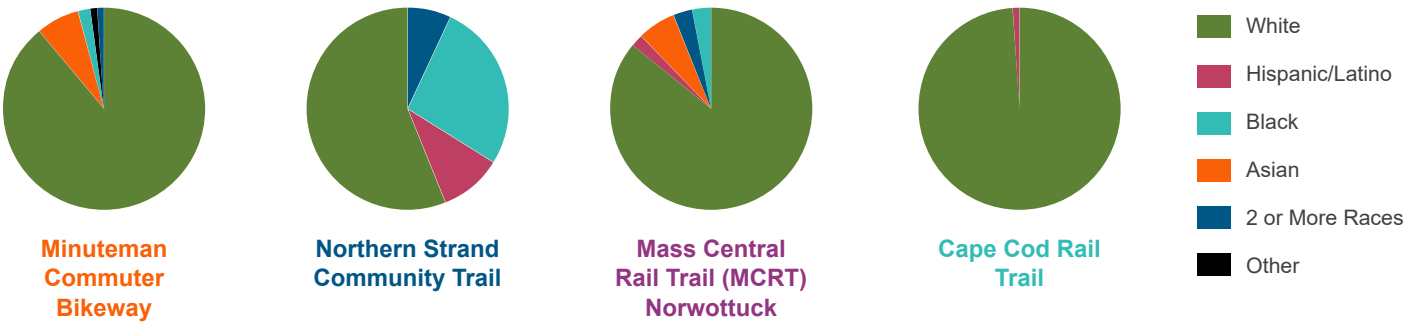
	INTERCEPTED PATH USERS	HOMEOWNERS	BUSINESS OWNERS
Minuteman Commuter Bikeway	108	10	3
Northern Strand Community Trail	40	17	7
MCRT-Norwottuck	183	8	4
Cape Cod Rail Trail	116	0	9
Total	477	35	23

Table 6 Path User Demographics

	AVERAGE HOUSEHOLD INCOME	AVERAGE AGE*	EDUCATION: % WITH SOME COLLEGE EDUCATION	AVERAGE TIME SPENT ON PATH (MINUTES)
Minuteman Commuter Bikeway	$134,286	44	93%	61
Northern Strand Community Trail	$103,278	39	69%	75
Mass Central Rail Trail (MCRT) Norwottuck	$83,268	42	89%	96
Cape Cod Rail Trail	$118,000	57	89%	155

* Age of survey respondent

Figure 6 Path User Demographics: Race



SURVEY FINDINGS

As previously noted, the survey questionnaire was developed to help answer the question, “How do paths impact communities?” Each question was targeted to provide more information on how paths impact the environment, transportation patterns, social behaviors, expenditures, and user health. A spreadsheet analysis was used to assess survey respondent information, including travel modes, frequency of path usage, and user activity.

Figure 7 details the transportation modes path users used to access the paths. Most users access the path by bicycle or on foot. **Figure 8** shows the results from asking users how often they visit the paths. The Minuteman Commuter Bikeway and Northern Strand Community Trail show the highest percentage of daily path usage, confirming the commuter-based nature of these trails. The Cape Cod Rail Trail shows the highest percentage of first-time users, reflecting the trail’s predominately recreational nature.

Figure 9 shows transportation mode distribution on each of the paths. People who bike and walk make up the majority of path users. Other users include people on skateboards, people jogging, people with rollerblades, and people on mobility scooters. The data from **Figure 9**, combined with user reported total time spent on the path and the weekly frequency of path were used to determine the health, transportation, and environmental impacts per user. A summary of these expenditures is displayed in **Figure 10.** The evaluation methodology is detailed in the next section.

Figure 7 Path User Travel Mode to the Paths

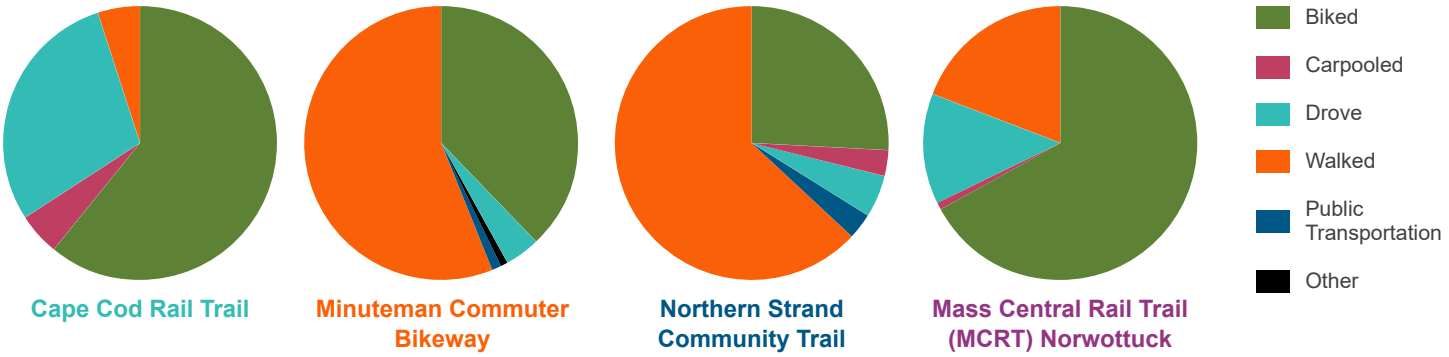


Figure 8 Path User Frequency of Path Use

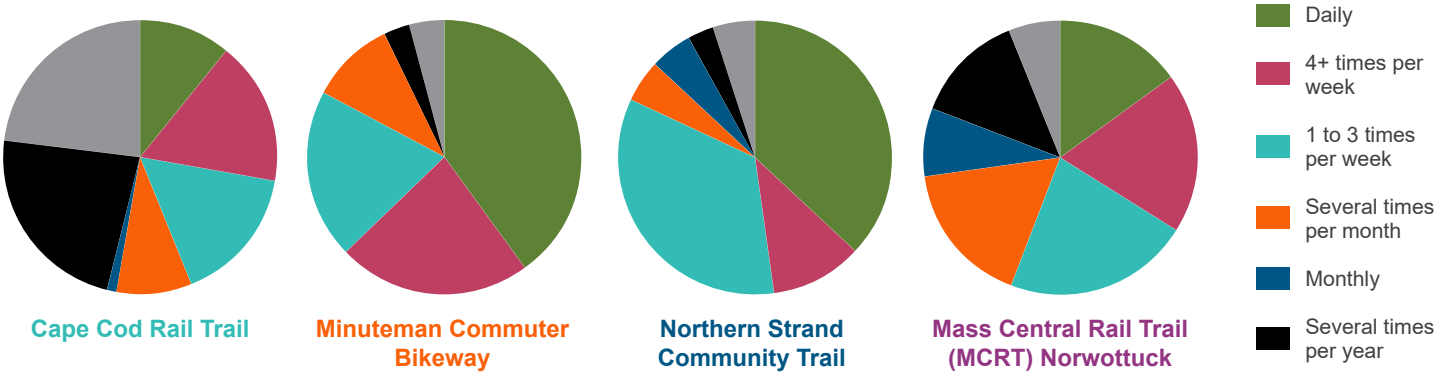
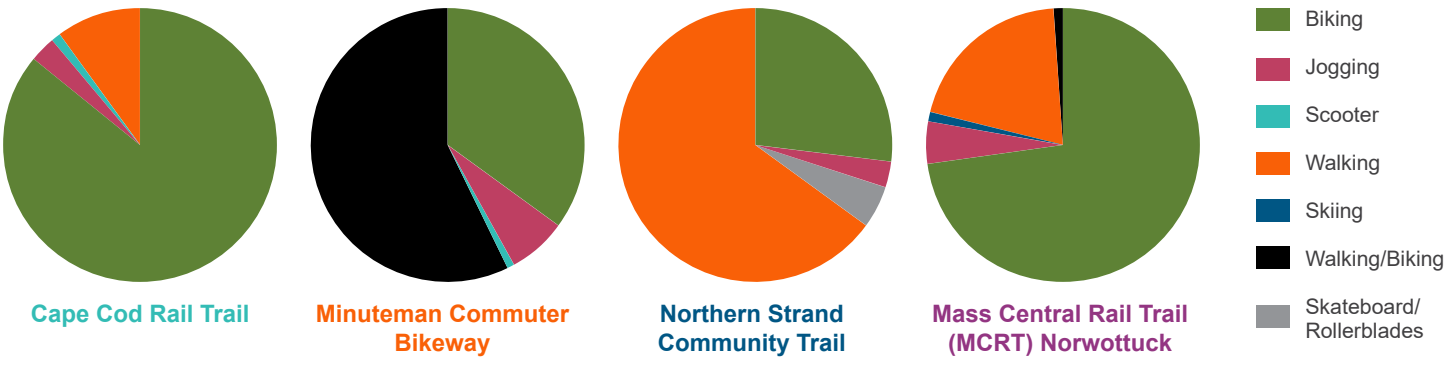


Figure 9 Path User Activity on Paths



Analysis and Assumptions

The data collected from the path counts and surveys were combined with the evaluation methodology to understand and quantify the impacts of paths on their surrounding communities. The project team developed the methodology by combining best practices from other jurisdictions throughout the country. The impact areas are categorized into six sections: economy, health, transportation, environment, safety, and accessibility & equity.

The evaluation extrapolates path user behavior from the 477 path user survey responses. Given the project's broad scope, there are limitations for each area of analysis. The following sections will summarize the limitations and assumptions made during the evaluation. **Table 7** summarizes the data and evaluation methods used for each area of path impact.

Table 7 Summary Evaluation of Shared Use Path Impacts

IMPACT AREA	IMPACT SUBAREA	DATA	EVALUATION METHOD
Economy	User Expenditures, Business, Employment, and Tax Revenue	Path User Survey • Categorical per person spending during path visit (restaurants, fuel, retail/rental, lodging, other) • Total path user counts	IMPLAN Spreadsheet analysis
	Property Values	MassGIS Interactive Property Map	Geographic analysis Statistical analysis
Health	Medical Costs	Path User Survey • Mode of travel • Frequency of path use • Duration spent on path • Propensity for exercising Estimated Annual Healthcare Costs (compared to active adults)[1] • $1,313 inactive adults • $576 insufficiently active adults	Spreadsheet analysis
	Chronic Illnesses	Massachusetts Risk Factor Surveillance System	Research comparisons between nationwide, statewide, and countywide chronic disease rates
	Quality of Life	US Census Data Path User Survey • Written comments • Commute behavior • Total commute distance traveled Victoria Transport Policy Institute's value per non-motorized mile: $0.26[2]	Geographic analysis Spreadsheet analysis

1 Carlson, Susan A., et al. "Inadequate Physical Activity and Health Care Expenditures in the United States." Progress in Cardiovascular Diseases, vol. 57, no. 4, 2015, pp. 315-323., doi:10.1016/j.pcad.2014.08.002.
2 Evaluating Active Transport Benefits and Costs. Victoria Transport Policy Institute (2020).

IMPACT AREA	IMPACT SUBAREA	DATA	EVALUATION METHOD
Transportation	Active Transportation and Congestion Impacts	US Census Data • Percentage of single occupancy vehicle commuters Path User Survey • Commute behavior • Total time spent commuting • Transportation mode to the path • Mode choice TIGER Benefit Cost Analysis (BCA) Resource Guide's congestion cost per vehicle mile[3] American Community Survey • Journey to Work	Geographic analysis Spreadsheet analysis
Environment	Air Quality	Path User Survey • Commute behavior • Mode choice	Congestion Mitigation and Air Quality Improvement Program (CMAQ) Spreadsheet analysis Spreadsheet analysis
	Carbon Emissions	Path User Survey • Commute behavior • Total commute distance traveled Social cost of carbon	TIGER Benefit-Cost Analysis Resource Guide: Value of Emissions
Safety	Crime	Path User Survey • Perceived crime	Spreadsheet analysis
	Crash Rates	TIGER Benefit Cost Analysis cost of crash by severity Path User Survey • Commute behavior • Total commute distance traveled Average Daily Traffic Volumes Roadway Classifications	Highway Safety Manual Spreadsheet analysis Geographic analysis
Social Justice	Access and Equity	GIS Data • Sidewalk and bicycle facilities surrounding paths • Essential destinations Walk- and bike-sheds American Community Survey • Demographic data	Geographic analysis Network analysis

3 TIGER Benefit-Cost Analysis (BCA) Resource Guide. U.S. Department of Transportation (2015).

Economy

The economic impacts of paths can be widespread. The methodology for analyzing and quantifying these impacts includes using the economic modeling software, IMPLAN, path counts, and intercept surveys. The methodologies outlined in this section focus on quantifying the economic impacts of property values, business revenue, employment trends, and tax revenue. **Figure 10** summarizes the estimated economic impacts and **Table 8** summarizes the data and evaluation method used. Information is provided in more detail below for each impact subarea.

USER EXPENDITURES

Quantifying the economic impacts of path user spending formed the basis of the economic evaluation. **Figure 11** displays the survey question that targeted the user expenditure while using the path. Path user expenditures primarily fall under the categories shown in Question 10 (**Figure 11**), including restaurants, fuel, retail stores, lodging, museums, parks, and zoos. The team also provided an option to fill in spending not related to the listed categories with an option of "Other." The survey question displayed in **Figure 12** was used to calculate total group expenditures on a per person basis.

Figure 11 Question #10 from Path User Survey

10. We are trying to assess the path's local economic impact. As a result of your trip today, how much money are you and your dependents/others in your group each spending on :

- ☐ $_____ Restaurants
- ☐ $_____ Fuel
- ☐ $_____ Retail stores (rentals)
- ☐ $_____ Lodging
- ☐ $_____ Museums, Parks, Zoos
- ☐ $_____ Other

Figure 12 Question #7 from Path User Survey

7. Indicate the number of your dependents on the path or others on the path with you who are not taking this survey that fit into the following age groups. Do not include yourself:

- ☐ 0-12_____
- ☐ 13-18_____
- ☐ 19-30_____
- ☐ 31-50_____
- ☐ 51 +_____

Figure 10 Path Expenditures

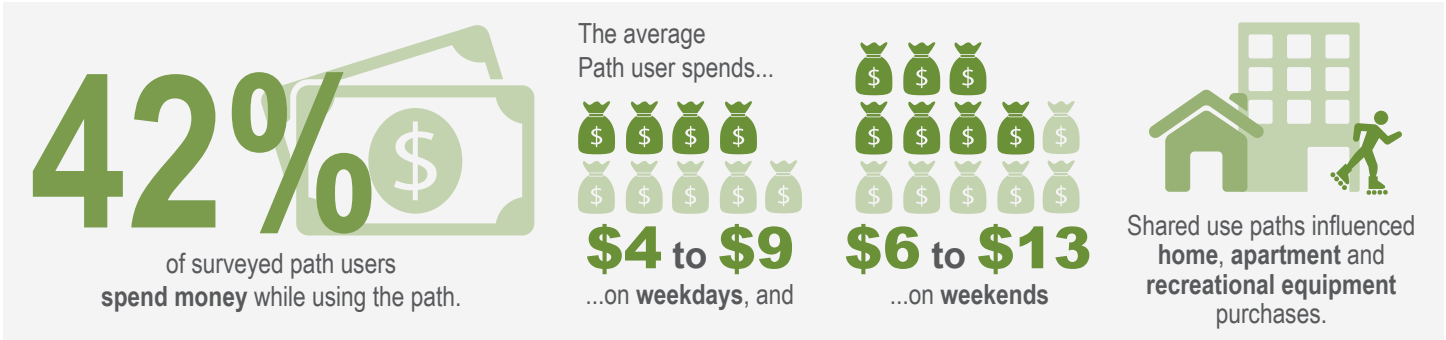


Table 8 Economic Impact Evaluation Summary

IMPACT AREA	IMPACT SUBAREA	DATA	EVALUATION METHOD
Economy	User Expenditures, Business, Employment, and Tax Revenue	Path User Survey • Categorical per person spending during path visit (restaurants, fuel, retail/rental, lodging, other) • Total path user counts	IMPLAN Spreadsheet analysis
	Property Values	• MassGIS Interactive Property Map	Geographic analysis Statistical analysis

First, the project team determined per person spending for each category as a direct result of using the path. In instances where groups or families were using the path together, one person from each group was directed to complete the survey. To determine the spending per person, each expenditure category (restaurants, fuel, retail stores, etc.) was divided by the total number of people in each reported group. For instance, if a family of four completed the survey together as one entry and reported spending $100 that day at restaurants, the per person expenditure for restaurants was calculated as $25. The project team calculated per person expenditures for each survey response entry and for each expenditure category, as well as total expenditures.

The project team also manually corrected some data provided in the expenditure analysis ensure consistency. The following outlines recurring items for which the team made corrections:

- **HOME OWNERSHIP** Several survey respondents indicated that they purchased their home in the area because the path was nearby and included the cost of their home purchases ($400,000+) in their answers. Although the paths may have influenced their purchase of a home nearby, this expenditure analysis was focused on the amount of economic activity created in the community per trip and the team determined that including home prices would affect the data and potentially misrepresent the amount of spending per trip. This analysis focused on daily per person spending while visiting the path at the time the survey was administered. It is unlikely that survey respondents purchased homes at the time of the survey.
- **VISITOR LODGING** Several survey respondents who indicated that they were visiting the area and spending on lodging near the paths reported their expenditures for their entire stay. These responses inaccurately inflated the total daily expenditures. To remedy this inconsistency, all survey responses indicating lodge expenditures were evaluated to estimate the length of their stay. The evaluation assumed average nightly lodging costs to be approximately $200 per night based on a rounded average of the cost of lodging options in the area during the time the team administered the surveys. Then, the total reported lodging expenditures were divided by the assumed $200 to determine the estimated number of nights visited by the survey respondent.
    - For example, one survey entry recorded traveling alone and spending $750 on lodging. This $750 is assumed to be the total lodging costs for the duration of the visit. To determine the nightly lodging expenditures, the reported $750 was divided by $200 to yield 3.75, then rounded up to four. The total lodging expenditure ($750) was then divided by the assumed trip duration (four days) to determine the daily lodging expenditure of $187.50. This number was then divided by the number of people in the group.
- **UNRELATED ‘OTHER’ EXPENDITURES** Several survey respondents indicated spending on ‘Other’ expenditures. If those expenditures were not considered local spending (example: airfare), the project team did not include the expenditures in the evaluation.

Following the cleaning and organizing of the intercept survey results, the project team calculated average per person expenditures for each category for both weekday (**Table 9**) and weekend day (**Table 10**) path use. The average per person expenditures calculated from the survey results were then extrapolated to quantify total path user expenditures. The project team applied the survey user behavior with total peak path usage (July-October 2019) collected from the path counters. **Table 11** displays the average path counts by weekday and weekend day, while the total peak path usage collected from the path counters are delineated in **Table 12**.

After calculating the per person expenditures from the survey responses and reviewing the total path user counts collected, the project team multiplied the daily path counter data by the daily per person expenditures to determine assumed overall expenditures. By combining the path count data with the path user survey data, the project team extrapolated the total direct expenditures as a result of path use during the peak months of July-October 2019. **Table 13** displays the estimated total monthly expenditures during the peak path usage period, July to October.

Table 9 Weekday Average Per Person Expenditures from Survey Responses

	RESTAURANTS	FUEL	RETAIL/ RENTAL	LODGING	MUSEUMS, PARKS, ZOOS	OTHER	TOTAL
Minuteman Commuter Bikeway	$2	$1	$3	$0	$0	$0	$6
Northern Strand Community Trail	$0	$0	$0	$0	$0	$0	$1
MCRT-Norwottuck	$5	$2	$0	$2	$0	$2	$11
Cape Cod Rail Trail	$16	$3	$8	$19	$1	$2	$49

Table 10 Weekend Day Average Per Person Expenditures from Survey Responses

	RESTAURANTS	FUEL	RETAIL/ RENTAL	LODGING	MUSEUMS, PARKS, ZOOS	OTHER	TOTAL
Minuteman Commuter Bikeway	$7	$0	$1	$0	$0	$2	$10
Northern Strand Community Trail	$4	$0	$3	$0	$0	$4	$10
MCRT-Norwottuck	$7	$1	$5	$0	$0	$1	$14
Cape Cod Rail Trail	$23	$3	$4	$25	$0	$0	$55

Per the analysis, the combined total spending for the four trails from July through October 2019 is estimated to be approximately $10,606,000. The majority of this spending occurred along the Cape Cod Rail Trail at $6,350,000. The Cape Cod Rail Trail had the highest number of visitors and is known to attract bicycle tourism.

Although the MCRT-Norwottuck has the second highest amount spent per person, the Minuteman Commuter Bikeway saw the second most total spending, at $2,388,000 during the four-month period, due to higher trail usage. No respondents on the Minuteman Commuter Bikeway or Northern Strand Community Trail included lodging in their listed costs, which aligns with the predominately local, commuter-based nature of the path.

Table 11 Average Daily Path Counts

	WEEKDAY TOTAL	WEEKEND DAY TOTAL
Minuteman Commuter Bikeway	2,466	3,023
Northern Strand Community Trail	776	735
MCRT-Norwottuck	887	1,397
Cape Cod Rail Trail	885	1,330

Table 12 Path Counter Total Peak Usage (July-October 2019) by Path

	WEEKDAY TOTAL	WEEKEND DAY TOTAL
Minuteman Commuter Bikeway	219,450	102,791
Northern Strand Community Trail	69,044	24,973
MCRT-Norwottuck	78,900	47,482
Cape Cod Rail Trail	78,808	45,210
Total	446,202	220,456

Table 13 Calculated Monthly Expenditures from Trail Survey Users by Category: Total (July-October)

	RESTAURANTS	FUEL	RETAIL/ RENTAL	LODGING	MUSEUMS, PARKS, ZOOS	OTHER	TOTAL
Minuteman Commuter Bikeway	$1,247,000	$290,000	$664,000	$0	$0	$187,000	$2,388,000
Northern Strand Community Trail	$94,000	$14,000	$62,000	$0	$29,000	$119,000	$318,000
MCRT-Norwottuck	$706,000	$169,000	$306,000	$127,000	$0	$242,000	$1,549,000
Cape Cod Rail Trail	$2,341,000	$359,000	$808,000	$2,614,000	$47,000	$181,000	$6,350,000

BUSINESS, EMPLOYMENT, AND TAX REVENUE

In addition to understanding expenditures associated with path usage, the team evaluated the employment and tax impacts of the paths. For these evaluations, the project team used the economic modeling software IMPLAN. IMPLAN is an input-output economic model, which tracks the effect of an input on a system based on the interdependencies of economic sectors. For this analysis, the project team input the monthly expenditures for each spending category for each path and the location of each path. IMPLAN then tracked the expected direct, indirect, and induced economic impacts of each path. These are defined as follows:

- **Direct economic impacts:** the direct amount spent at a business (primary business) as a result of using the path
- **Indirect economic impacts:** the impact to businesses (secondary businesses) that supply goods to the primary business
- **Induced economic impacts:** The impact due to spending by those working at primary and secondary businesses

The combination of these three forms of economic impacts creates the economic output for each path, which are delineated in **Table 14**.

The total economic output of the paths is over $13 million for the July-October 2019 period. This economic activity generates and sustains jobs in the communities near the paths. The amount of employment created and sustained includes full-time, part-time, and temporary positions and is outlined in **Table 15** below, and the associated labor income is outlined in **Table 16**.

Table 14 Economic Output for Each Trail, July-October 2019

OUTPUT	JULY	AUGUST	SEPTEMBER	OCTOBER	TOTAL
Minuteman Commuter Bikeway	$616,000	$738,000	$769,000	$510,000	$2,633,000
Northern Strand Community Trail	$114,000	$99,000	$92,000	$63,000	$367,000
MCRT-Norwottuck	$480,000	$546,000	$442,000	$273,000	$1,742,000
Cape Cod Rail Trail	3,262,000	3,837,000	1,629,000	$496,000	$9,224,000

Table 15 Employment Created and Sustained by Each Trail, July-October 2019

EMPLOYMENT	JULY	AUGUST	SEPTEMBER	OCTOBER	TOTAL
Minuteman Commuter Bikeway	6	7	8	5	26
Northern Strand Community Trail	1	1	1	1	4
MCRT-Norwottuck	5	6	5	3	20
Cape Cod Rail Trail	35	41	17	5	99

Table 16 Labor Income Associated with Each Trail, July-October 2019

LABOR INCOME	JULY	AUGUST	SEPTEMBER	OCTOBER	TOTAL
Minuteman Commuter Bikeway	$257,000	$307,000	$320,000	$212,000	$1,096,000
Northern Strand Community Trail	$48,000	$41,000	$38,000	$26,000	$153,000
MCRT-Norwottuck	$191,000	$218,000	$177,000	$110,000	$695,000
Cape Cod Rail Trail	$1,395,000	$1,641,000	$697,000	$213,000	$3,946,000

Together, the paths sustain approximately 140 jobs across their local areas and have generated over $5.5 million in labor income. Most of the jobs sustained by economic activity due to the Cape Cod Rail Trail and MCRT-Norwottuck were in the accommodation and restaurant service areas. The top two service areas sustained by the Minuteman Commuter Bikeway were restaurants and general merchandise retail stores, and the top service areas sustained by the Northern Strand Community Trail were restaurants and museums, historical sites, zoos, and parks.

The economic activity generated by the paths also affects local, state, and federal taxes. The taxes generated by each trail are outlined below, with state and local taxes delineated in **Table 17** and federal taxes summarized in **Table 18**.

The combined tax revenue from the paths is over $860,000 from state and local taxes and $1.1 million in federal taxes for July-October 2019. Paths are often funded by government agencies, so this provides a glimpse at the amount of tax revenue generated in return by the investment in paths .

Table 17 State/Local Tax Dollars Generated by Each Trail, July-October 2019

STATE/LOCAL GOVT TAXES	JULY	AUGUST	SEPTEMBER	OCTOBER	TOTAL
Minuteman Commuter Bikeway	$38,000	$46,000	$47,800	$31,800	$164,300
Northern Strand Community Trail	$6,300	$5,600	$200	$3,500	$15,600
MCRT-Norwottuck	$33,000	$37,200	$30,300	$18,700	$119,100
Cape Cod Rail Trail	$216,000	$254,700	$108,300	$33,100	$612,800

Table 18 Federal Tax Dollars Generated by Each Trail, July-October 2019

FEDERAL TAXES	JULY	AUGUST	SEPTEMBER	OCTOBER	TOTAL
Minuteman Commuter Bikeway	$46,100	$55,200	$57,400	$38,200	$196,800
Northern Strand Community Trail	$8,500	$7,300	$300	$4,700	$20,700
MCRT-Norwottuck	$35,100	$40,100	$32,500	$20,100	$127,800
Cape Cod Rail Trail	$306,000	$360,000	$153,000	$46,700	$865,700

Limitations

The spending categories presented in the survey included “Restaurants”, “Fuel”, “Retail Stores (Rentals)”, “Lodging”, “Museums, Parks, and Zoos”, or “Other”. IMPLAN takes spending and models the monetary effects differently based on spending category. At the time of the analysis, IMPLAN did not offer an option for money spent if it did not fit into a spending category. For spending that was categorized by those surveyed as “Other”, the project team applied ratios for each impact based on a combination of the other spending categories. Specifically, the project team determined the ratio for each dollar spent to each economic impact (economic output, employment, labor income, state/local tax dollars, and federal tax dollars) for the compilation of other spending categories and applied that ratio to determine the approximate impact of “Other” spending.

PROPERTY VALUES

To further investigate the economic impacts of shared use paths, property value data was collected to compare residential properties within the proximity of shared use paths to similar properties further away from them. Property values were determined from tax lot parcel data obtained from Mass.Gov's Interactive Property Map. According to Mass.Gov, the data are collected from community assessors, their mapping consultants, and other stakeholders. Property values were provided as the value at the time the property was sold. To ensure property values are consistent for all parcels in the dataset, a 2018 value was calculated by converting the value of the property in the year it was sold to a 2018 value using the consumer price index (CPI). Price per square foot was also calculated for each property to consider that properties are of different sizes (e.g., number of bedrooms and bathrooms, square footage of building property, etc.).

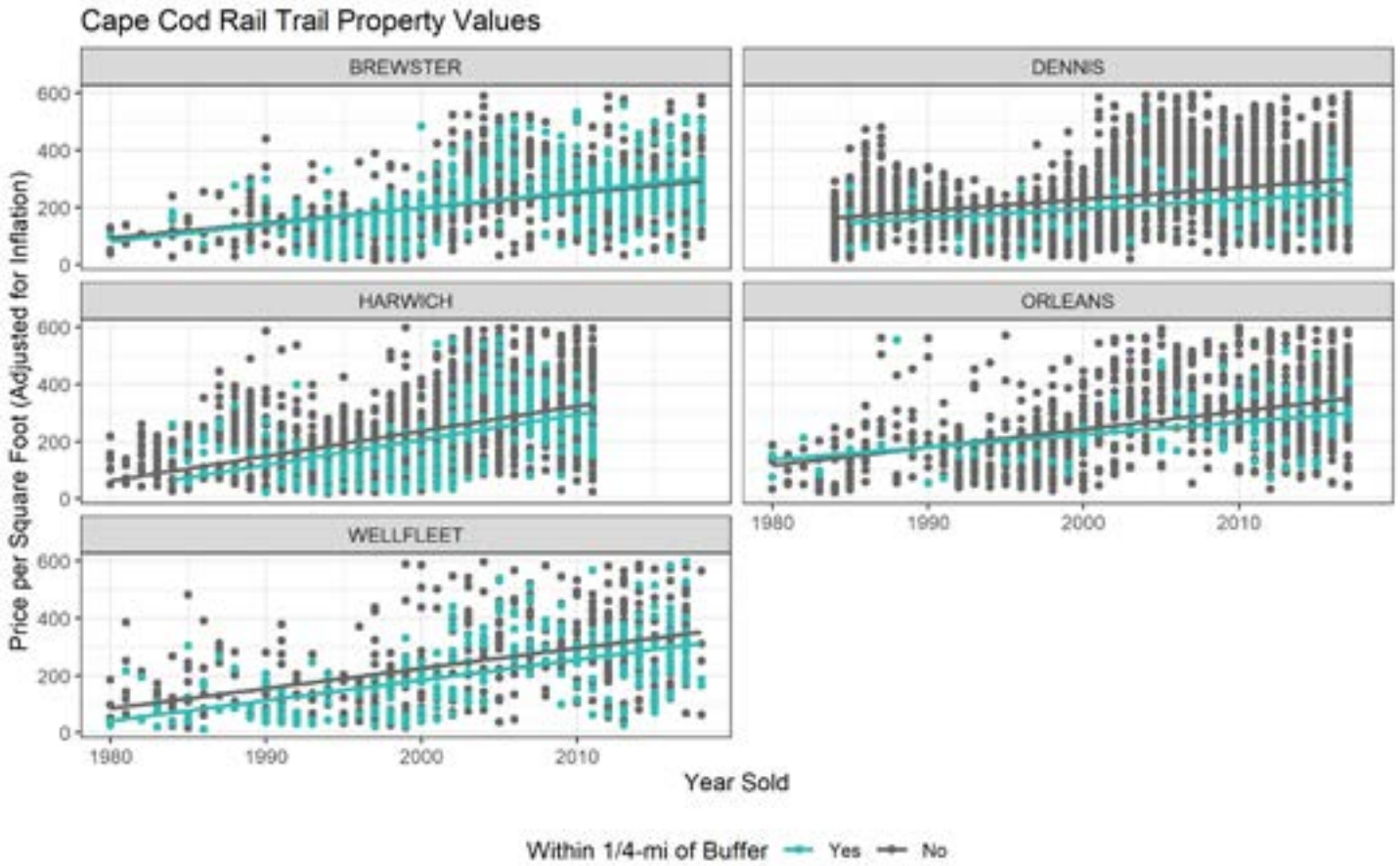
The dataset was verified for missing data and potential outliers. Houses that had a property value of zero were removed from the dataset. The project team found that houses under $50,000 total or over $600 per square foot were outliers, and likely not representative of the actual property value so they were removed from the dataset. Finally, houses that were not single-family homes were removed from the dataset due to inconsistencies with multi-family home reporting in the dataset.

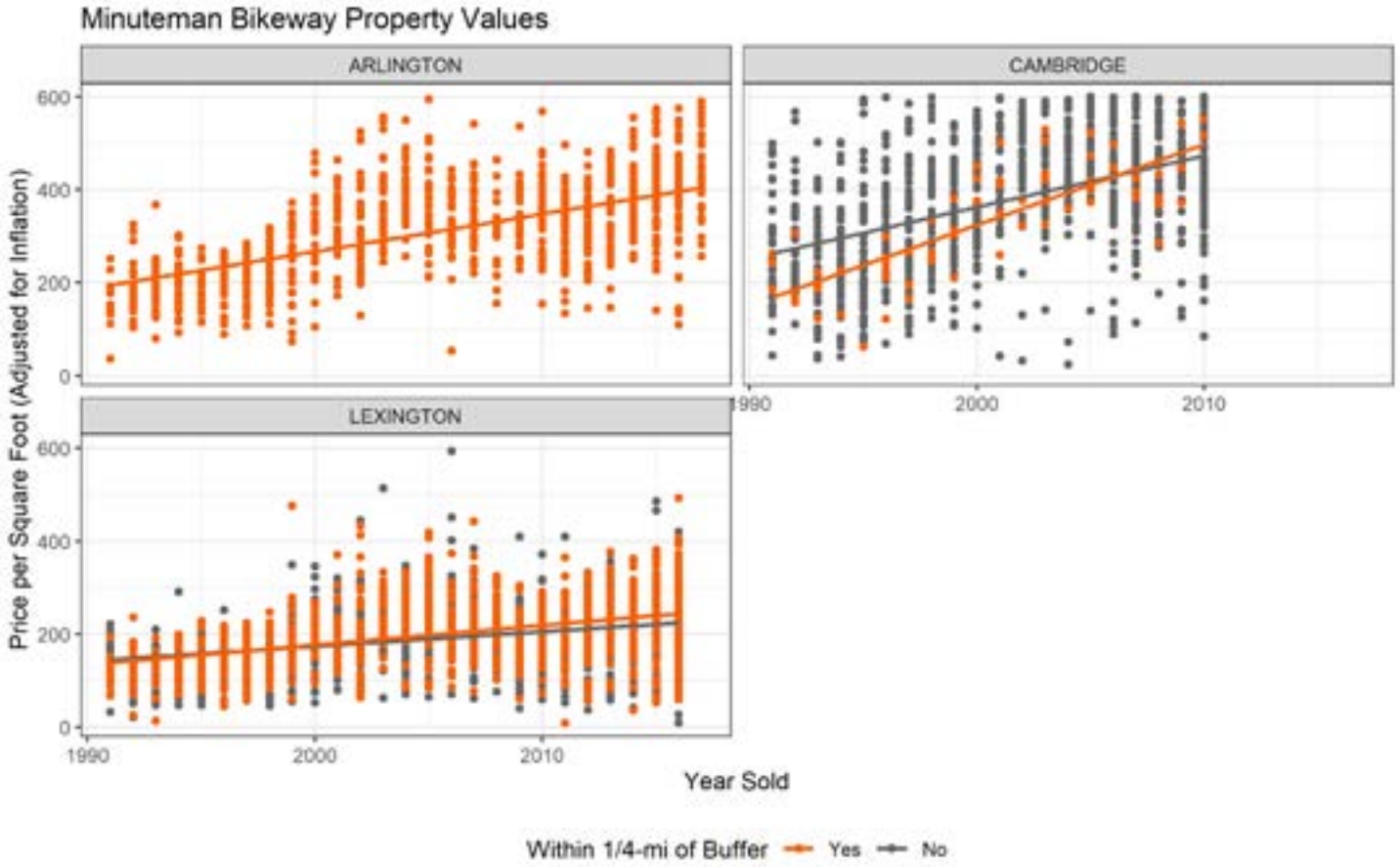
The project team conducted a geospatial buffer analysis to analyze the effects of shared use paths on property values. Property values within 0.25 miles of a shared use path were compared to properties within 1 to 3 miles. A similar analysis was conducted comparing properties within 0.50 miles of a shared use path and properties within 1 to 3 miles. A dummy variable was created to identify properties in the 0.25-mile and 0.50-mile buffers (hereby referred as "in proximity" to shared use paths) and those within the 1- to 3-mile buffers (hereby referred as "out of proximity" to shared use paths).

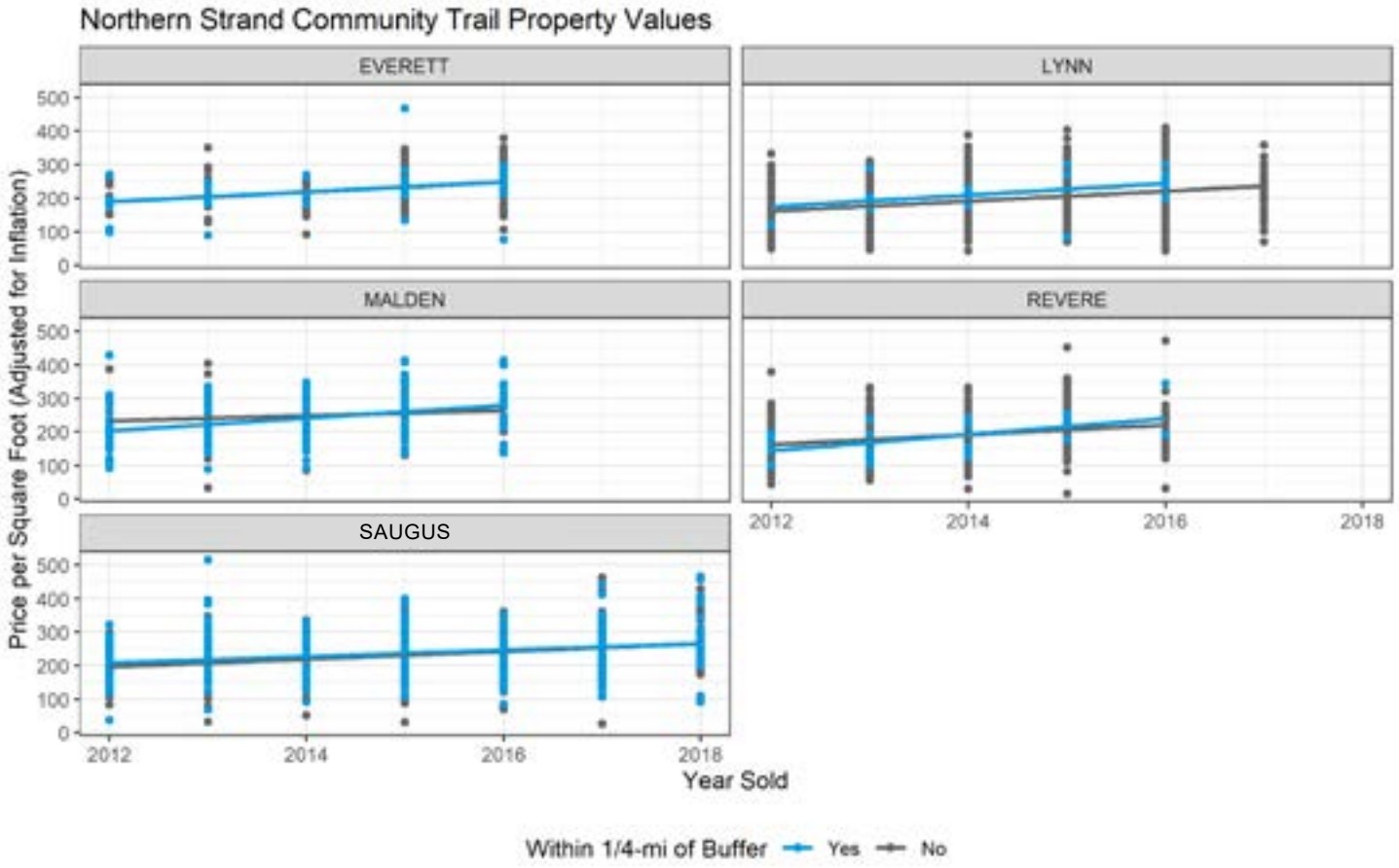
The team fit a linear model for each shared use path to analyze how property value per square foot is affected by proximity to the shared use path. The team included a variable to reflect each city that each traverses through to reflect any change in property values from city to city. The interaction between city and proximity was also included to consider that the effect of one of these variables may be directly related to the other (e.g., property value differences due to proximity of a shared use path may be apparent in one city, but not another).

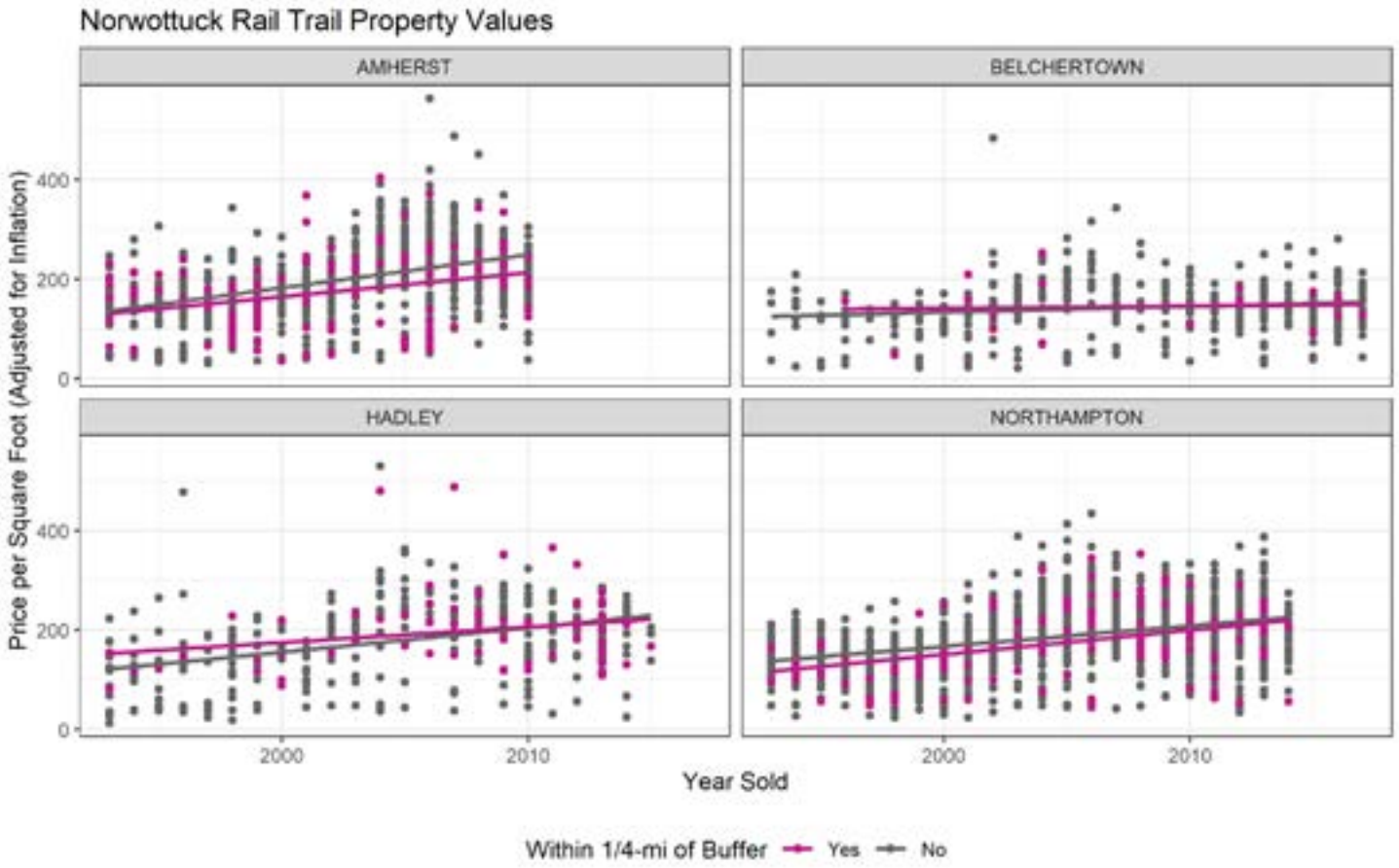
Overall, the models show that the effects of proximity to shared use paths on property values differ for each path. Furthermore, the city the shared use path runs through made a difference in whether property values were affected by proximity to shared use paths or not. For example, along the Cape Cod Rail Trail, property values were higher for properties near the rail trail in Brewster, but not in the adjacent towns, Dennis and Orleans. In general, the impacts that shared use paths had on property values in each city were inconsistent. A lack of data did not allow for an additional comparative analysis for each community before and after the paths were constructed. Additionally, variations in property values surrounding the paths may be attributed to rail corridor activity prior the construction of the path.

Figure 13 **Property Values**






Northern Strand Community Trail Property Values
EVERETT
LYNN
MALDEN
REVERE
SAUGUS
Price per Square Foot (Adjusted for Inflation)
0
100
200
300
400
500
2012
2014
2016
2018
Year Sold
Within 1/4-mi of Buffer
Yes
No


Norwottuck Rail Trail Property Values
AMHERST
BELCHERTOWN
HADLEY
NORTHAMPTON
Price per Square Foot (Adjusted for Inflation)
0
200
400
2000
2010
Year Sold
Within 1/4-mi of Buffer
Yes
No

Health

Physical activity, along with other factors such as eating a healthy diet and refraining from smoking are often associated with increased health and decreased likelihood of developing chronic illnesses. One CDC associated study found that over 11% of health care expenditures were associated with inadequate physical activity[7].

This analysis aims to understand and measure health impacts attributable to the presence of the four study paths within their communities and to determine how the increased physical activity they foster has impacted medical costs.

The project team used a combination of research, survey results, and path usage data to estimate the paths' impact on public heath. **Table 19** summarizes the data and evaluation methods used for each health impact subarea. The process designed to quantify these health impacts are outlined in the following sections.

PHYSICAL ACTIVITY AND MEDICAL COSTS

National guidelines recommend at least 150 minutes of moderate-intensity aerobic activity per week, with 75 minutes of vigorous-intensity aerobic activity[8]. **Figure 14** depicts the CDC's categories for levels of physical activity used in this analysis. The project team assessed the direct health impacts related to path usage by surveying path users to determine their levels of regular physical activity, based on type, duration, and frequency of exercise.

The total reduced annual medical costs per person were quantified by measuring increased physical activity as a result of using the shared use paths. The limitations and assumptions for this analysis are detailed below. It should be noted that peak path counts (July-October) were used in this analysis. Although seasonal path usage and activity levels were used in the analysis, the team determined the reduction in medical costs on an annual basis. This calculation assumes the physical activity of path users remains constant throughout the year.

Table 19 Health Impact Evaluation Summary

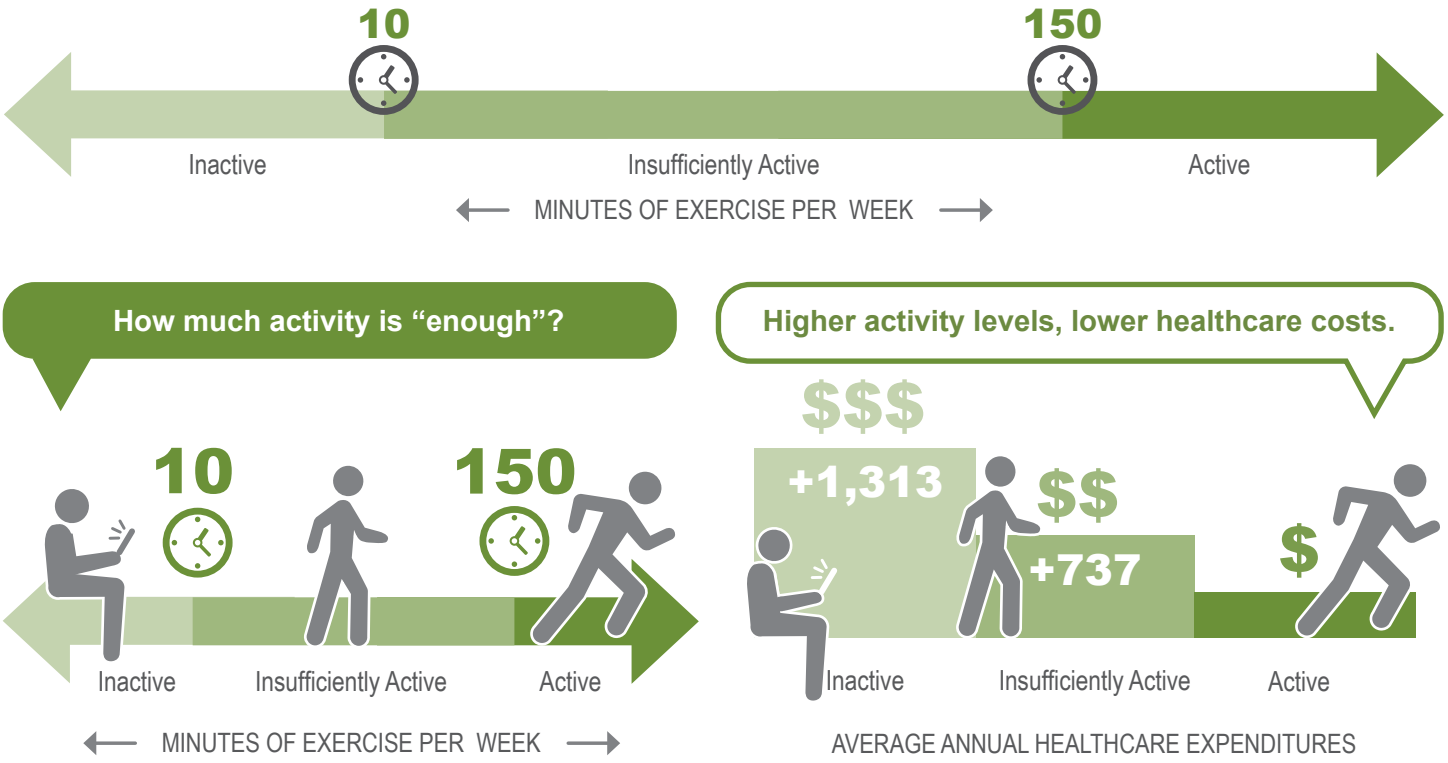
IMPACT AREA	IMPACT SUBAREA	DATA	EVALUATION METHOD
Health	Levels of Physical Activity and Medical Costs	Path User Survey • Mode of travel • Frequency of path use • Duration spent on path • Propensity for exercising CDC recommended weekly activity: 150 minutes CDC Estimated Annual Healthcare Costs (compared to active adults) • $1,313 inactive adults • $576 insufficiently active adults	IMPLAN Spreadsheet analysis
	Chronic Illnesses	Massachusetts Risk Factor Surveillance System	Research comparisons between nationwide, statewide, and countywide chronic disease rates
	Quality of Life	US Census Data Path User Survey • Written comments • Commute behavior • Total commute distance traveled Victoria Transport Policy Institute's value per non-motorized mile: $0.26[1]	Geographic analysis Spreadsheet analysis

1 Evaluating Active Transport Benefits and Costs. Victoria Transport Policy Institute (2020).

7 Susan A. Carlson et. al, Inadequate Physical Activity and Health Care Expenditures in the United States (Elsevier, Inc., 2015).

8 US Department of Health and Human Services, 2008 Physical Activity Guidelines for Americans.

Figure 14 Weekly Physical Activity "Levels"



Source: Centers for Disease Control and Prevention

The CDC calculates average annual healthcare expenditures based on weekly levels of physical activity. This analysis assumed the different levels of physical activity summarized in **Figure 14**. Adults who are physically active for fewer than 10 minutes per week are considered inactive. The CDC considers 10 minutes of walking moderate physical activity. Adults who are physically active between 10 and 150 minutes per week are considered insufficiently active, and adults who are physically active for 150 minutes or more are considered active, as depicted in **Figure 14**.

Research found that active adults save an average of $1,313 on annual healthcare expenditures compared to inactive adults. When compared to insufficiently active adults, active adults save an average of $576 annually on health care expenditures[9]. The study assesses individual physical activity and estimates the percentage of health care expenditures associated with inadequate levels of physical activity at the individual level. The calculated health care expenditures include all services, such as emergency room visits, dental, vision, and prescription drugs.

9 Susan A. Carlson et. Al, Inadequate Physical Activity and Health Care Expenditures in the United States (Elsevier, Inc., 2015).

Cleaning and organizing the survey data

In order to be able to understand and quantify the health impacts of the study paths, the project team organized and summarized the survey data to determine the total number of path users who are insufficiently active and active. Survey respondents were prompted to answer questions related to physical activity in the path user survey. The related questions include:

1. How often do you visit this path?
2. Which of these activities best describes your use of the path today?
3. If the path did not exist, would you still participate in this activity elsewhere today?
4. How long do you plan to stay on the path today?
5. What is your primary purpose for using the path?

The analysis considered those respondents who used the path at least once per week whose primary purpose of using the path was for health or exercise, and who otherwise would not be participating in the activity if the path did not exist.

Question number one provides information about how often trail users typically visit the paths and determines user average weekly path use. The methodology includes survey responses that indicate using the path at least once a week in order to meet the U.S. Department of Health and Human Services recommendations for weekly physical activity. The U.S. Department of Health and Human Services recommends 150 minutes of weekly moderate-intensity or 75 minutes weekly of vigorous-intensity aerobic activity. Question number two helps to determine the intensity of the users' physical activity. Based on the CDC's research[10], respondents who indicated that they were jogging for exercise were assigned a longer duration of physical activity. Users' reported duration on the paths were doubled for users indicating that they were jogging for exercise, which the CDC considers a more vigorous aerobic form of physical activity than walking.

Question number three determines the user's propensity for physical activity and provides information as to whether users are participating in physical activity as a direct result of the path, or if they would be exercising elsewhere if the path did not exist. Path users were determined to be "regular exercisers" if they answered 'yes' to this question. Answering 'yes' to question number three indicated that the path users would be exercising even if the paths did not exist. This analysis includes responses only from path users who indicated that they would not be participating in physical activity elsewhere if the path were not present (by indicating 'No,' or 'Unsure,' to question number three). To determine the health impacts of the paths, the methodology evaluates only the net "new exercisers" that began exercising because of the paths. If path users were determined to be "regular exercisers", it was assumed that they would find ways to exercise with or without the paths. The evaluation measured and quantified the new exercisers who were motivated to exercise because of the path's existence.

Question number four provides information on how long users plan to spend on the paths at the time of completing the survey. This analysis assumes that the user spends the same amount of time on the path every time they use it. For example, if a respondent indicated that they planned to stay on the path for 30 minutes at the time of completing the survey and previously indicated on question number one that they use the path daily, this user is estimated to spend 210 minutes per week exercising on the path. For the purposes of this analysis, the responses from question one (path use frequency) and question four (path use duration) were combined to determine estimated weekly user time spent on the paths.

Question number five was used to differentiate between path users with different purposes. The health impact evaluation sought to include only users who reported using the path for health/exercise, or any combination including health/exercise. Some respondents reported using the path for recreation, health/exercise, and commuting/traveling.

Determining the total number of new insufficiently active and active path users

The project team determined the total weekly minutes of physical activity for each survey respondent by multiplying user weekly frequency of path use with the number of minutes each respondent reported using the path. The data was organized into weekend days and weekdays and path users were put into two categories: active (exercising for 150 minutes or more per week) and insufficiently active (exercising for more than 10 minutes and less than 150 minutes per week). As previously discussed, these users indicated that they were using the path for health/exercise purposes and would not be exercising if the paths did not exist. These survey respondents are categorized as new exercisers, as a direct result of the path. **Table 20** presents the percentage of insufficiently active and active users for each path, based on survey responses.

10 Susan A. Carlson et. al, Inadequate Physical Activity and Health Care Expenditures in the United States (Elsevier, Inc., 2015).

Table 20 Percentage of Insufficiently Active and Active Path Users

	INSUFFICIENTLY ACTIVE ADULTS (LESS THAN 150 MIN EXERCISE/WEEK)		ACTIVE ADULTS (150+ MIN EXERCISE/WEEK)	
	WEEKEND DAY	WEEKDAY	WEEKEND DAY	WEEKDAY
Minuteman Commuter Bikeway	3.7%	14.8%	16.7%	25.9%
Northern Strand Community Trail	21.4%	25.0%	14.3%	25.0%
MCRT-Norwottuck	3.5%	11.8%	20.0%	25.0%
Cape Cod Rail Trail	3.1%	4.8%	9.4%	9.5%

Calculating the number of unique path users experiencing health impacts

This step was included to avoid overcounting path users when determining total health impacts. For instance, daily path users should not be included when calculating the number of users who exercise on the path 1-3 times per week, or 4+ times per week. **Table 21** shows the results of calculating the weekly path users that experience health impacts.

Column A reflects all of the survey respondents who reported using the paths for exercise and indicated that they would not be exercising otherwise if the paths did not exist. These survey respondents were used to determine overall path user health-related impacts. Column B shows the total number of surveys collected at each of the paths. Column C was calculated in a few steps:

1. First, the path counter data was reviewed to determine the average number of path users each week. An average of 9,924 people used the path each week during the peak period of July to October 2019.
2. Then, the survey data was used to estimate how many times per week individuals exercised on the paths. Using information from the surveys, an estimated 1,341 unique exercise events occurred on the paths weekly.
    a. For instance, a survey respondent who reported using the path for exercise daily received a weight of 7x, 1-3 times per week frequency was weighted with an average 2x, and 4+ times per week frequency was weighted 4x. This calculation determined the total weekly exercise activity of survey users.
3. Lastly, the weekly unique health users were calculated by:
    a. Multiplying the total survey responses by average weekly trail counts (calculated in Step 1)
    b. Dividing the result by the weekly survey trips (calculated in Step 2)

Column D was calculated by dividing column A (health impacted survey respondents) by column B (total survey responses) and multiplying the result by column C (weekly unique health impacted users). Column D represents the total number of path users during the peak period of July through October 2019 who experienced some health impact as a direct result of using the paths.

As shown in **Table 21**, the Minuteman Commuter Bikeway had the highest number of unique path users who experienced direct health-related impacts as a result of using the path at least once a week.

Table 21 Calculated Weekly Path Users with Health Impacts

	(A) HEALTH IMPACTED SURVEY RESPONDENTS	(B) TOTAL SURVEY RESPONSES	(C) WEEKLY UNIQUE PATH USERS	(D) WEEKLY UNIQUE HEALTH IMPACTED USERS
Minuteman Commuter Bikeway	88	108	4,511	3,676
Northern Strand Community Trail	31	40	1,503	1,165
MCRT-Norwottuck	101	183	2,850	1,573
Cape Cod Rail Trail	43	116	3,460	1,283
Total	263	447	12,324	7,696

Applying path user counts to determine total weekly path users with health impacts attributed to path use

The project team combined the previously calculated weekly unique health impacted users (**Table 21**) with the percentages of insufficiently active and active path users (**Table 20**). The results in **Table 22** indicate total unique path trips that directly contributed to health impacts. The results in this table will be used to determine total annual healthcare savings for path users.

Applying CDC annual healthcare savings to the total number of unique active and insufficiently active path users

Table 23 displays annual healthcare savings estimated by the CDC. As shown in the table, the greatest healthcare savings occur when an inactive individual becomes active ($1,313 annual savings). The next greatest savings can be seen when comparing an inactive individual to an insufficiently active individual. Insufficiently active individuals save approximately $737 on annual healthcare expenditures when compared to inactive individuals.

Table 22 Total Unique Weekly Path User Trips with Health Impacts

	INSUFFICIENTLY ACTIVE ADULTS (<150 MIN EXERCISE/WEEK)		ACTIVE ADULTS (150+ MIN EXERCISE/WEEK)	
	WEEKEND DAY	WEEKDAY	WEEKEND DAY	WEEKDAY
Minuteman Commuter Bikeway	136	545	613	953
Northern Strand Community Trail	250	291	166	291
MCRT-Norwottuck	55	185	315	393
Cape Cod Rail Trail	40	61	120	122
TOTAL	481	1,082	1,214	1,760

Table 23 CDC Annual Healthcare Savings

	HEALTH EXPENDITURES FROM CDC	
Inactive vs Active	$1,313.00	Now active, would otherwise be inactive
Inactive vs. Insufficiently Active	$737.00	Now insufficiently active, would otherwise be inactive
Insufficiently Active vs Active	$576.00	Now active, would otherwise be insufficiently active

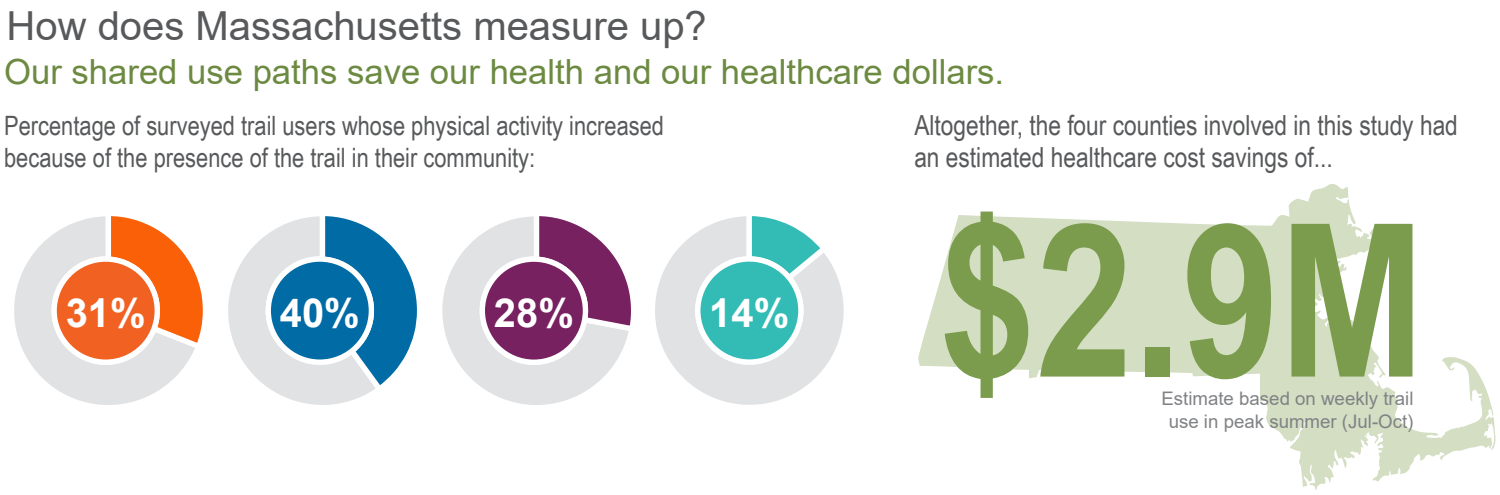
For the purposes of this study, path users determined to be insufficiently active were assumed to have previously been inactive (resulting in $737 annual healthcare savings). This analysis assumes one level of advancement in activity levels. Path users who meet the CDC's requirements for being active were assumed to previously have been insufficiently active (resulting in $576 annual healthcare savings).

The average healthcare savings shown in **Table 23** were combined with the total unique weekly path user trips with health impacts shown in **Table 21**. The total rounded estimated annual healthcare savings are shown in **Table 24**. The values represent annual healthcare savings based on path usage collected during the peak period of July through October 2019. Physical activity and path usage are known to peak during the summer months and dwindle during colder winter months. As mentioned, the annual healthcare savings were estimated by assuming a continued level of physical activity throughout the year. The limitations in this approach method are detailed in the following section. Based on the survey results and the total path counts from July through October, the four studied paths are responsible for annual healthcare savings of over $2.8 million dollars, with the Minuteman Commuter Bikeway path alone attributing approximately $1.4 million annually in healthcare savings, as displayed in **Figure 15**.

Table 24 Annual Healthcare Costs per Path based on Total Path Counts (July-October 2019)

	INSUFFICIENTLY ACTIVE ADULTS (<150 MIN EXERCISE/WEEK)		ACTIVE ADULTS (150+ MIN EXERCISE/WEEK)		PATH TOTAL
	WEEKEND DAY	WEEKDAY	WEEKEND DAY	WEEKDAY	
Minuteman Commuter Bikeway	$100,000	$401,000	$353,000	$549,000	$1,404,000
Northern Strand Community Trail	$184,000	$215,000	$96,000	$168,000	$662,000
MCRT-Norwottuck	$40,000	$136,000	$181,000	$226,000	$584,000
Cape Cod Rail Trail	$30,000	$45,000	$69,000	$70,000	$214,000
TOTAL	$354,000	$797,000	$699,000	$1,014,000	$2,864,000

Figure 15 Increased Physical Activity Levels Across the State



Limitations

The research and data related to healthcare savings as a result of increased physical activity were presented as annual healthcare savings. The CDC acknowledges that healthcare savings attributed to increased physical activity and a healthy lifestyle are significant with regular physical activity. There is a limitation in applying the CDC's estimated annual healthcare savings on a sample of users' annual physical activity. It is possible that path users are highly active during summer months and highly inactive during winter months. Because survey data collection and the sample trail counts summarize data during the summer months, the reported physical activity may be somewhat amplified.

Although the project team collected continuous path user data with the trail counters, several errors and unforeseen counter malfunctions resulted in an incomplete annual path count and the inability to apply complete annual counts to the analysis.

CHRONIC ILLNESSES

When investigating the health impacts the four paths have on surrounding residents and path users, it is important to understand the geographic context of each area. Several confounding factors may be contributors to the health statistics of specific areas, including socioeconomic factors, political influence, etc. This section investigates Countywide rates of chronic illnesses and compares each county to the state and nation. This section does not directly relate to the data collected from the project's trail counters or surveys, but instead provides additional insight into the context of each trail.

Chronic illnesses are responsible for nearly three-fourths (70%) of all deaths in the United States. Among chronic illnesses, heart disease, cancer, and diabetes are the leading causes of death and disability. Many cases of chronic illnesses result from lack of physical activity and other unhealthy lifestyle choices[11].

Research continues to show how critical a healthy lifestyle is in preventing chronic illnesses. Nearly all individuals can benefit from regular physical activity[12], especially when combined with other healthy lifestyle factors, such as eating a balanced diet and refraining from smoking. One study analyzed four health lifestyle factors: never smoking, having a body mass index (BMI) lower than 30, exercising at least three and a half hours per week, and following healthy dietary principles. The study found these four factors were associated with reduced risk of diabetes (93%), heart attack (81%), stroke (50%), and cancer (36%)[13]. The CDC associates regular physical activity, such as walking, jogging, and bicycling, with reduced risk for health conditions, such as cardiovascular disease, coronary heart disease, high blood pressure, type 2 diabetes, certain cancers, and depression.

Although physical activity is just one component of living a healthy and active lifestyle, its importance should be noted. In the previous section, the project team assessed the annual healthcare expenditure savings as a result of Massachusetts residents using shared use paths for physical activity.

The scope of this project did not include a detailed assessment of chronic illness reduction as a direct result of the four studied shared use paths. However, the project team conducted an evaluation to understand the rate of chronic illnesses in the populations surrounding the paths and compared these rates to the state and country at large. **Table 25** displays several metrics to understand current rates of chronic illness in the four counties surrounding the studied shared use paths. Chronic illness rates for the state of Massachusetts and the United States are provided for comparison.

11 National Center for Chronic Disease Prevention and Health Promotion. Chronic Diseases in America.

12 U.S. Department of Health and Human Services. Physical Activity Fundamental to Preventing Disease (2002).

13 ScienceDaily. Healthy Lifestyle Habits May Be Associated with Reduced Risk of Chronic Disease (2009).

Table 25 Chronic Illnesses by County, State, and Country

RISK FACTORS, DISEASE & MORTALITY RATES	MINUTEMAN COMMUTER BIKEWAY (MIDDLESEX COUNTY)	NORTHERN STRAND COMMUNITY TRAIL (ESSEX COUNTY)	MCRT - NORWOTTUCK BRANCH (HAMPSHIRE COUNTY)	CAPE COD RAIL TRAIL (BARNSTABLE COUNTY)	MASS.	USA
Access to exercise opportunities[1]	97%	95%	84%	89%	94%	83%
Obese adults[2]	23%	26%	20%	21%	24%	28%
Adults with diabetes[3]	7%	8%	6%	6%	8%	9%
% Physically inactive adults[4]	20%	22%	18%	17%	22%	23%

1 2018 County Health Rankings % of population with adequate access to locations for physical activity
2 2018 County Health Rankings % of adults that report a BMI ≥ 30
3 CDC Diabetes Atlas https://gis.cdc.gov/grasp/diabetes/DiabetesAtlas.html# 2016 Adults Aged 20+ Years
4 2018 County Health Rankings % of adults aged 20+ reporting no leisure-time physical activity

Table 25 shows that residents in all four counties that are home to the studied shared use paths have better access to exercise opportunities than the US as a whole, with residents in Essex County (Northern Strand Community Trail) and Middlesex County (Minuteman Commuter Bikeway) having the highest access to exercise opportunities. The percentage of the population with diabetes is lowest in Barnstable County, near the Cape Cod Rail Trail, and Hampshire County, near the MCRT-Norwottuck. The percentage of adults with diabetes is lower in all four counties than the country, but relatively on par with the state. Furthermore, the percentage of adults who meet the criteria for being physically inactive is lower in all counties than in the rest of the country.

QUALITY OF LIFE

Quality of life may be defined and experienced differently by everyone. Generally, quality of life describes an individual's health, comfort, and happiness. Walkability and bikeability contribute to the livability of a place, which is defined by the Partners for Livable Communities as "the sum of factors that add up to a community's quality of life." Shared use paths can directly enhance individual and community quality of life. This analysis was designed to understand the quality of life impacts that shared use paths have on their communities[14].

14 Partners for Livable Communities. "What is Livability?" http://livable.org/about-us/what-is-livability

This analysis is rooted in the research completed by the Victoria Transport Policy Institute's value per non-motorized mile, which is estimated at $0.26. This value quantifies the benefit of improved social experiences, as well as physical and mental health, which are defined in this analysis as components of quality of life.

This analysis used the survey data, census information, and a geographic analysis. Each survey respondent reported their expected length of time using the path that day, as well as their activity (walking, bicycling, jogging, scooting, skating, rollerblading). For each activity mode, an average speed was determined through industry resources:

- Walking: 3.1 mph
- Bicycling 9.6 mph
- Jogging: 6.0 mph
- Rolling / Skating: 5.0 mph

Time spent on the path and estimated activity speed were used to calculate an approximate mileage for each user, which was then multiplied by the social benefit value ($0.26) to determine the social benefit accrued to each user. This analysis assumes that each visit a user makes to the path is the same duration as the visit when completing the survey.

Additionally, this analysis assumes that the user employs the same mode of activity for each visit to the path.

Survey respondents also indicated how often they use the shared use paths in their communities. To quantify the value the paths provide over different timescales and to account for respondents' frequency of use over time, frequency multipliers were developed for each 'frequency' response option. The survey response choices, as well as the frequency multiplier developed for each, are displayed in **Table 26**. The appropriate frequency multiplier was then applied to the mileage developed for each user to determine a new value for social benefit accrued.

Usage Frequency Effect on Quality of Life

The survey prompted respondents to indicate the following details about their path usage:

- The duration of their time on the path during that trip, in minutes
- Their mode of activity on the path
  - Walk, bike, jog/run, roll, skate, etc.
- How often they use the paths
  - Responses varied from 'daily' to 'several times per year.'

Respondents' travel modes informed their speed, which was then multiplied by their duration of time on the path to calculate the distance traveled. Then, to account for respondents' reported use over time, the project team determined frequency multipliers based on how often respondents use the path. These frequency multipliers accounted for each frequency option provided on the survey and allowed for aggregate comparisons of the quality of life results over time. These values were multiplied by the Victoria Transport Policy Institute's social benefit value ($0.26) to calculate the benefit accrued to the user. **Table 27** delineates the average value accrued by the paths for the different paths and time periods.

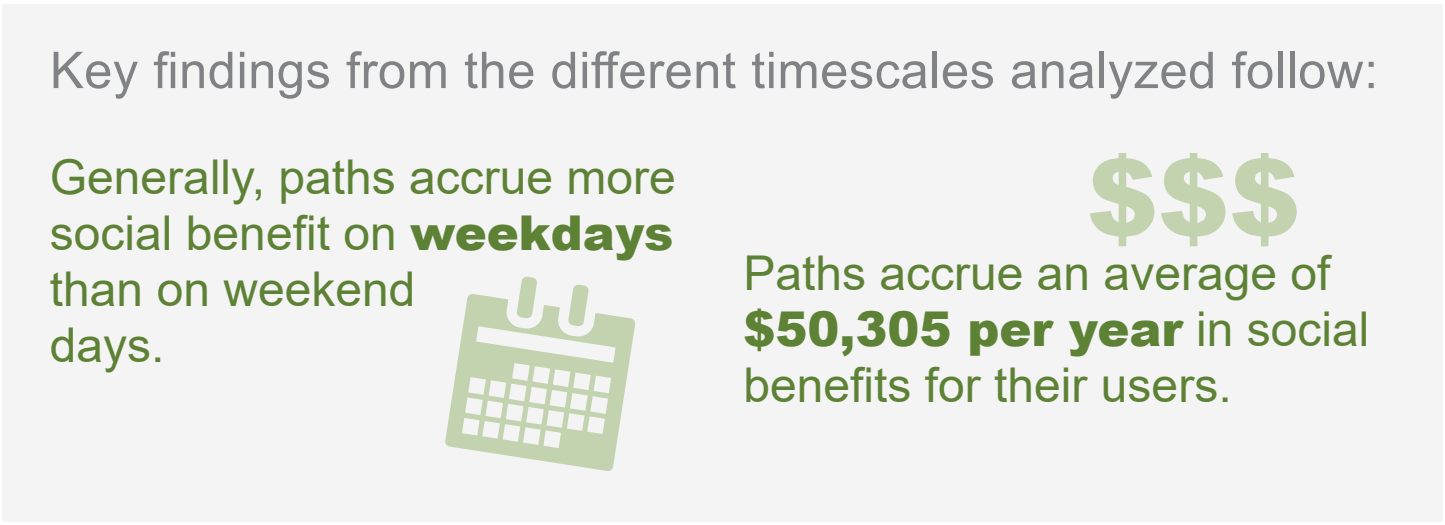
Table 26 Quality of Life Frequency Multipliers by Response Option

FREQUENCY	FREQUENCY MULTIPLIERS							
	WEEKLY		WEEKEND DAY		WEEK DAY		ANNUAL	
	Multiplier	Method	Multiplier	Method	Multiplier	Method	Multiplier	Method
This is my first time	1	First time	1	Filter by day of week, exclude if weekday	1	Filter by day of week, exclude if weekend day	1	
Daily	7	Every day in the week	2	Each weekend day	5	Each weekday	360	Almost every day
4+ Times per Week	4	Average 4x per week	1.14	Average 4x per week * 2/7 days	2.84	Average 4x per week * 5/7 days	200	Average 4x per week * 50 weeks
1-3 Times per Week	2	Average 2x per week	0.58	Average 2x per week * 2/7 days	1.42	Average 2x per week * 5/7 days	100	Average 2x per week * 50 weeks
Several Times per Month	1	Average 1x per week	0.28	Average 1x per week for 3 weeks of month (3/30 days)	0.71	Average 1x per week for 3 weeks of month (3/30 days) * 5/7 days	36	Average 3x per month * 12 months
Monthly	0.25	One day of average thirty days	0.07	Average 4 weeks in month, 1 weekend day of 8	0.18	Average 4 weeks in month, 1 weekday of 22	12	Average 1x per month * 12 months
Several Times per Year	0	Exclude	0	Exclude	0	Exclude	4	Average 1x per season
Write-Ins	0	Exclude	0	Exclude	0	Exclude	0	Exclude
Blanks	0	Exclude	0	Exclude	0	Exclude	0	Exclude

Table 27 Total Social Benefit by Path and Time Period

PATH	WEEKLY	WEEKEND DAY	WEEKDAY	ANNUAL
Minuteman Commuter Bikeway	$540.00	$160.00	$390.00	$26,730.00
Northern Strand Community Trail	$120.00	$50.00	$90.00	$5,200.00
MCRT-Norwottuck	$1,660.00	$490.00	$1,190.00	$82,130.00
Cape Cod Rail Trail	$1,880.00	$670.00	$1,400.00	$86,080.00
AVERAGE	$1,050.00	$342.50	$767.50	$50,035.00

Figure 16 Social Impacts of Shared Use Paths



COMMENT ANALYSIS

Survey respondents were asked if they had any additional thoughts regarding the paths at the close of the survey, with highlights summarized in **Figure 17**. In addition to 32 mentions of loving the path and 11 mentions of the paths' greatness, some highlights from the comments section of the survey include:

The opportunities for interactions within neighborhoods, exposure to greenery, and exercise can all contribute to an individual's quality of life. Supporting commentary from path users also indicated improved mental health conditions due to path usage. Shared use paths serve as a channel to connect neighbors, build community, engage with nature, enjoy green space, safely exercise, and take a break from every day stressors.

Asset/Resource to the Community

- "I rely on the trail for commute and recreation. It is *Arlington's greatest asset*."
- "*Amazing asset to community*, various diverse mix of users combination with community garden etc. Big bonus."
- "This trail is a *tremendous resource*. Same for other bike trails."
- "Resource for community"
- "There is nothing like early morning or dusk on the path. The light, the tranquility, even with bikes passing by and seeing community - enjoying themselves is always uplifting"

Long-term Attraction

- "We love the path! *Definitely influenced our decision to buy in this area.*"
- "The trail system is *the envy of my friends and family* who don't have access (they live too far away). Wish they had something like it in their town!"
- "Love living near the bike trail. It's very convenient. Never want to not live on it."
- "Have been using since opened *20+ years*"
- "Been using this trail since it opened in 1980"

Figure 17 Highlighted Survey Responses

Transportation

Transportation options impact the way people move through communities. Transportation modes provide access to jobs, schools, parks, recreation facilities, restaurants, grocery stores, and other destinations. Transportation should be convenient, safe, accessible, and affordable for all. This section assesses the overall transportation impacts that paths have on communities.

As individuals choose to commute by active transportation mode, they have a direct impact on reducing the number of vehicles on the surrounding road network. At the individual level, one fewer vehicle on the roadway may seem insubstantial, but when aggregated, the impacts are significant. The project team conducted the analysis by first understanding path user behavior related to commute patterns and mode choice. The findings were then used to determine the total congestion impacts, measured by reduced vehicle miles traveled (VMT), that result from individuals using the path for commute purposes.

The methodologies for quantifying transportation impacts included a combination of Census data analysis, geographic analysis, and survey data analysis. The information highlighted below focuses on measuring the transportation impacts paths have on surrounding areas. **Table 28** summarizes the data and evaluation methods used to quantify transportation-related impacts that can be attributed to shared use paths.

ACTIVE TRANSPORTATION & CONGESTION IMPACTS

Active transportation includes bicycling, walking, rollerblading, skateboarding, scooting, and any other active mode that is not motorized. The shared use paths evaluated in this study promote active transportation by providing a direct connection to origins and destinations throughout Massachusetts. The paths provide direct, safe, comfortable, and accessible routes for people of all ages and abilities. Active transportation that is accessible and feasible can reduce dependence on vehicles.

This section evaluates the direct impact shared use paths have on encouraging new active transportation commute trips. The evaluation determines the number of commuters that switched from commuting by vehicle to an active mode as a direct result of the path's availability.

Table 28 Transportation Impact Evaluation Summary

IMPACT AREA	IMPACT SUBAREA	DATA	EVALUATION METHOD
Transportation	Active Transportation & Congestion Impacts	Census Data • (American Community Survey 2017 5-Year Estimates – Journey to Work data) • Mode choice • Percentage of single occupancy vehicle commuters	Geographic Analysis
		Path User Survey • Commute behavior • Total time spent commuting • Transportation mode to the path	Spreadsheet analysis
		TIGER BCA Resource Guide's congestion cost per vehicle mile	

Cleaning and organizing the survey data

The survey questions (and responses) used for this evaluation include:

1. How often do you visit this path? (Provided Responses Options: Daily, 1-3 times per week, 4+ times per week)
2. How long do you plan to stay on the path today?
3. If the path did not exist, would you still participate in this activity elsewhere today? (No, Unsure)
4. What is your primary purpose for using the path? (Commuting/traveling)

Question 1 enabled the project team to understand how frequently users are on each of the paths. The responses from this question determined users' weekly active transportation commute activity. Only respondents who indicated they use the path at least once a week were considered in this evaluation. Question 2 collected information about how long users spend commuting on the path. The responses from this question were used to estimate the total time each user spent on the path each time they commuted.

Question 3 determined user propensity to commute by active mode. This question provided insight about whether individuals would otherwise commute by active mode if the paths did not exist. The project team only included individuals whose primary trip purpose was commuting, as this analysis intended to determine the marginal differences in active commuting behavior.

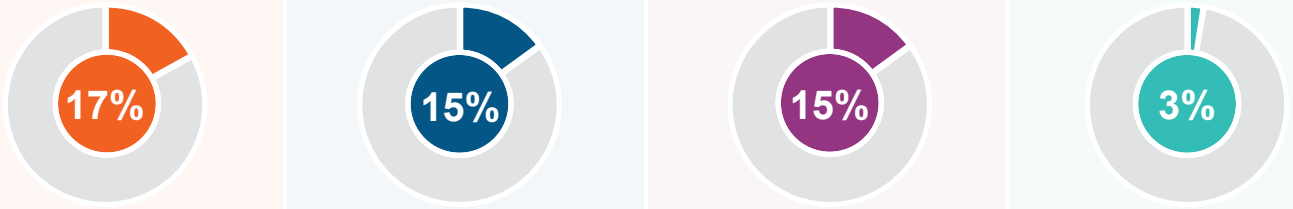
It was important for the project team to identify the path users' purpose for using the path. Question 4 provided information about the users' trip purpose. To evaluate the congestion impacts, the project team filtered out all survey responses that did not indicate using the path for commute purposes. This evaluation was not intended to capture path users enjoying the path for recreation or health purposes.

Calculating the number of survey respondents who indicated they commute using their path at least once a week

After organizing and filtering the survey data, the project team initiated the transportation analysis by calculating the total and average time spent commuting by path and by day of week (weekday and weekend day). Weekend day and weekday path users were kept separate during this analysis to understand how commute behaviors vary between weekdays and weekend days. There were 447 total surveys collected from the four paths. The results show significantly more weekday commuters than weekend commuters. The majority of weekend trips were taken for recreational or health purposes.

Table 29 Transportation Impacts of Shared Use Paths

An average of **13%** of total commuters within a half mile of each path commute by active mode.



Minuteman Commuter Bikeway	Northern Strand Community Trail	MCRT-Norwottuck	Cape Cod Rail Trail
Path users replaced approximately 90,500 one-way motor vehicle commuter trips with active mode trips from July-October 2019.			
-50,291	-18,054	-18,162	-4,002
This equates to approximately **170,600** fewer vehicle miles traveled.			
-74,834	-20,879	-59,420	-15,506

Weekend day commuters consisted of 81% bicycling, 6% jogging, and 13% walking. Weekday commuters consisted of 75% bicycling, 3% jogging, 20% walking, and 3% scooting. These values were incorporated into the analysis to determine total commute VMT.

Applying total path counts to the percentage of survey respondents who commute by active mode to determine the total number of new active transportation users directly resulting from the paths

By collecting path user behavior from the survey questionnaire, the project team was able to extrapolate the total number of new commuters using the paths by active mode. **Table 30** shows a relatively low percentage of weekend day survey respondents who reported using the paths for commute purposes who would not otherwise be commuting by active mode. Conversely, **Table 31** shows higher percentages of path-dependent active mode commuters using the paths on weekdays, with Cape Cod Rail Trail as an exception. The percentages of survey respondents that met the criteria for new active mode commuters were combined with the total weekend day and weekday path counts during the peak period from July through October 2019. As shown in **Table 30** and **Table 31**, the shared use paths encouraged over 15,000 weekend day active commute trips and over 80,000 active weekday commute trips from July through October 2019. The next section on congestion impacts will explore the direct vehicle miles that can be attributed to these new active commute trips.

Table 30 New Weekend Day Active Transportation Commuters

	TOTAL SURVEYED COMMUTERS	% SURVEY RESPONDENTS	TOTAL PATH COUNTS	TOTAL NEW ACTIVE COMMUTERS
Minuteman Commuter Bikeway	1	2%	102,791	1,904
Northern Strand Community Trail	2	7%	24,973	1,784
MCRT-Norwottuck	12	10%	47,482	4,955
Cape Cod Rail Trail	1	3%	45,210	1,413

Table 31 New Weekday Active Transportation Commuters

	TOTAL SURVEYED COMMUTERS	% SURVEY RESPONDENTS	TOTAL PATH COUNTS	TOTAL NEW ACTIVE COMMUTERS
Minuteman Commuter Bikeway	17	31%	219,450	69,086
Northern Strand Community Trail	4	33%	69,044	23,015
MCRT-Norwottuck	16	24%	78,900	18,565
Cape Cod Rail Trail	3	4%	78,808	2,815

This evaluation determined the congestion impacts that result from individuals using the paths to commute by walking, bicycling, or other active mode. As commuters shift from single-occupancy vehicles to other modes, such as bicycling and walking, the project team anticipated a reduction in overall congestion near the paths. Similar to the evaluation methods for path user expenditures and health impacts, the congestion impact evaluation involves combining results from the path user survey with total path counts for each of the paths. The following section outlines the project team's method for determining the congestion impacts that can be attributed to the four paths.

Calculating total and average time spent on each path by commute mode

After calculating the number of survey respondents who reported using the paths for commuting, the project team then identified the total and average time spent by commuters on each of the paths. Similar to the previous step, weekend day and weekday commute behavior were kept separate.

The survey results in this analysis were limited by the following user characteristics:

- Use the paths at least once a week
- Use the path for commute purposes
- Would not commute by active mode if the paths did not exist

Given these limitations, the usable survey responses were limited. In the previous step, only one survey respondent met the above criteria for both the Cape Cod Rail Trail and the Minuteman Commuter Bikeway Path on weekend days. The path user commute data collected on weekdays was more robust. Due to the limited survey data, the total commute time for Cape Cod Rail Trail and Minuteman Commuter Bikeway were based on one survey response for the weekend day evaluation. The total commute time for Northern Strand Community Trail was based on two survey responses. This is a limitation to consider as this data is carried through the transportation impacts analysis.

The project team calculated the total and average commute times reported by the survey respondents. The total commute times were used to determine the average time spent commuting on the paths, based on the number of survey respondents who reported commuting on each path during weekend days and weekdays. The average times spent commuting on the paths for weekend days is shown in **Table 32** and weekday average commute times are shown in **Table 33**. As shown from the results, people reported commuting by bicycling, jogging, walking, and using a scooter (on weekdays).

Table 32 Average Time Spent Commuting on Path: Weekend Day

	PEOPLE BICYCLING	PEOPLE JOGGING	PEOPLE WALKING	AVERAGE COMMUTE TIME
Minuteman Commuter Bikeway	120	0	0	120
Northern Strand Community Trail	30	0	30	30
MCRT-Norwottuck	77	120	120	84
Cape Cod Rail Trail	60	0	0	60

Table 33 Average Time Spent Commuting on Path: Weekday

	PEOPLE BICYCLING	PEOPLE JOGGING	PEOPLE WALKING	PEOPLE ON SCOOTERS	AVERAGE COMMUTE TIME
Minuteman Commuter Bikeway	61	60	40	0	56
Northern Strand Community Trail	0	0	34	0	34
MCRT-Norwottuck	89	0	0	0	89
Cape Cod Rail Trail	68	0	0	40	58

Using Census data to determine the percentage of people in the area who travel to work by single occupancy vehicle

After the commute behavior of the survey respondents was captured and evaluated, the project team then extrapolated the results using Census information about how the broader area commutes. **Table 34** displays the Census distributions of commute modes for the areas surrounding each of the four paths. As shown in the total column, the commute mode percentages do not add up to 100%, due to the margins of error associated with each modal count when Census five-year estimates were calculated.

The columns, 'Drove Alone' and 'Carpooled' were use to determine the total percentage of people who commute by motor vehicle, shown in **Table 34**. Census commute behavior shows that the majority of commute trips surrounding the Cape Cod Rail Trail are taken by vehicle (95%). Alternatively, commute trips surrounding the Minuteman Commuter Bikeway are much lower, with 71% of commute trips taken by vehicle. The more urban context of the Minuteman Commuter Bikeway, compared to the Cape Cod Rail Trail path, is a likely contributor, as other commute mode options are more available, including rail and bus. These percentages will be used to estimate how many reported non-auto commute trips on the shared use paths might have otherwise been vehicle commute trips.

Calculating the miles traveled based on survey respondent activity

The project team then collected information on average speeds for different commute modes. **Table 35** displays the estimated average miles per hour for people bicycling, people jogging, and people walking. These values will be used to determine the total distance traveled by weekend day and weekday commuters using the paths.

Table 35 Estimated Average Speed by Mode (Miles per Hour)

PEOPLE BICYCLING[1]	PEOPLE JOGGING[2]	PEOPLE WALKING[3]
9.6 mph	6 mph	3.1 mph

1 https://web.archive.org/web/20131212093813/http://subsite.kk.dk/sitecore/content/Subsites/CityOfCopenhagen/SubsiteFrontpage/LivingInCopenhagen/CityAndTraffic/CityOfCyclists/CycleStatistics.aspx

2 https://www.healthline.com/health/average-jogging-speed#:~:text=In%20general%2C%20average%20jogging%20speed,before%20having%20a%20full%20conversation.

3 https://www.healthline.com/health/exercise-fitness/average-walking-speed#:~:text=The%20average%20walking%20speed%20of%20a%20human%20is%203%20to,an%20indicator%20of%20overall%20health.

To calculate the total commute miles traveled by the survey respondents, the project team combined the average speeds per mode displayed in **Table 35** with the total time spent commuting on weekend days and weekdays that were previously calculated. The results showed that the majority of miles spent commuting were traveled by people on bicycles. It is important to note that the reported average commute miles traveled for the Minuteman Commuter Bikeway is longer than the length of the path itself. Although the survey respondents were asked, "How long do you plan to spend on the path today?" many respondents interpreted this question differently and responded with their total time spent commuting (both on and off the path). Therefore, the project team evaluated the reported commute miles traveled as total commute miles (including both on and off the paths), as it is very likely that most commuters using the paths began commuting on a different facility (other bicycle facility, on road facility, sidewalk, etc.) to reach the path, then commuted on the path and exited the path to reach their final destinations.

Table 34 Census Data Commute Patterns

	BICYCLED	WALKED	DROVE ALONE	CARPOOLED	RODE TRANSIT	OTHER	TOTAL
Minuteman Commuter Bikeway	2.4%	2.9%	59.8%	5.8%	21.7%	7.4%	92.6%
Northern Strand Community Trail	0.05%	2.7%	61.3%	8.7%	23.4%	3.85%	96.15%
MCRT-Norwottuck	2.6%	13.3%	61.6%	7.9%	4.6%	10%	90%
Cape Cod Rail Trail	1%	2.7%	77.6%	7.8%	1.1%	9.8%	90.2%

Additionally, average commute miles traveled were calculated by combining the average miles per hour speeds in **Table 35** with the average weekend day (**Table 32**) and weekday (**Table 33**) commute time spent on the paths. **Table 36** displays the average commute miles traveled on each path during a weekend day and **Table 37** displays the same information for average weekday commute activity.

Calculating reduced vehicle commute trips and reduced Vehicle Miles Travelled (VMT)

Table 38 displays both the reduced vehicle commute trips and the corresponding miles traveled for each trip. The reduced vehicle commute trips were calculated by multiplying the total number of survey respondents who reported using one of the paths for commute purposes on weekend days and weekdays with the Census percentage of people commuting by vehicle (**Table 34**).

Survey Respondent Reported Total Miles Traveled on Paths by Census Percentage Commute by Vehicle

For example, on the MCRT-Norwottuck during a weekend day, 12 survey respondents reported using the path for commute purposes. To calculate the number of vehicle commute trips that were replaced with active mode trips, mode split percentages derived from Census data were then applied to the sample population. Using this methodology, the MCRT-Norwottuck Census data showed 77% of total commute trips occurring by single occupancy vehicle, which equals 9.24 (rounded 9.3) total vehicle commute trips when applied to the survey sample of 12 responses.

Table 36 Weekend Day Average Commute Miles Traveled

	PEOPLE BICYCLING	PEOPLE JOGGING	PEOPLE WALKING	AVERAGE MILES TRAVELED
Minuteman Commuter Bikeway	19.2	0.0	0.0	19.2
Northern Strand Community Trail	4.8	0.0	1.6	3.2
MCRT-Norwottuck	12.3	12.0	6.2	11.8
Cape Cod Rail Trail	9.6	0.0	0.0	9.6
Average VMT Reduction by Mode	12.1	12.0	3.9	11.0

Table 37 Weekday Average Commute Miles Traveled

	PEOPLE BICYCLING	PEOPLE JOGGING	PEOPLE WALKING	PEOPLE ON SCOOTERS	AVERAGE MILES TRAVELED
Minuteman Commuter Bikeway	9.7	6.0	2.1	0.0	7.3
Northern Strand Community Trail	0.0	0.0	1.7	0.0	0.4
MCRT-Norwottuck	14.2	0.0	0.0	0.0	14.2
Cape Cod Rail Trail	10.8	0.0	0.0	2.1	7.9
Average VMT Reduction by Mode	12.2	6.0	1.9	2.1	9.4

Table 38 Total Reduced Vehicle Trips and VMT

	REDUCED VEHICLE COMMUTE TRIPS			REDUCED VMT		
	WEEKEND DAY	WEEKDAY	TOTAL TRIPS	WEEKEND DAY	WEEKDAY	TOTAL TRIPS
Minuteman Commuter Bikeway	0.7	12.0	12.8	13.6	88.5	102.1
Northern Strand Community Trail	1.5	2.9	4.4	4.6	1.3	5.9
MCRT-Norwottuck	9.3	12.4	21.6	109.2	175.4	284.6
Cape Cod Rail Trail	0.9	2.8	3.8	9.1	22.4	31.5

The results from **Table 38** were used to then extrapolate the congestion impacts from total path users (during the peak period from July - October 2019) who switched from commuting by vehicle to commuting by active mode.

Table 39 displays the total reduced commute trips and total reduced VMT for the survey respondent sample, as well as the peak (July-October 2019) user population. **Table 39** shows that of the total trips reported by survey respondents, vehicle commute trips were reduced by 42.5 as a direct result of the shared use paths. These 42.5 vehicle commute trips totaled approximately 424 total reduced vehicle miles. These calculated totals from the survey responses were extrapolated and used to determine the total path user commute trip and mileage reduction using the path counts, summarized in the bottom row in **Table 39**. The project team determined that the shared use paths directly contributed to reducing total vehicle commute trips by over 90,000, resulting in over 710,000 fewer commute VMT from July to October of 2019.

Summarizing survey respondent commute behavior and applying survey respondent commute behavior to total path user counts

To calculate the most accurate estimate of transportation impacts directly resulting from shared use path use, the project team reviewed the distribution of mode choice among the survey respondents. Survey respondents who reported using the path at least once a week for commute purposes were commuting by bicycle, jogging, or walking. One survey respondent reported commuting on a weekday by mobility scooter (which was combined with walkers). This step in the analysis combines the previously calculated average time spent commuting on the path and average reduction in VMT.

Table 40 and **Table 41** display the distribution of survey respondents by commute mode type: people who bicycle, jog, and walk. **Table 40** and **Table 41** also summarize the average time spent commuting on the shared use paths (calculated when cleaning and organizing the data) and the average commute miles traveled (calculated in the previous section of this document).

Table 39 Extrapolated Total Reduction in Vehicle Trips and VMT (Incorporated Path Counts)

	VEHICLE COMMUTE TRIPS ELIMINATED			REDUCTION IN VMT		
	WEEKEND DAY	WEEKDAY	TOTAL TRIPS	WEEKEND DAY	WEEKDAY	TOTAL TRIPS
Survey Sample	12.4	30.2	42.5	136.5	287.6	424.1
Population (July-October 2019 Total Users)	7,811	82,698	90,509	87,940	629,311	717,251

Table 40 Weekend Day Survey Commuter VMT

	PEOPLE BICYCLING	PEOPLE JOGGING	PEOPLE WALKING
% Commuters	81%	6%	13%
Average Time Spent Commuting on Path (min)	75	120	75
Average VMT Reduction	12.1	12.0	3.9

Table 41 Weekday Survey Commuters VMT

	PEOPLE BICYCLING	PEOPLE JOGGING	PEOPLE WALKING
% Commuters	75%	3%	23%
Average Time Spent Commuting on Path (min)	76	60	38
Average VMT Reduction	12.2	6.0	2.0

The next step the project team took to understand path user commute behavior was to separate the impacts by day of week (weekend day and weekday) and by shared use path then apply the total path count data. **Table 42** and **Table 43** incorporate the path counts and extrapolate total impacts based on the survey responses. The tables summarize the total distribution of commute mode type, reduced one-way commute trips, and reduced commute VMT per path on weekend days and weekdays, respectively, during the peak period of July through October 2019.

The total path user counts for each path are displayed in **Table 42** and **Table 43**. The distribution of commute modes varies by path. For instance, on both weekend days and weekdays, the majority of commuters on the Cape Cod Rail Trail commute by bicycle. Alternatively, commuters using the Northern Strand Community Trail are predominately people who walk on both weekend days and weekdays. The total percentages of commuters using the shared use paths were derived from the commuters who responded to surveys, shown previously in **Table 30** and **Table 31**. During the weekend day survey data collection, only one commuter (a person bicycling) completed the survey and met the criteria for this analysis (commutes on the shared use path at least once a week and wouldn't otherwise be commuting by non-auto mode if the path did not exist). Therefore, 100% of weekend day commuters using the Cape Cod Rail Trail are people bicycling. The small sample size of this subset was a limitation in this analysis.

To determine the number of reduced one-way commute trips, the commute mode percentages were multiplied with the total reduced one-way commute trips, calculated previously.

Lastly, the project team determined the total reduced commute VMT by multiplying the calculated reduced one-way commute trips with the previously calculated average miles traveled based on mode (**Table 35**) and duration spent on each shared use path.

Table 44 displays the total calculated reduction in one-way commuter trips that can be attributed to shared use path use, as well as the total reduced commute VMT. These estimated totals represent shared use path usage during the peak period from July through October 2019. As shown in the table, the Minuteman Commuter Bikeway has a significantly larger impact on reducing vehicle trips and VMT. This bikeway is used by a large number of commuters compared to the Cape Cod Rail Trail, which serves primarily recreational and health-related trips. The MCRT-Norwottuck is second behind the Minuteman Commuter Bikeway for most significant reduction in vehicle trips.

Table 42 Weekend Day Commute Mode Percentages, Commute Duration, and VMT Reduction

	PEOPLE BICYCLING	PEOPLE WALKING	
Minuteman Path (Path User Counts) *	55,807	46,984	
% Total	100%	0%	0%
One-Way Commute Trip Reduction	1,349	0	0
Commute VMT Reduction	25,891	0	0
Northern Strand Community Trail (Path User Counts) *	10,275	14,698	
% Total	50%	0%	50%
One-Way Commute Trip Reduction	649	0	649
Commute VMT Reduction	3,117	0	1,006
MCRT-Norwottuck (Path User Counts) *	32,946	14,536	
% Total	83%	8%	8%
One-Way Commute Trip Reduction	3,188	319	319
Commute VMT Reduction	39,281	3,826	1,977
Cape Cod Rail Trail (Path User Counts) *	40,066	5,144	
% Total	100%	0%	0%
One-Way Commute Trip Reduction	1,338	0	0
Commute VMT Reduction	12,841	0	0

* Path user counts were collected the during peak period from July through October 2019.

Table 43 Weekday Commute Mode Percentages, Commute Duration, and VMT Reduction

	PEOPLE BICYCLING	PEOPLE WALKING	
Minuteman Path (Path User Counts) *	124,506	94,944	
% Total	71%	6%	24%
One-Way Commute Trip Reduction	34,547	2,879	11,516
Commute VMT Reduction	336,262	17,274	23,799
Northern Strand Community Trail (Path User Counts) *	25,070	43,974	
% Total	0%	0%	100%
One-Way Commute Trip Reduction	0	0	16,755
Commute VMT Reduction	0	0	29,217
MCRT-Norwottuck (Path User Counts) *	54,020	24,882	
% Total	100%	0%	0%
One-Way Commute Trip Reduction	14,336	0	0
Commute VMT Reduction	203,572	0	0
Cape Cod Rail Trail (Path User Counts) *	69,681	9,127	
% Total	67%	0%	33%
One-Way Commute Trip Reduction	1,777	0	888
Commute VMT Reduction	19,187	0	0

* Path user counts were collected the during peak period from July through October 2019.

Table 44 Extrapolated Reduction in Vehicle Trips

	TOTAL REDUCTION IN ONE-WAY COMMUTER TRIPS		TOTAL REDUCTION IN VMT (BASED ON AVERAGE TRIP LENGTH)	
	WEEKEND DAY	WEEKDAY	WEEKEND DAY	WEEKDAY
Minuteman Commuter Bikeway	1,349	48,942	25,891	377,335
Northern Strand Community Trail	1,299	16,755	4,123	29,217
MCRT-Norwottuck	3,826	14,336	45,084	203,572
Cape Cod Rail Trail	1,338	2,665	12,841	19,87
TOTAL	7,811	82,698	87,940	629,311

Overall, commuter trips are more prevalent on weekdays, with most trips on weekend day trips falling under recreational and/or health-related categories. **Table 45** summarizes the total per person impact from reduced VMT based on total shared use path users and **Figure 18** depicts the key commuting findings. As shown in the aggregated VMT per person for all paths, weekday path commuters are each contributing approximately 1.4 fewer miles of vehicle travel on weekdays and approximately 0.4 miles on weekend days. This reduction in VMT and in total vehicle trips ultimately reduces vehicular congestion and eliminates tons of greenhouse gases and other noxious chemicals that would otherwise contribute to polluting the atmosphere. The environmental impacts of shared use path usage will be summarized in the next chapter.

MODE SPLIT

In order to understand how shared use paths affect commuter behavior, the project team analyzed American Community Survey Journey to Work data from 2018 (five-year estimates) at the tract level. Overlaying the studied shared use paths on the tracts and using the 'select by location' tool, Census tracts within one mile of each path were selected and analyzed to understand localized commuting trends for places with access to shared use paths. The results of this analysis are displayed in **Table 46**. These results reflect simple averages. They incorporate a margin of error associated with each modal specific count, and may not, therefore, add up to 100%.

Compared to Massachusetts statewide averages, Census tracts within a mile of one of the studied shared use paths have, on average, an equal amount of walking commuters, higher amount of bicycle commuters, higher amount of transit commuters, and lower number of single-occupancy vehicle commuters. The commuter trends for walking, bicycling, riding transit, and driving alone in the areas near each studied shared use path are displayed in **Figures 20-23**.

Table 45 Reduction in VMT Per Person (Based on Total Path Users)

	WEEKEND DAY	WEEKDAY
Minuteman Commuter Bikeway	0.252	1.719
Northern Strand Community Trail	0.165	0.423
MCRT-Norwottuck	0.949	2.580
Cape Cod Rail Trail	0.284	0.243
Total	0.399	1.410

Table 46 Average Commuter Mode Split (Studied Paths vs. Statewide)

	Average % Walk Commuters	Average % Bike Commuters	Average % Transit Commuters	Average % Carpool Commuters	Average % Single Occupancy Vehicle Commuters	Average % Tele-commuters	Average % Other Commuters
Minuteman Commuter Bikeway	5%	4%	26%	10%	52%	7%	1%
Northern Strand Community Trail	2%	0%	22%	20%	61%	3%	1%
MCRT-Norwottuck	11%	2%	4%	18%	65%	9%	1%
Cape Cod Rail Trail	3%	1%	1%	11%	79%	10%	1%
Study Paths Average	5%	2%	13%	15%	64%	7%	1%
Massachusetts Statewide Average	5%	1%	10%	8%	70%	5%	1%

Figure 18 Commute Trips Key Findings

Sources: Survey responses, US Census averages, Massachusetts statewide Journey to Work data (2016), approximated speed per mode

Figure 19 **Commuter Trends: Walking**

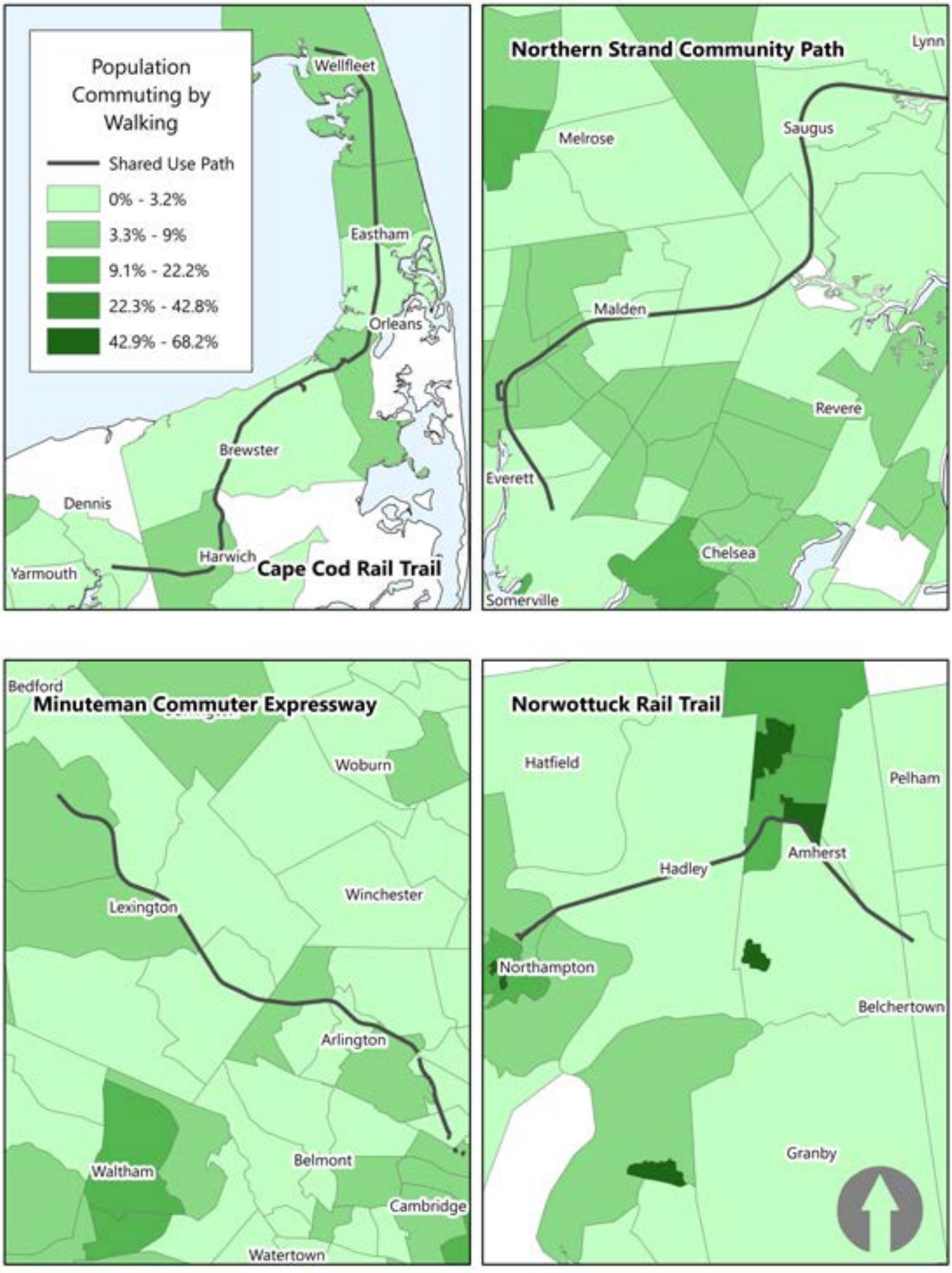


Figure 20 **Commuter Trends: Bicycling**

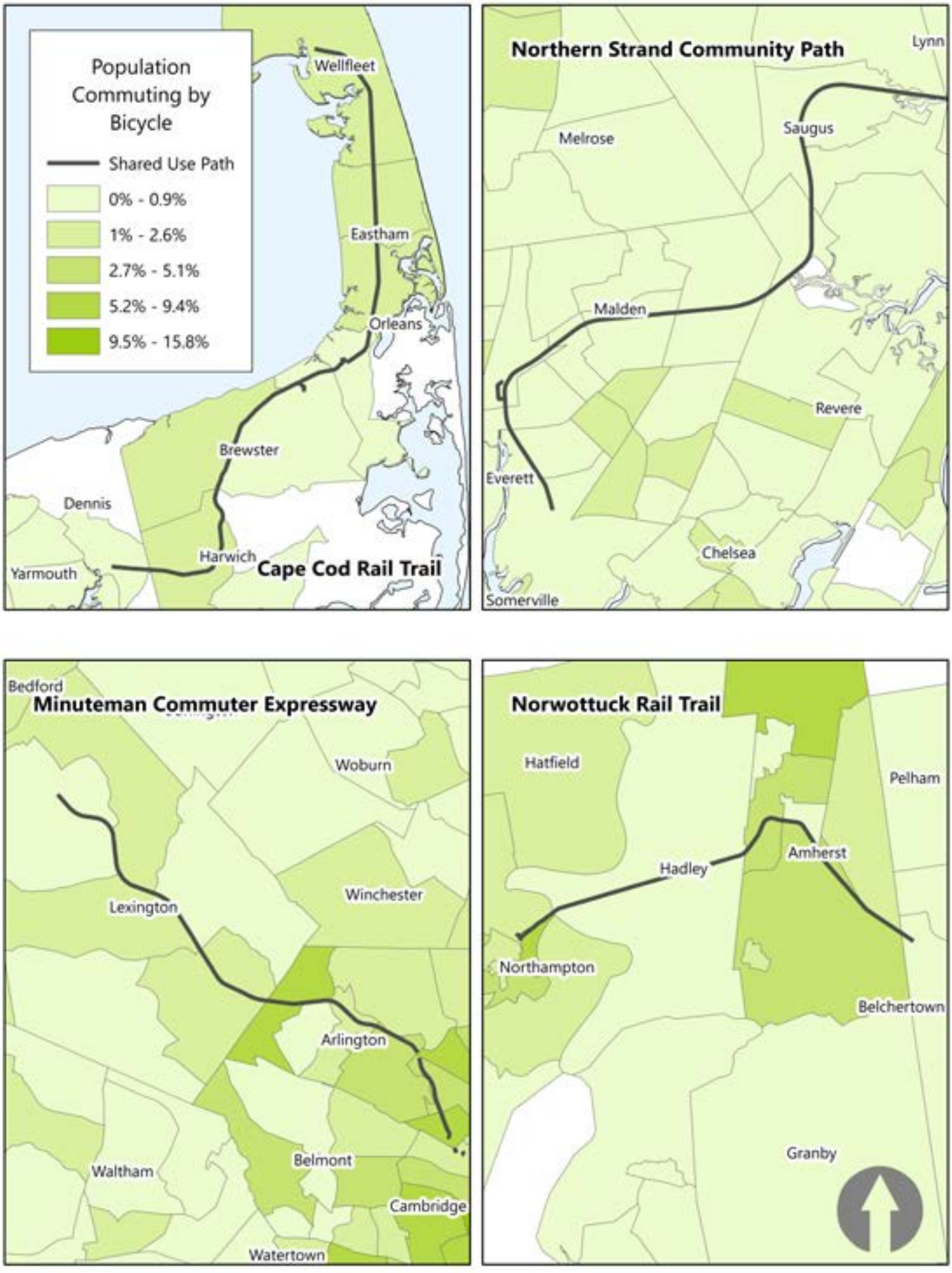


Figure 21 **Commuter Trends: Transit**

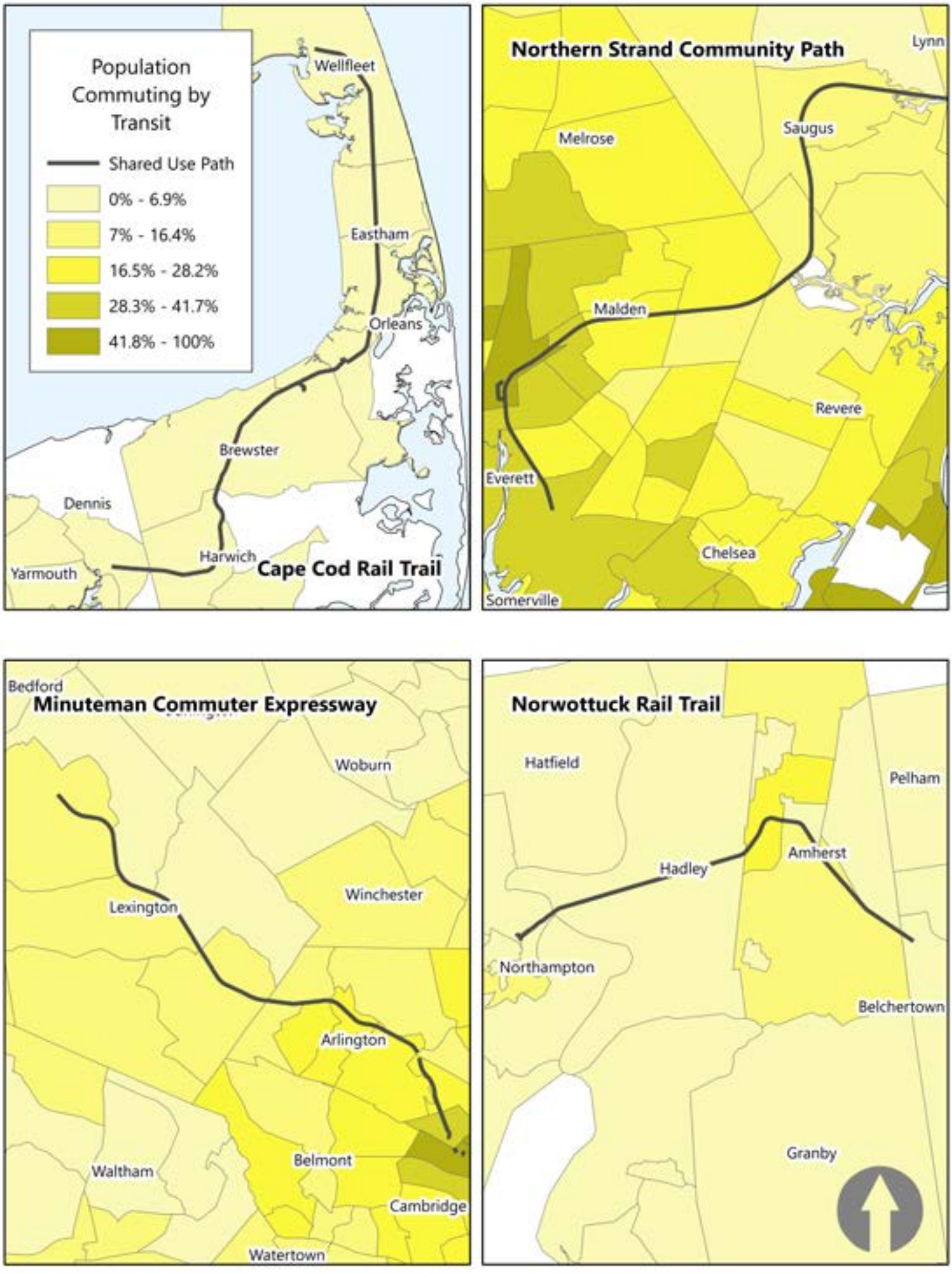
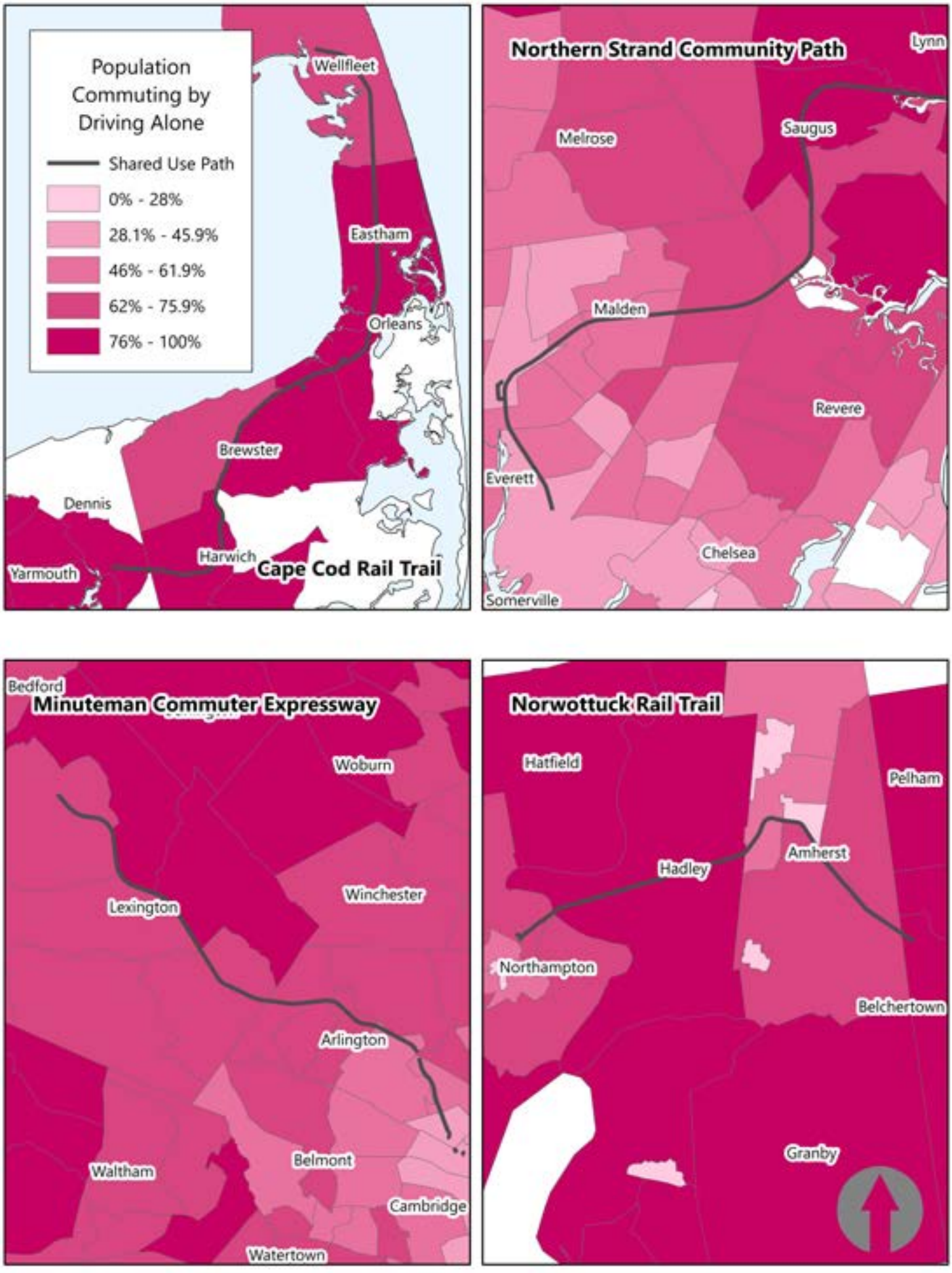


Figure 22 Commuter Trends: Driving Alone



Environment

This section focuses on applying a variety of methodologies found from the literature review to quantify both local and global environmental impacts. The studies highlighted below used a variety of methodologies, including assigning economic values to environmental benefits, measuring air quality, carbon emissions, and VMT, and using the TIGER Benefit-Cost (BCA) Resource Guide. Key findings are displayed in **Figure 23**.

Shared use paths may contribute many environmental impacts over their lifespan. These may include ecological impacts, natural habitat and biodiversity impacts, stormwater management impacts, and carbon sequestration, among others. These impacts are substantial but were not included in the scope of this evaluation, which focuses on the direct environmental impact of reducing the number of vehicle trips and reduced VMT. The outputs from the transportation evaluation were used to determine the total environmental impact of an increase in commute trips using active transportation modes. The project team used the Federal Highway Administration's Congestion Mitigation and Air Quality Improvement (CMAQ) Program tool to conduct this evaluation[15][16]. The TIGER BCA was used to quantify the total fiscal cost of carbon and other greenhouse gas (GHG) emissions[17]. **Table 47** summarizes the data and evaluation methods used to understand and quantify the impacts shared use paths have on air quality and carbon emissions.

15 CMAQ Program Tool for Bicycle and Pedestrian Improvements. https://www.fhwa.dot.gov/environment/air_quality/cmaq/toolkit/.

16 The CMAQ tool uses emission rates based on a national-scale run of the EPA MOVES model. Emission estimates from tools in the CMAQ Toolkit are not intended for use in State Implementation Plans (SIPs) or transportation conformity analyses and do not meet the same requirements necessary for SIP and conformity reporting.

17 TIGER BCA Resource Guide. https://www.transportation.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

Figure 23 Environmental Analysis Key Findings

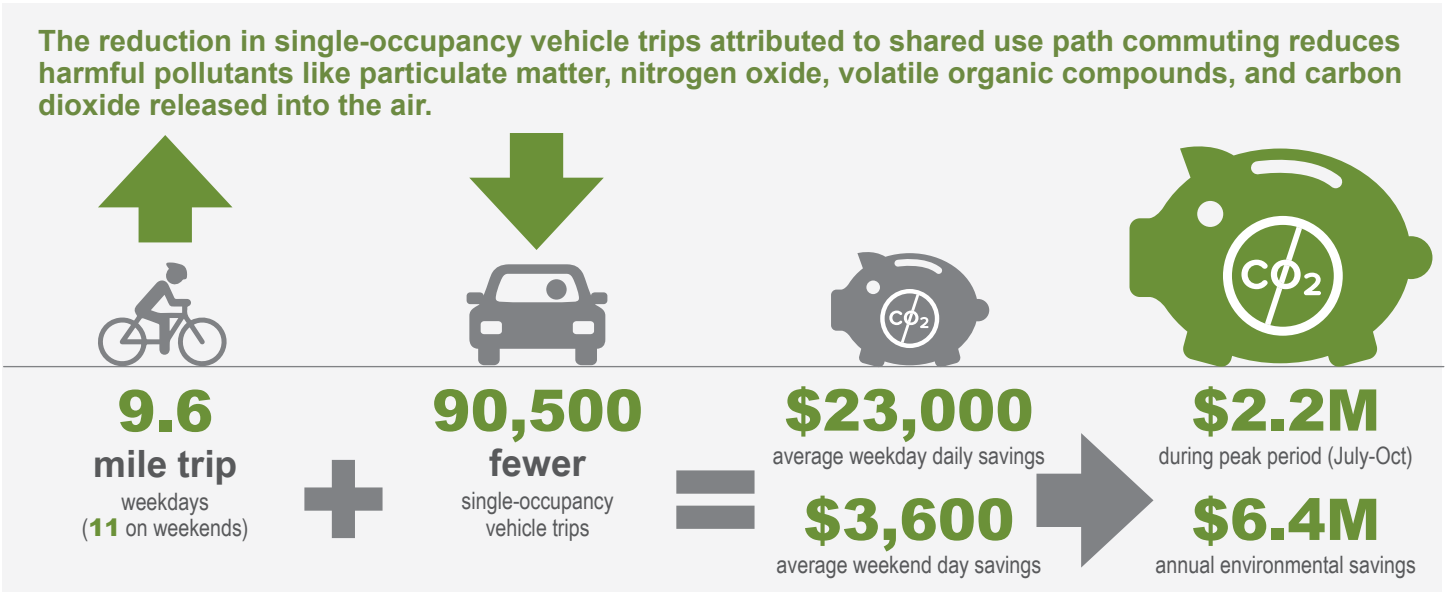


Table 47 Environmental Impact Evaluation Summary

IMPACT AREA	IMPACT SUBAREA	DATA	EVALUATION METHOD
Environmental	Air Quality	Path User Survey • Commute behavior • Mode choice	Congestion Mitigation and Air Quality Improvement Program (CMAQ Spreadsheet analysis Geographic analysis
	Carbon Emissions	Path User Survey • Commute behavior • Total commute distance traveled • Transportation mode to the path Social cost of carbon	TIGER Benefit-Cost Analysis Resource Guide: Value of Emissions

AIR QUALITY AND CARBON EMISSIONS

The project team began to assess the direct impacts the studied shared use paths have on air quality and carbon emissions by determining the number of vehicle trips and VMT as users shifted to commuting on the paths by active mode. The methodology for this evaluation is summarized in the Transportation section of this report and the results are summarized below in **Table 48**.

The data in **Table 48** were used as inputs to the CMAQ spreadsheet evaluation tool. The CMAQ calculator estimates the reduction in emissions resulting from improvements to bicycle and pedestrian infrastructure (construction of shared use paths) and associated mode shift from passenger vehicles to bicycling or walking. The CMAQ tool can be used to assess the environmental impacts of added sidewalks, dedicated bicycle infrastructure, improved wayfinding, mid-block crossing installations, bike share systems, and bike parking improvements. The inputs for the CMAQ tool include:

1. Project evaluation year
2. Estimated change in daily motorized passenger vehicle trips as a result of the bicycle/pedestrian infrastructure
3. Average typical one-way trip distance

Using these inputs, the CMAQ estimates the impact to the following types of emissions: carbon monoxide, particulate matter, nitrogen oxide, volatile organic compounds (VOCs), carbon dioxide equivalent, and total energy consumption (MMBTU).

Summarizing and collecting the findings from the transportation evaluation, including total reduced commuter one-way trips, total reduced VMT, and average commute distance traveled per path

The previous evaluation to determine total direct transportation impacts involved filtering survey respondents to include only path users who use the path for commute purposes at least once a week and would not otherwise commute by active mode if the paths did not exist. These individuals' responses are the only ones relevant to determine total transportation and environmental impacts of the shared use paths. **Table 49** summarizes the results from the transportation impact analysis that were used as inputs in the environmental evaluation.

Table 48 Extrapolated Reduction in Vehicle Trips

	TOTAL REDUCTION IN ONE-WAY COMMUTER TRIPS		TOTAL REDUCTION IN VMT (BASED ON AVERAGE TRIP LENGTH)	
	WEEKEND DAY	WEEKDAY	WEEKEND DAY	WEEKDAY
Minuteman Commuter Bikeway	1,349	48,942	25,891	377,335
Northern Strand Community Trail	1,299	16,755	4,123	29,217
MCRT-Norwottuck	3,826	14,336	45,084	203,572
Cape Cod Rail Trail	1,338	2,665	12,841	19,187
TOTAL	7,811	82,698	87,940	629,311

Table 49 Summarized Results from Transportation Impacts Evaluation

	TOTAL REDUCTION IN ONE-WAY COMMUTER TRIPS	TOTAL REDUCTION IN VMT	AVERAGE COMMUTE DISTANCE (MILES) PER PATH	
	TOTAL TRIPS	TOTAL TRIPS	WEEKEND DAY	WEEKDAY
Minuteman Commuter Bikeway	50,291	403,226	19	7
Northern Strand Community Trail	18,054	33,340	3	<0
MCRT-Norwottuck	18,162	248,656	12	14
Cape Cod Rail Trail	4,002	32,028	10	8
TOTAL	90,509	717,251	11	9

Inputting the data into the CMAQ spreadsheet tool and summarizing outputs

The project team used the CMAQ tool to calculate the total environmental impacts as a result of shared use path usage. The results were based on the reduction in total pollutants resulting from fewer vehicle commute trips. The CMAQ tool provided the total units of each pollutant. The project team used the TIGER BCA to determine the economic values for each unit of pollutant. The TIGER BCA provided information on economic values for each pollutant based on the value of each emission. It also provided the social cost of carbon emissions, valuing it at $49 per metric ton[18] in 2018 (the year survey data was collected). The reduction in vehicle emissions for weekday and weekend path users are summarized in **Table 50** below. The reduction in GHG emissions and air pollutants were measured in pounds and converted into daily and annual cost savings.

The project team then extrapolated these results to the total trip users during the peak period from July through October 2019. The reduced GHG emissions were based only on new active commute trips that can be attributed directly to path use. **Table 51** summarizes the total cost savings that result from reduced GHG emissions as commuters opt to switch from commuting by vehicle to commuting on the path by active mode.

According to these results, shared use paths contribute substantially to reducing commuter-based GHG emissions. Based solely on path use during July-October 2019, reduced GHG emissions translate to over $24,000 in cost savings on an average weekday and approximately $3,700 on a weekend day. During peak summer months, active commuters contribute over $2 million dollars in environmental savings.

Table 50 Weekday Reduction in Vehicle-Related Emissions from Surveyed Path Users

	2018 TOTAL DAILY (LBS.)		DAILY COST 2018		2018 ANNUAL ESTIMATED COST ($2013)
	Weekday	Weekend Day	Weekday	Weekend Day	Total
Volatile Organic Compounds (VOCs)	345	54	$315	$50	$86,675
Nitrogen Oxides (NOx)	522	81	$1,865	$290	$516,970
Carbon Dioxide Equivalent (CO_2e)	504,420	78,330	$11,210	$1,740	$3,107,175
Particulate Matter < 10µm (PM10)	59	9	$9,685	$1,505	$2,684,400
		TOTAL	$23,075	$3,585	$6,395,225

18 Cost is reflected in 2013 dollars.

Table 51 Total Savings from Reduced Vehicle Emissions for Total Trail Users (July-October 2019 Trips)

	AVERAGE WEEKDAY DAILY SAVINGS	AVERAGE WEEKEND DAY DAILY SAVINGS	ROUNDED TOTAL JULY-OCTOBER
Cape Cod Rail Trail	$850	$550	$94,900
Minuteman Commuter Bikeway	$13,800	$1,050	$1,265,200
Northern Strand Community	$300	$150	$31,800
MCRT-Norwottuck	$8,100	$1,850	$783,600
Total	$23,100	$3,600	$ 2,175,500

Photo by Jeff Dietrich

Safety

It is critical to understand and measure the safety, comfort, and well-being of path users. Safety impacts can be both measured and perceived. The project team sought to understand both perception and physical safety impacts provided by the shared use paths. This section includes safety impacts related to crash and crime rates. **Table 52** summarizes the data and evaluation methods that the project team used to quantify the safety impacts of shared use paths.

Table 52 Safety Impact Evaluation Summary

IMPACT AREA	IMPACT SUBAREA	DATA	EVALUATION METHOD
Safety	Crash Rates	TIGER BCA cost of crash by severity Path User Survey • Commute behavior • Total commute distance traveled Average Daily Traffic Volumes Roadway Classifications	*Highway Safety Manual* Geographic analysis
	Crime	Path User Survey • Perceived crime	Spreadsheet analysis

CRASH RATES

The project team used the American Association of State Highway and Transportation Officials' (AASHTO) *Highway Safety Manual (HSM)* tool to quantify the impacts on crash rates near each of the four shared use paths. The HSM uses roadway characteristics, such as roadway classifications and volumes, to estimate the crash rate on a particular 0.5-mile roadway segment. The HSM calculations vary slightly depending on the roadway type: Urban/Suburban Arterial or Rural Roadway.

The *HSM* tool was used to determine crash rates for the corridors near each shared use path under two scenarios:

1. No change in travel mode
2. Vehicular trips replaced by active mode trips on the shared use paths

The project team used the vehicular trip reductions determined in the transportation impacts section as an input for the crash impact analysis.

Identifying representative 0.5-mile roadway segments near each of the four shared use paths

The *HSM* analyzes 0.5-mile segments, so the project team identified representative roadway segments near each of the four shared use paths. **Table 53** summarizes the *HSM* inputs for each of the four shared use paths, including the selected representative 0.5 mile roadway segment, *HSM* classification tool used, roadway volume, and approximate reduced volume (as a result of vehicle trips being replaced by trips taken on the paths). Two paths, the Cape Cod Rail Trail and the MCRT-Norwottuck, run alongside both Urban/Suburban Arterial type roadways and Rural Roadways (as classified by the *HSM*).

Entering data into the HSM tool to determine crash reduction

The *HSM* tool uses the inputs shown in **Table 53** and calculates the resulting crash rate (crashes per mile per year). It determines the crash rates for both fatal and injury crashes, and property damage only crashes. The tables below summarize crash rate reductions for each 0.5-mile segment of roadway near the four shared use paths. Crash rates were measured in number of crashes per mile per year. As shown in **Table 53**, the shared use paths are several miles long, so the crash rates listed below do not reflect the crash rate reduction for the entire length of each trail. The crash rate reduction results by path are delineated in **Tables 54 - 57**.

Table 53 Roadway Segments for HSM Calculations

	Parallel Roadways	0.5 Mile Road Segment Extents	*HSM* Classification	ADT	Approximate Reduced ADT*
Minuteman Commuter Bikeway (2.38 mi)	Massachusetts Ave	Clarke Street to Hunt Road	Urban/Suburban Arterial	20,800	534
Northern Strand Community Trail (2.35 mi)	Eastern Ave	Franklin Street to Main Street / Madison Street	Urban/Suburban Arterial	21,500	140
MCRT-Norwottuck Rail Trail (3.34 mi)	Northampton Road	University Drive to Greenleaves Drive	Urban/Suburban Arterial	20,000	113
	Highway 9	Rolling Green Drive to Logtown Road	Rural	11,500	113
Cape Cod Rail Trail (7.57 mi)	6A Old King's Highway	Wall Street to Taylor Lane	Urban/Suburban Arterial	11,500	25
	6A Old King's Highway	Main Street to Alden Drive	Rural	11,000	25

* Based on reduced VMT from path counts collected (July-October 2019)

Table 54 Minuteman Commuter Bikeway Crash Rate Reduction

CRASH SEVERITY LEVEL	CRASH RATE (CRASHES/MI/YEAR)
Fatal and injury	-0.082
Property damage only	-0.185
Total	-0.267

Table 55 Northern Strand Community Trail Crash Rate Reduction

CRASH SEVERITY LEVEL	CRASH RATE (CRASHES/MI/YEAR)
Fatal and injury	-0.038
Property damage only	-0.077
Total	-0.114

Table 56 MCRT-Norwottuck Crash Rate Reduction

	URBAN AND SUBURBAN ROADWAY SEGMENTS	RURAL ROADWAY SEGMENTS
CRASH SEVERITY LEVEL	CRASH RATE (CRASHES/MI/YEAR)	
Fatal and injury	-0.010	-0.010
Property damage only	-0.027	-0.022
Total	-0.037	-0.033

Table 57 Cape Cod Rail Trail Crash Rate Reduction

	URBAN AND SUBURBAN ROADWAY SEGMENTS	RURAL ROADWAY SEGMENTS
CRASH SEVERITY LEVEL	CRASH RATE (CRASHES/MI/YEAR)	
Fatal and injury	-0.005	-0.003
Property damage only	-0.011	-0.006
Total	-0.016	-0.008

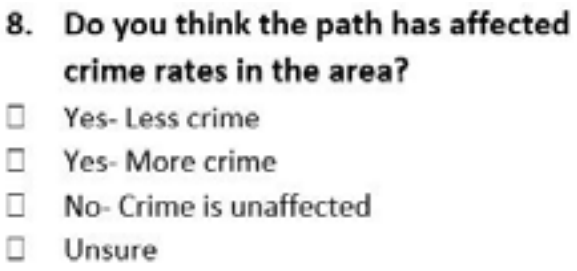
By assuming that path users would otherwise be driving on the adjacent roadways listed in **Table 53**, the results of the analysis show that the reduction in vehicular trips resulting from people choosing to travel on the shared use paths results in a lower crash rate on the roadways directly adjacent to them. The Minuteman Commuter Bikeway shows the most significant effect, with a crash rate reduction of 0.267 crashes per mile per year. There are not HSM calibration factors for Massachusetts roadways, and therefore these HSM numbers have not been calibrated and can not be validated as the actual crash rate reduction due to the paths.

There are many factors that contribute to crash rates along a roadway. This analysis is meant to serve as a starting point for understanding the total safety impacts that can be attributed to shared use paths. The next section will evaluate the perceived effect on safety and criminal activity that result from the shared use paths.

PERCEIVED EFFECT ON SAFETY & CRIMINAL ACTIVITY

This analysis quantifies the sentiments of shared use path users regarding personal and community safety by utilizing intercept survey data. Each survey respondent reported their opinions on the following question:

Figure 24 Question #8 from Path User Survey


8. **Do you think the path has affected crime rates in the area?**

- ☐ Yes- Less crime
- ☐ Yes- More crime
- ☐ No- Crime is unaffected
- ☐ Unsure

Simple percentages were calculated for these survey questions, and opinions on crime were then juxtaposed with the respondents' path use frequency and likeliness to pursue their activity elsewhere to determine if perceived safety concerns influence path usage. The results of this analysis are displayed in **Figure 25**.

Overall, 48% of respondents indicated they think the shared use path has had no effect on crime rates in the area, while 23% think that the path's presence has reduced crime rates in the area. Approximately 29% of users responded that they felt unsure whether or not the path had an effect on crime. Only one respondent indicated that the presence of the MCRT Norwottuck has increased crime in the area. Interestingly, the MCRT-Norwottuck Rail Trail data included the largest sample size of the four studied paths, and 30% of users indicated that they felt the path has decreased crime in the area. Respondents on the Cape Cod Rail Trail indicated being unsure most often, which could be due to the large number of tourists who use the path.

Table 58 combines the frequency with which respondents report visiting the path with their perception of safety in the area.

Those who visited the paths at least four times per week responded at the highest rate that the path's presence has no effect on or decreases crime, while users who were visiting for the first time or who visited several times per year responded at the lowest rate that the path's presence has no effect on or decreases crime. This finding could indicate that the more time a user spends on the path, the more likely they might be to perceive the path reducing crime or having no effect on crime in the area. Conversely, the finding could also indicate that a user is more likely to use a path if they perceive it to improve the safety of the area.

Table 59 compares respondents' perception of safety with their likelihood to pursue the same activity (walking, bicycling, etc.) elsewhere if the path did not exist.

Across the substitution responses (No, Unsure, Yes), the opinion that the path has no effect on crime predominates, and is most common among users who would likely pursue their intended activity if the path were not present. Interestingly, of respondents who think the path has decreased crime in the area, those who would not be pursuing their intended activity elsewhere held this opinion at the highest rate, which could indicate a positive perception of safety on the path.

Figure 25 Perceived Safety by Path

"Do you think the path has affected crime rates in the area?"

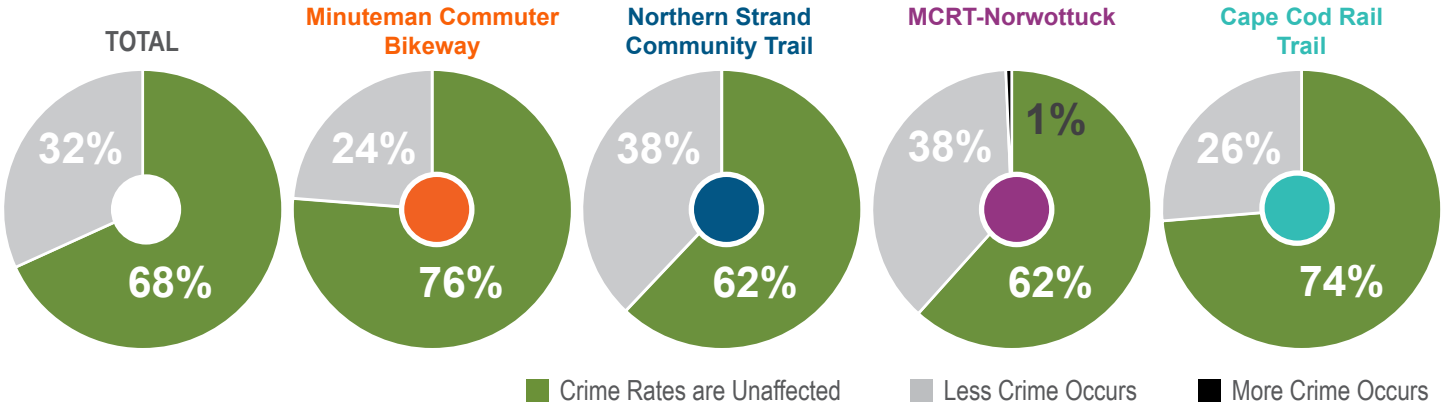


Table 58 Perceived Safety by Path Visiting Frequency

FREQUENCY VISITING THE PATH	"DO YOU THINK THE PATH HAS AFFECTED CRIME RATES IN THE AREA?"				
	No - Unaffected	Unsure	Yes - Less	Yes - More	Total
Daily	47%	26%	28%	0%	100%
4+ times per week	68%	21%	12%	0%	100%
1-3 times per week	50%	26%	24%	0%	100%
Monthly	44%	28%	22%	6%	100%
Several times per month	42%	25%	33%	0%	100%
Several times per year	43%	37%	20%	0%	100%
This is my first time	32%	47%	21%	0%	100%
TOTAL	**49%**	**28%**	**23%**	**0%**	**100%**

Table 59 Perceived Safety by Path Use Substitution

"IF THE PATH DIDN'T EXIST, WOULD YOU STILL PARTICIPATE IN THIS ACTIVITY ELSEWHERE TODAY?"	"DO YOU THINK THE PATH HAS AFFECTED CRIME RATES IN THE AREA?"				
	No - Unaffected	Unsure	Yes - Less	Yes - More	Total
No	48%	28%	24%	0%	100%
Unsure	45%	32%	23%	0%	100%
Yes	50%	28%	22%	0%	100%
TOTAL	**48%**	**29%**	**23%**	**0%**	**100%**

Accessibility & Equity

It is crucial to recognize the role that transportation serves in either empowering or undermining communities. Similarly, access to transportation is an issue that many disadvantaged groups face for various historically entrenched reasons. The following analyses were conducted to quantify how many essential destinations shared use paths can provide access to, and to whom this access is provided. **Table 60** summarizes the data and evaluation methods that the project team used to quantify the accessibility & equity impacts of shared use paths.

For these analyses, the project team used Census information, GIS analysis, route modeling, and intercept surveys. The methodologies outlined in this section focus on quantifying the societal impacts of accessibility and equity.

For the purpose of these analyses, transportation-disadvantaged populations include people who are

- aged 65 or older,
- aged 19 or younger,
- have a disability,
- are of a racial and/or ethnic minority,
- live in a household without access to a car,
- or live in a limited English-speaking household.

Some of these demographics were identified by the Massachusetts Executive Office of Energy and Environmental Affairs as 'Environmental Justice Communities' and included in the Massachusetts Bicycle Transportation Plan, while others were identified for inclusion by the project team in the aim of conducting both a broad and deep analysis of the role of shared use paths in equitably providing mobility options. For the purpose of these analyses, essential destinations include

- schools,
- libraries,
- community health centers,
- civic buildings,
- and institutes of higher education.

Key findings are displayed in **Figure 26**.

Table 60 Accessibility & Equity Evaluation Summary

IMPACT AREA	IMPACT SUBAREA	DATA	EVALUATION METHOD
Social Justice	Access and Equity	GIS Data • Sidewalk and bicycle facilities surrounding paths • Essential destinations Walk- and bike-sheds American Community Survey • Demographic data	Geographic analysis Network analysis

Figure 26 Equity & Access Key Findings

Essential destinations accessible via shared use path:

Minuteman Commuter Bikeway	Northern Strand Community Trail	MCRT-Norwottuck	Cape Cod Rail Trail
39	31	28	11

Total population within walking and biking distance of the shared-use path:

	Minuteman Commuter Bikeway	Northern Strand Community Trail	MCRT-Norwottuck	Cape Cod Rail Trail
	11,715	3,470	2,380	65
	290	175	220	40

ASSUMPTIONS

- The Walkability analysis was based on an average travel speed of 3 mph, which is associated with able-bodied adults, and therefore may not accurately reflect the variable speeds at which different users bicycle.
- The Walkability analysis assumed that all walking activity occurs on sidewalk facilities or roadways with a MassDOT functional class of 5 or 6, or a functional class of 4 with a speed limit less than 20 mph and average daily volume of less than 1,000 vehicles. These parameters are based on industry-accepted conditions for walking. The methodology does not account for unpaved walkways, which may serve people who walk but are not formally accounted for in the available data.
- The Bikeability analysis is based on an average travel speed of 9 mph, which is associated with able-bodied adults, and therefore may not accurately reflect the variable speeds at which different users bicycle.
- The Bikeability analysis assumes that all bicycle activity occurs on roadways with dedicated bicycle facilities (such as shared use paths, bicycle lanes, or shared vehicle-bicycle lanes—i.e., sharrows) or on roadways with a MassDOT functional classification between 4 and 6 with average daily volumes of less than 3,000 vehicles and a speed less than 25 mph. These parameters are based on industry-accepted conditions for biking.
- The Bikeability analysis assumes that no sidewalk riding occurs, which may not accurately represent the behaviors of people bicycling.
- Informal access points to the paths may exist that are unaccounted for within this analysis, but still serve the local community.
- This analysis assumes that transportation-disadvantaged populations are dispersed evenly within each Census tract.

ACCESS TO THE PATH

This analysis intended to quantify the number of people within walking and bicycling range of the shared use path in their community, by yielding estimated of people and households within 15 minutes' walking and 15 minutes' bicycling distance of the studied shared use paths. The paths and their walksheds are displayed in **Figure 27**, while the bikesheds and paths are displayed in **Figure 28**. The total population within walking and bicycling distance of their community path is displayed in **Table 61**. Naturally, areas with higher population density, such as the communities surrounding the Minuteman Commuter Bikeway and the Northern Strand Community Trail, exhibit higher counts of people and households with access to the shared use paths.

Table 61 Total Population within Walking & Bicycling Distance of Path on Dedicated Facilities

	WALK	BIKE
Minuteman Commuter Bikeway	33,400	7,725
Northern Strand Community Trail	26,000	7,815
MCRT-Norwottuck	4,170	3,050
Cape Cod Rail Trail	225	50

Figure 27 Shared Use Paths & Walksheds

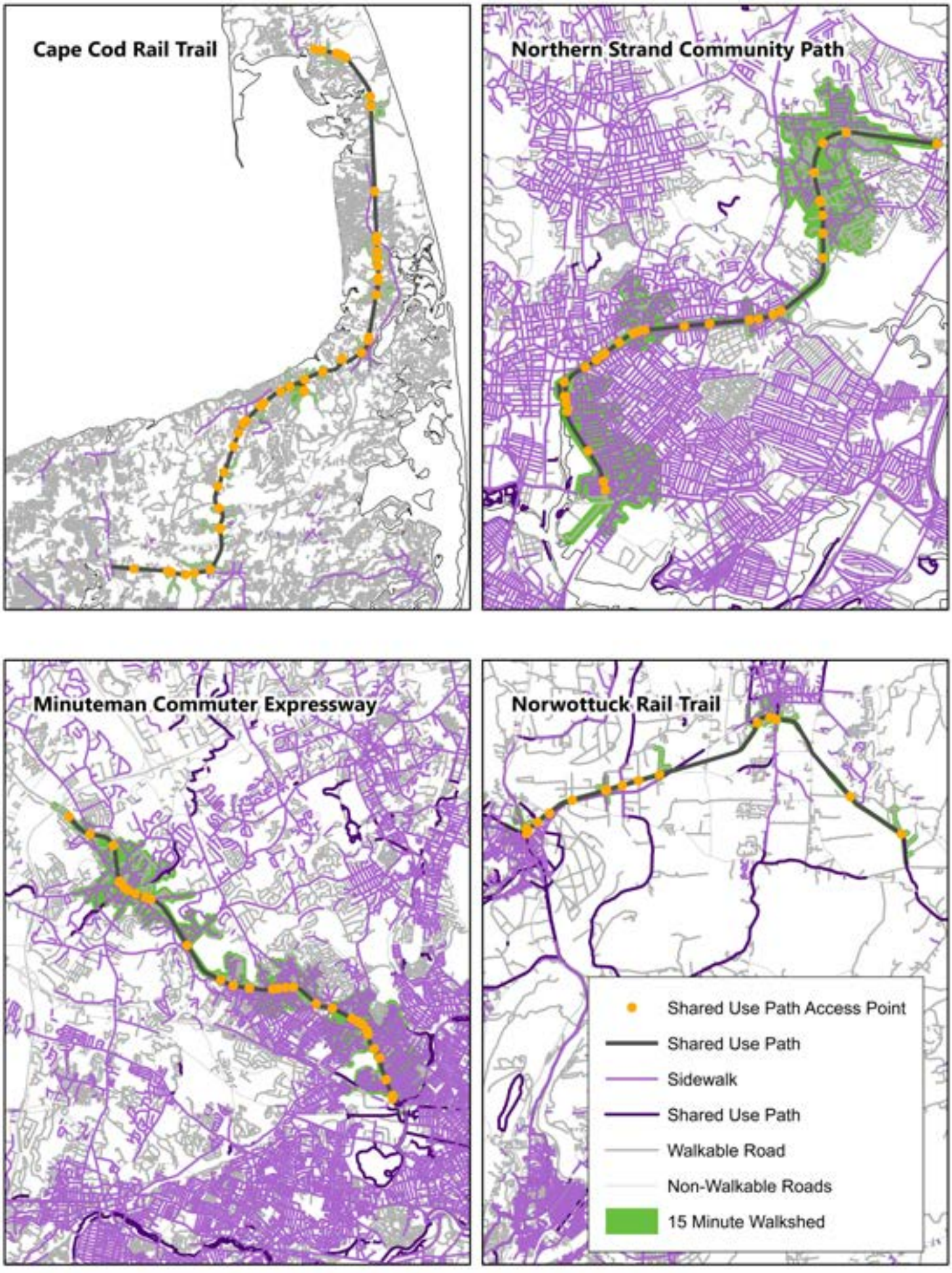
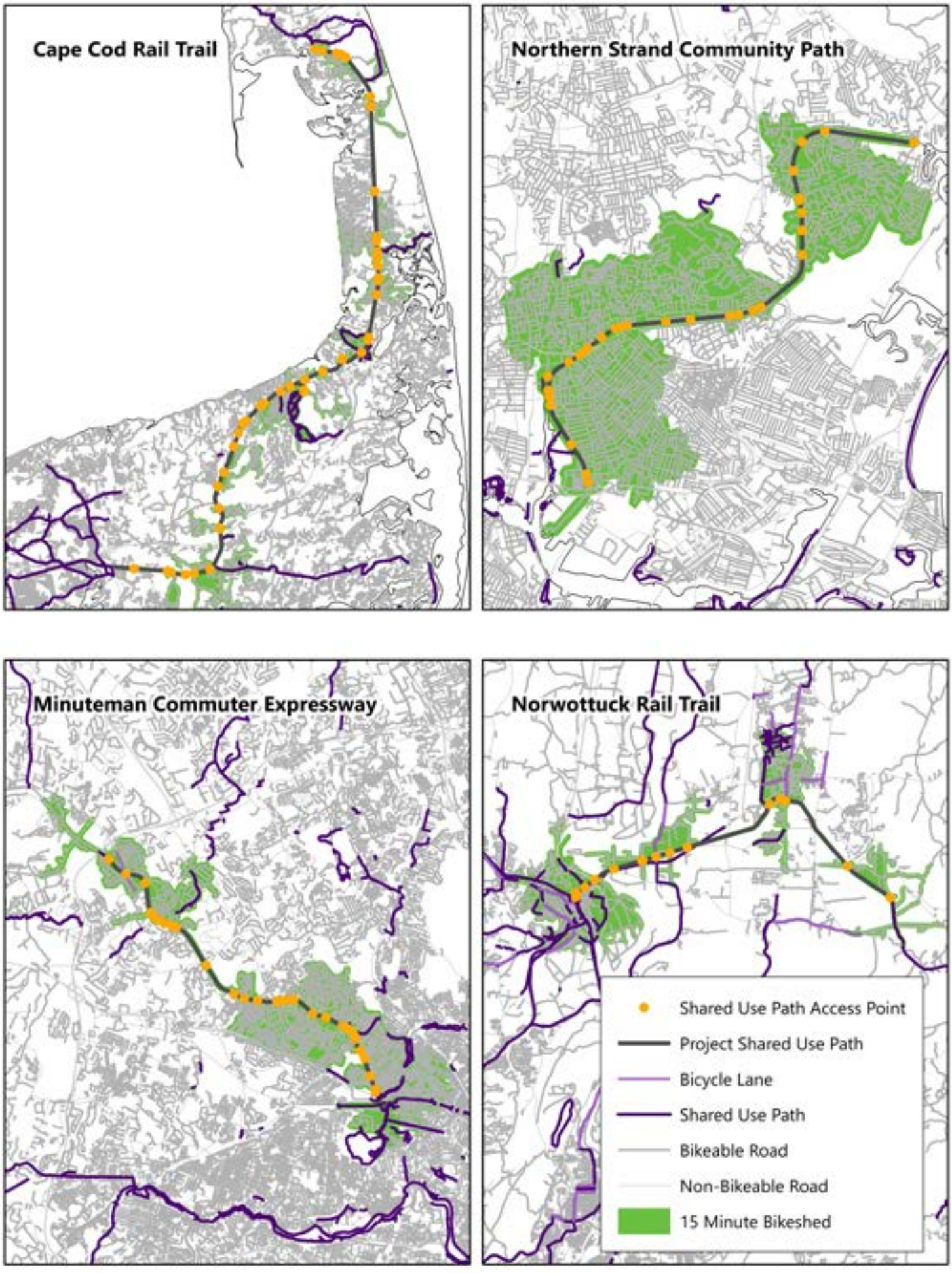


Figure 28 Shared Use Paths & Bikesheds



This analysis specifically sought to quantify the transportation-disadvantaged populations within walking and bicycling distance of their community path. The results of this analysis are displayed in **Table 62**.

On average:

- By walking 15 minutes, about 2,200 people aged 65+, 3,700 people aged 19-, 1,600 people with a disability, 4,100 of a racial and/or ethnic minority, 3,400 people experiencing poverty, 1,200 households without a car, and 1,000 households with limited English speaking ability can access one of the studied shared use paths.
- By bicycling 15 minutes, about 600 people aged 65+, 1,100 people aged 19-, 400 people with a disability, 1,300 people of a racial and/or ethnic minority, 900 people experiencing poverty, 400 households with limited English speaking ability, and 400 households without access to a car can access one of the studied shared use paths.

These results indicate that shared use paths are accessible to several transportation-disadvantaged populations for utilitarian, commuting, recreational, and exercise purposes. It is important to note a key consideration that arises from the data presented above: even though bicycling allows a user to travel further in the same time period than they would be able to by walking, more people are able to access the path by walking than bicycling. This indicates that pedestrian facilities, namely, sidewalks, are much more prevalent in the communities served by the paths than other on-street bicycle facilities are. This lack of connectivity for people on bikes can often result in forced sidewalk riding or prevented bicycle trips due to roadway barriers.

The demographic characteristics of the areas hosting the paths are displayed below in **Figure 30 – Figure 37**.

Table 62 Access to Shared Use Paths for Transportation-Disadvantaged Populations

	Minuteman Commuter Bikeway		Northern Strand Community Trail		MCRT-Norwottuck		Cape Cod Rail Trail	
	WALK	BIKE	WALK	BIKE	WALK	BIKE	WALK	BIKE
Elderly Population (65+)	5,420	1,090	2,800	880	555	285	75	20
Youth Population (19-)	7,635	1,645	6,050	1,760	900	960	35	10
Population with a Disability	2,885	655	3,000	875	385	240	30	10
Population of a Racial or Ethnic Minority	6,145	1,640	9,720	2,985	475	470	10	1
Population Experiencing Poverty	7,275	1,435	5,870	1,670	560	370	30	10
Households with Limited English Speakers	1,125	365	3,740	1,170	30	75	1	1
Households with No Vehicle Access	1,375	585	2,230	740	300	340	5	1

Figure 29 Population Density by Census Tract

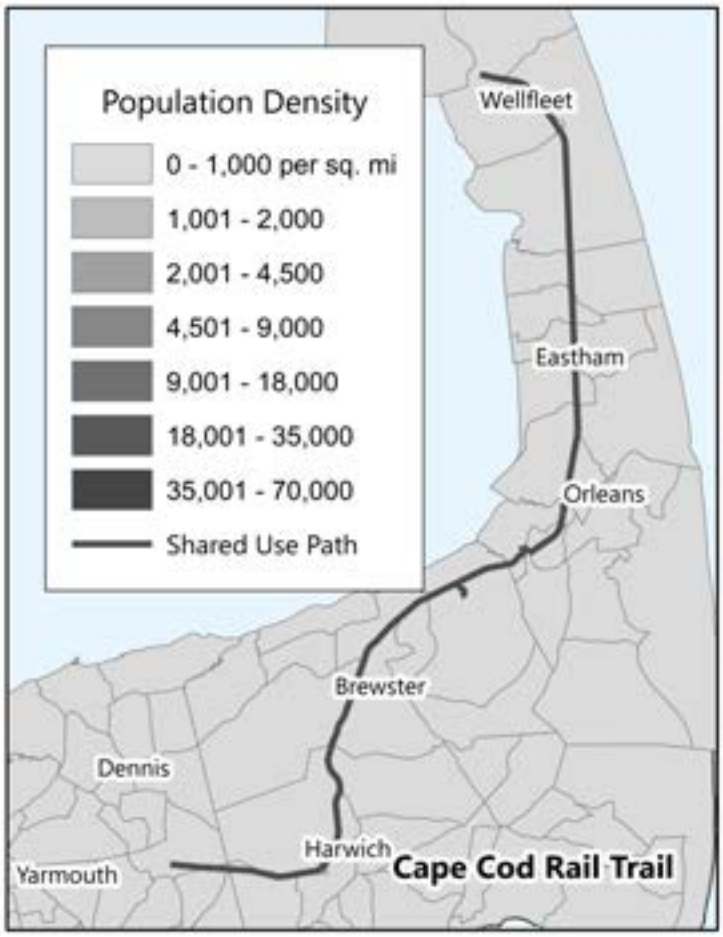


Figure 30 Households Without Vehicle Access by Census Tract

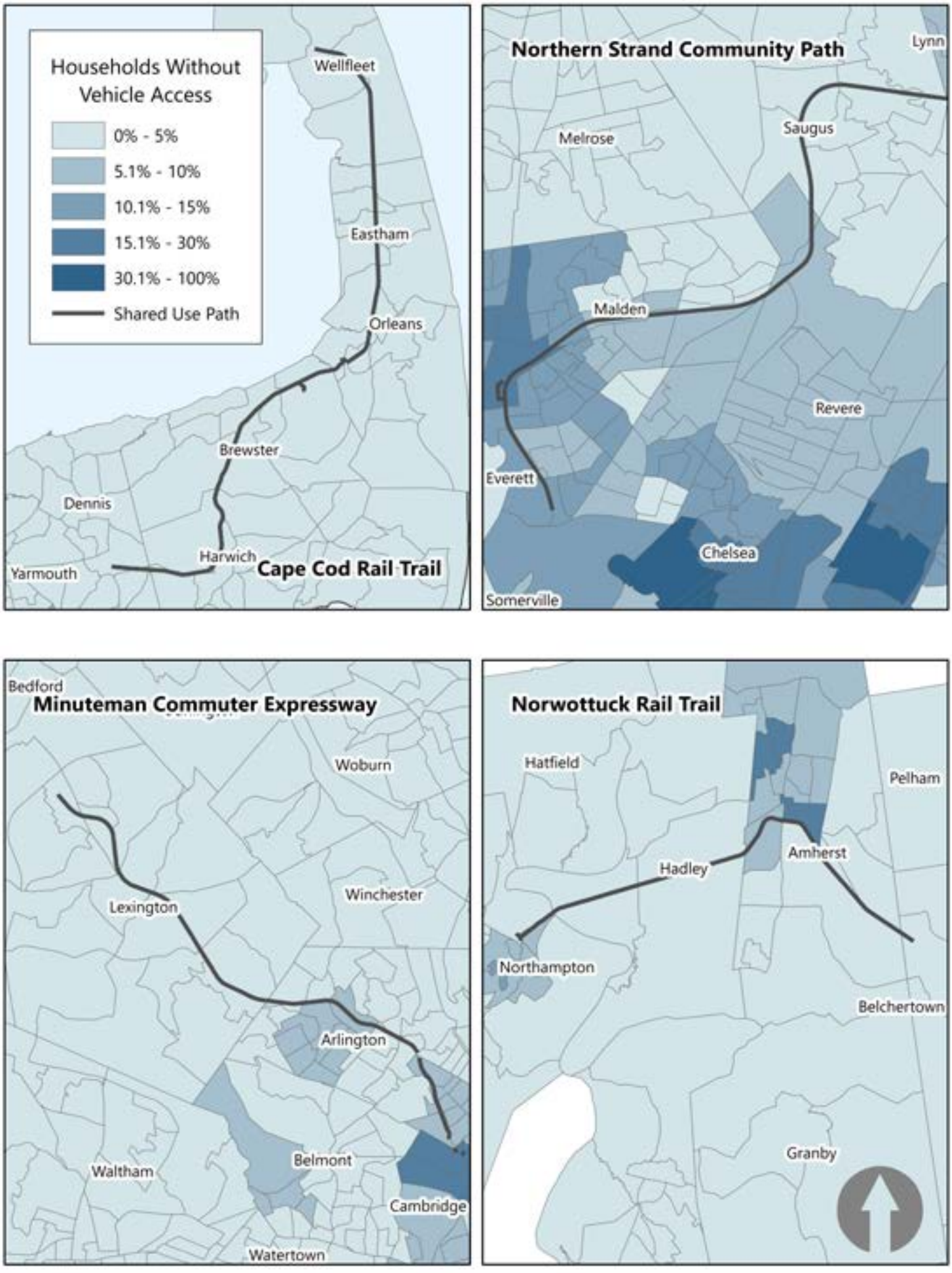


Figure 31 Limited English-Speaking Households by Census Tract

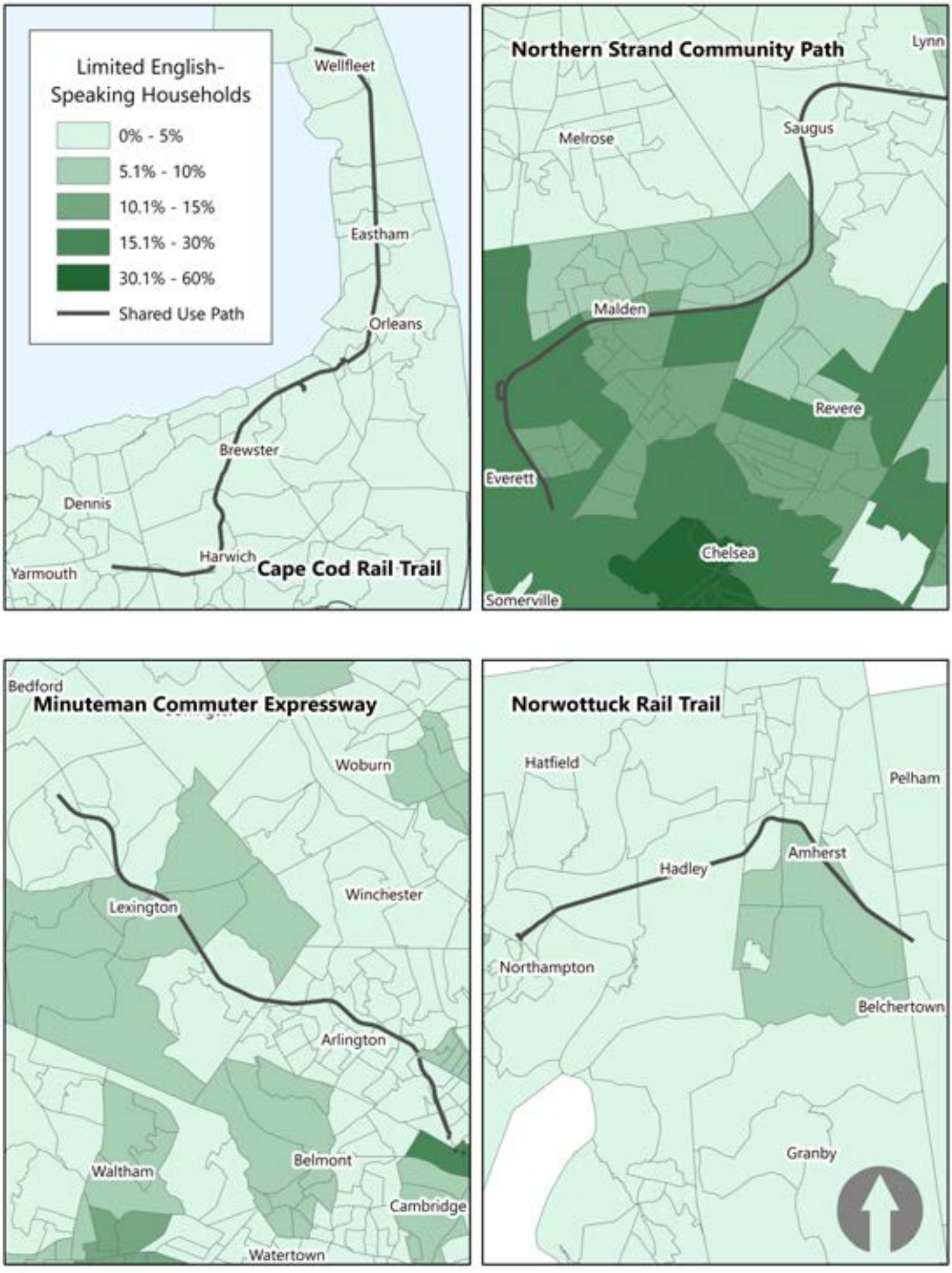


Figure 32 Population Aged 65 or Older by Census Tract

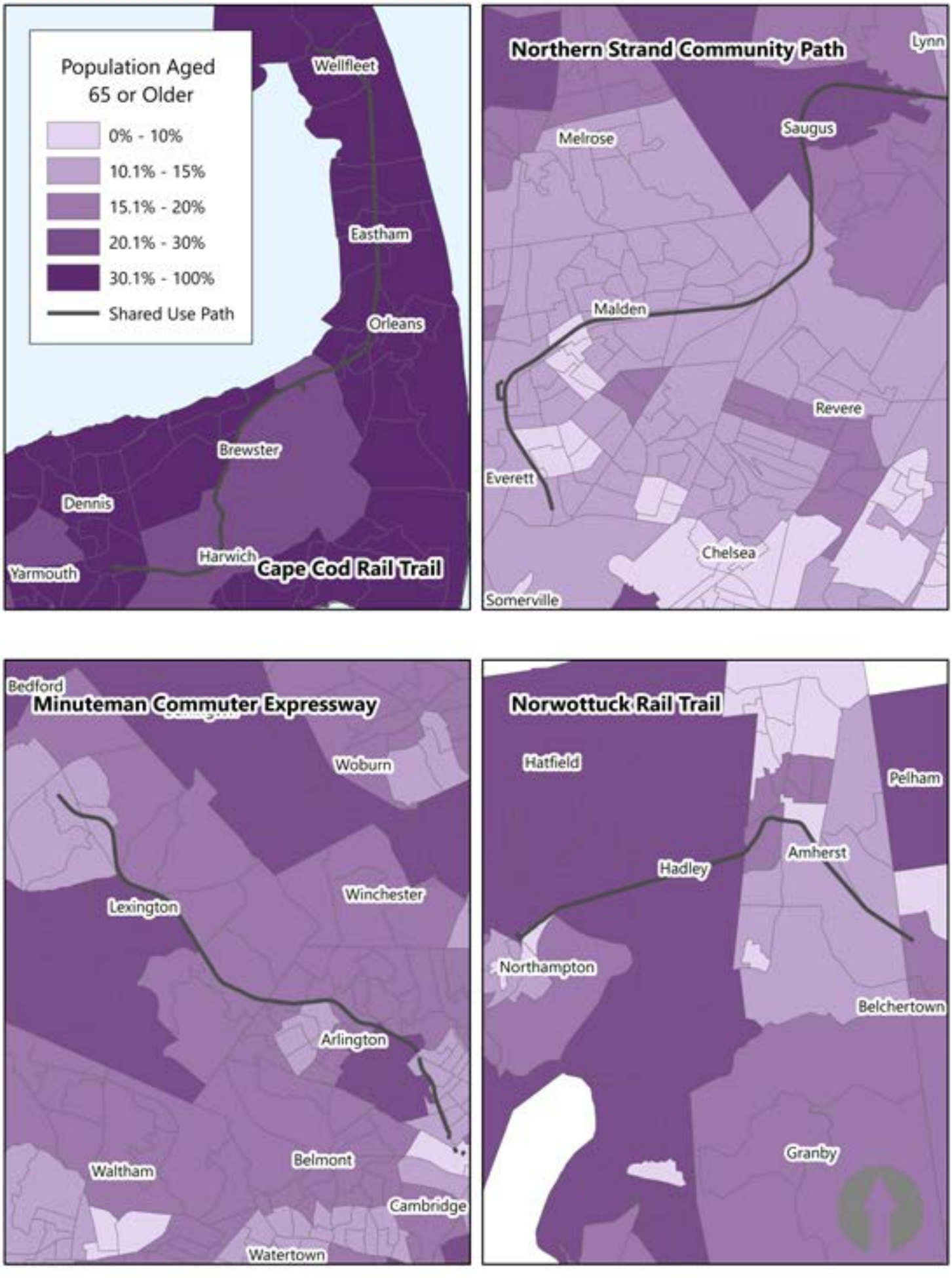


Figure 33 Population Aged 19 or Younger by Census Tract

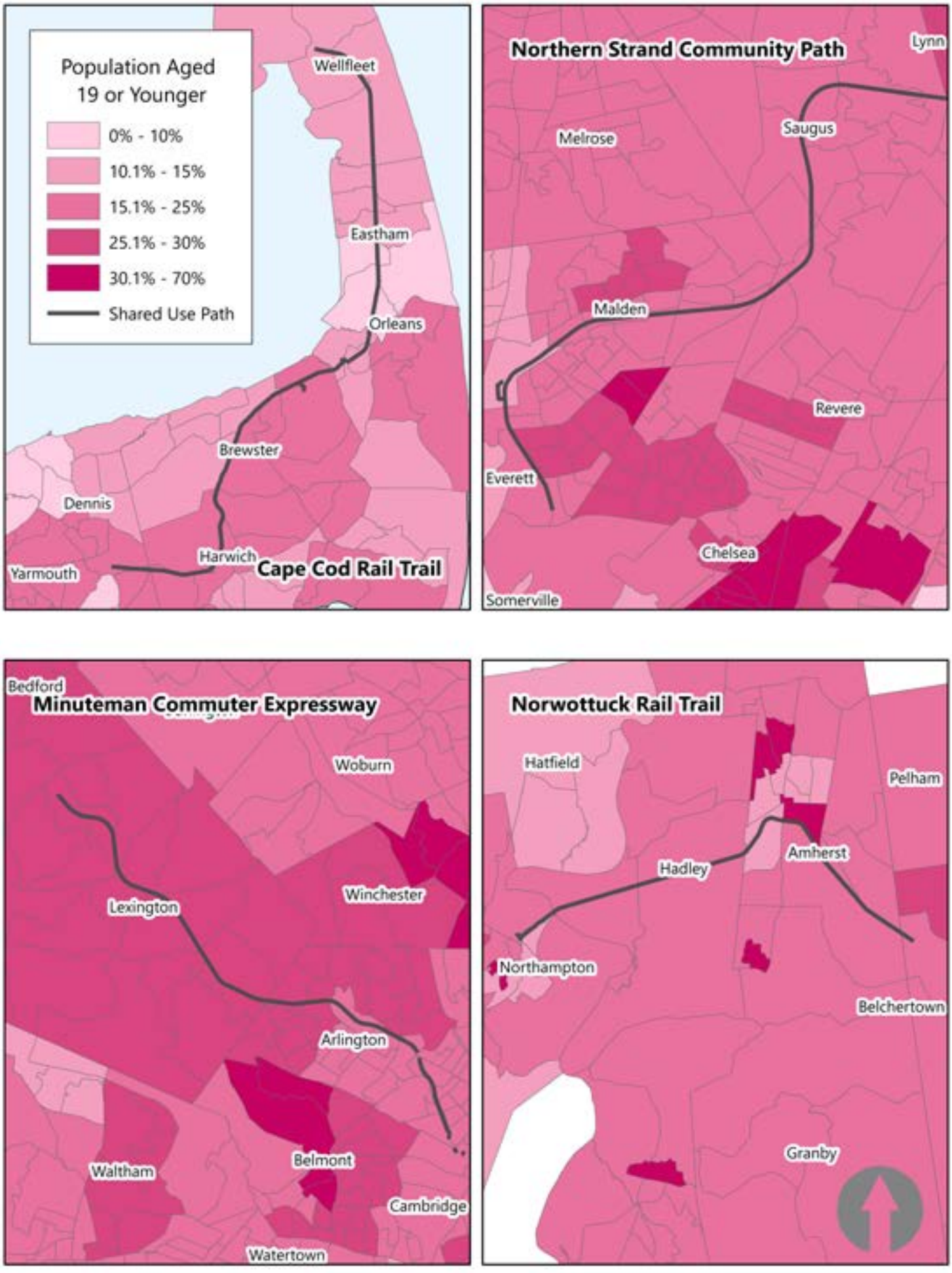


Figure 34 Population with a Disability by Census Tract

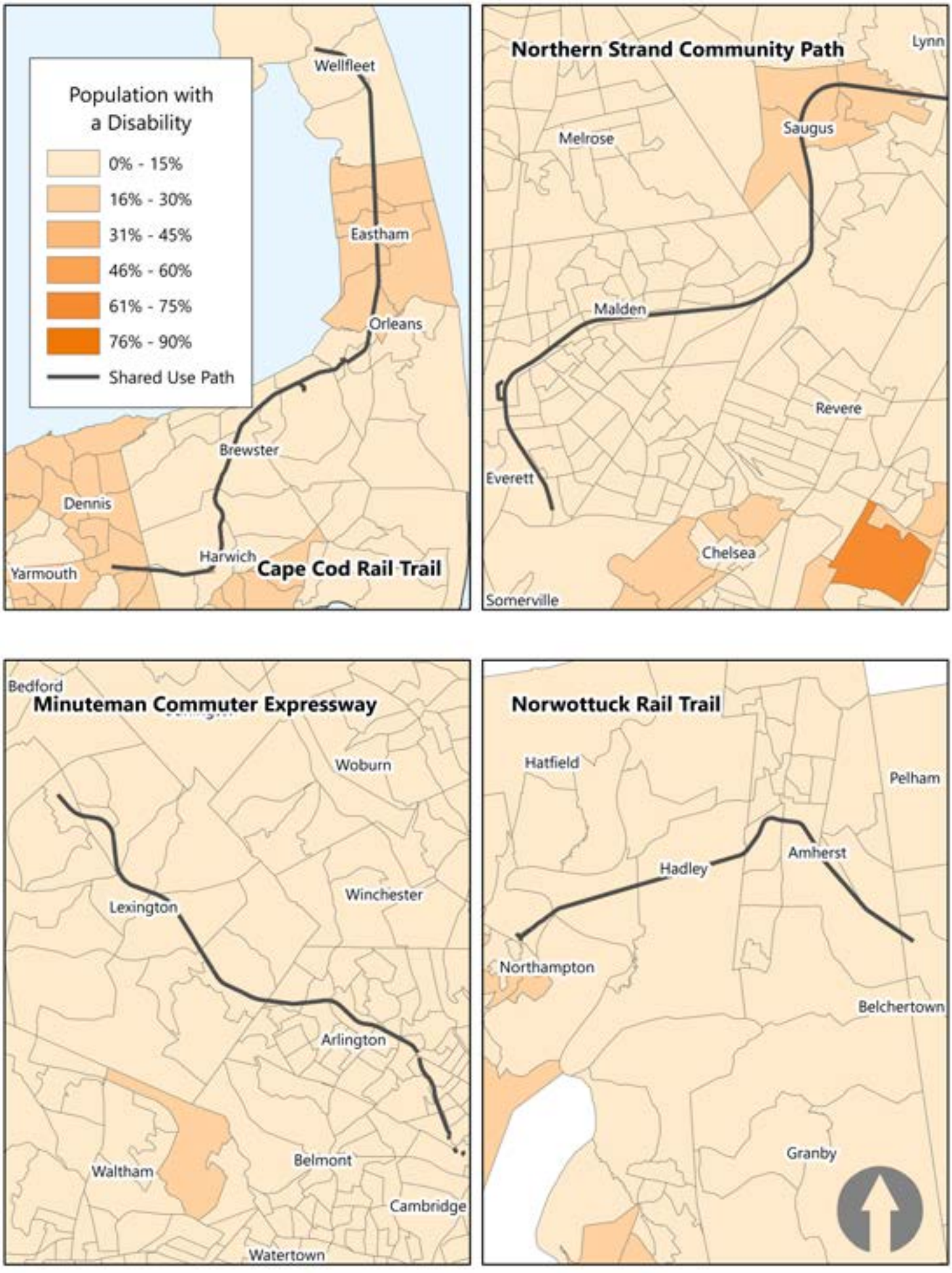


Figure 35 Population of an Ethnic or Racial Minority by Census Tract

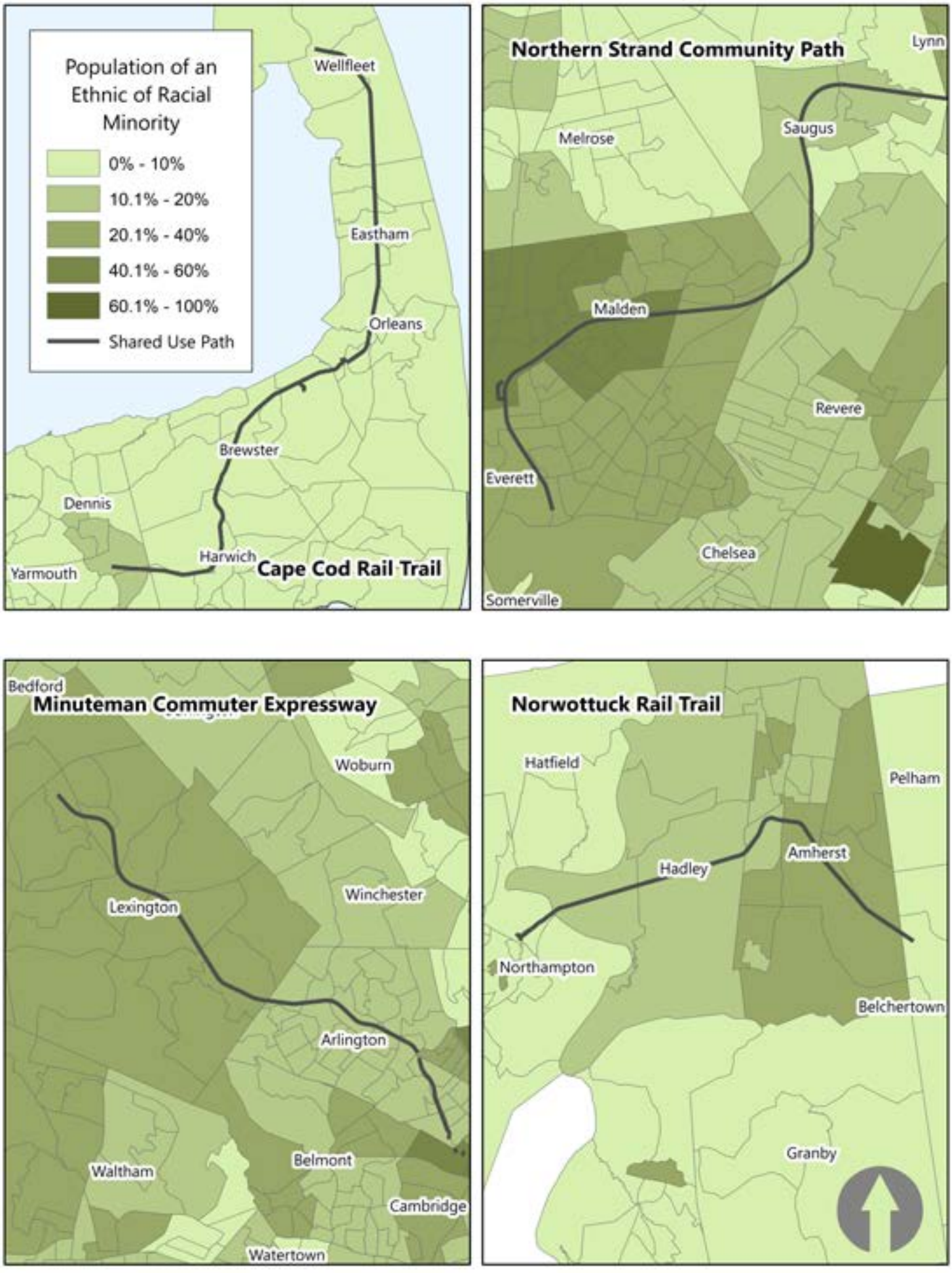


Figure 36 Population Experiencing Poverty by Census Tract

ACCESS TO ESSENTIAL DESTINATIONS

The purpose of this analysis was to quantify the number of people within walking and bicycling range of essential destinations in their community, in order to understand the role that shared use paths play in connecting people with essential destinations.

This analysis yielded approximations of the number of essential destinations that are accessible to the communities surrounding the studied shared use paths. These results are displayed in approximate counts of essential destinations within the 15 minute walk- and bikesheds, in **Table 63** below as well as **Figure 37**.

Additionally, for the access and equity analysis, future studies may be able to access more refined datasets to understand where within block groups residential parcels exist, to have a more refined analysis of the number of people with access to the paths. Accurate residential parcel data with enough detail to understand the number of residential units was not available for this study.

Table 63 Access to Essential Destinations for All Studied Shared Use Path Communities

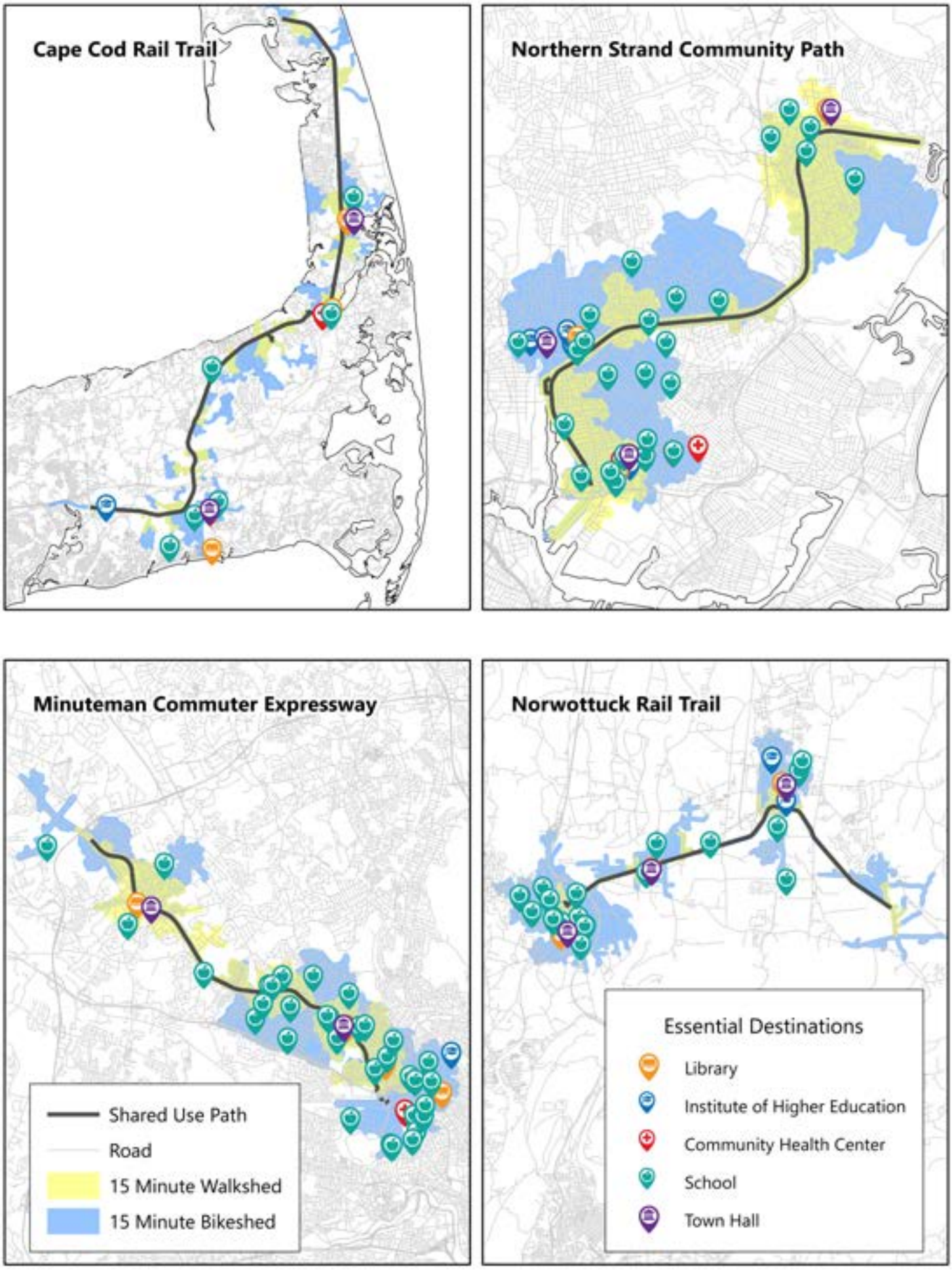
ESSENTIAL DESTINATION	(COUNT OF ESSENTIAL DESTINATIONS ACCESSIBLE)							
	Minuteman Commuter Bikeway		Northern Strand Community Trail		MCRT-Norwottuck		Cape Cod Rail Trail	
	WALK	BIKE	WALK	BIKE	WALK	BIKE	WALK	BIKE
Library	3	4	2	2	2	2	1	4
Community Health Center	-	1	-	5	-	4	3	-
School	-	1	1	2	-	-	1	-
Institute of Higher Education	18	31	14	20	2	19	2	5
Town Hall	2	2	2	2	1	3	1	2
TOTAL	23	39	19	31	5	28	8	11

FUTURE RESEARCH

Shared use paths provide opportunities for exercise and transportation for those bicycling, walking, scooting, skating, and taking other active modes, on a facility separated from vehicles. These opportunities impact the path users and communities near the paths in a variety of ways. An increase in exercise opportunities provides physical health benefits, mental health and well-being benefits, and reduced healthcare costs. Paths can also create transportation opportunities for active modes by connecting other active transportation facilities or connecting to destinations like schools, workplaces, or transit. People who use the path for transportation reduce vehicle usage, which subsequently decreases VMT, GHG emissions, and vehicular crashes. Not only do reduced vehicle trips contribute to a reduction in GHG emissions and overall improvement in local and global environmental conditions, but they also reduce noise pollution, enhance natural habitats and ecosystems, encourage healthy lifestyles, and generate revenue, benefitting the economy.

While this study focused on the peak usage period of July-October 2019 for the count and survey-based analyses, future studies may consider a full year of counts, which should be available through the permanent counters installed through this study. Future studies may also apply the same or a similar methodology as performed in this study to other paths to create a more comprehensive understanding of path impacts. Shared use paths contribute a wide range of benefits to communities in Massachusetts.

Figure 37 Walksheds, Bikesheds, & Accessible Destinations



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APPENDIX A: LITERATURE REVIEW

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BOSTON, MA 02108
P 617.377.4000

MEMORANDUM

Date:	October 18, 2018	Project #: 21410; Task 5
To:	Michael Trepanier— Massachusetts Department of Transportation	
From:	Camilla Dartnell, Conor Semler, and Caitlin Mildner—Kittelson and Associates, Inc.	
Project:	Shared Use Path Benefits Brochure	
Subject:	Literature Review of Impacts of Shared Use Paths	

INTRODUCTION

Shared use paths are known to provide opportunities for recreation and transportation, which can allow residents and visitors to bike, walk, skate, jog, and take part in other activities. Improved access to these types of activities are known to benefit the health of the users and sometimes provide access to schools, workplaces, community centers, restaurants, stores, and other destinations. Although we know that shared use paths can provide benefits to their users and communities, the quantified value of these benefits is not known. Do all shared use paths provide the same benefit to their communities, residents, and visitors? Do residents and visitors to shared use paths have decreased health costs and live longer? This literature review supports the larger effort of the Shared Use Path Benefits project by outlining the methodologies and results that others have determined for their paths. This information will aid in the development of a Shared Use Path Benefits Brochure for the state of Massachusetts.

This memorandum documents the reviewed literature, which contains a combination of trail studies for existing trails, grant application cost-benefit analyses of proposed paths, advocacy reports, and brochures. Although many more were reviewed, twenty-seven sources were deemed relevant to this effort and included in this literature review. Most resources focused on one or two types of benefits, like economic impact studies or health impact analyses, although a few resources also attempted to determine all the benefits from shared use paths, like the *North Carolina DOT's Evaluating the Economic Impact of Shared Use Paths in North Carolina (1).*

This literature review presents both the methodologies, tools, and programs found in the reviewed literature as well as the results of those methodologies. The organization of this document is intentional. It first presents the methodologies and metrics for economic-based measurements of the literature reviewed, which will help inform the methodologies for determining impacts of shared use paths in Massachusetts. Subsequently, the findings of the literature reviewed are presented, which will be compared to the findings of the impacts of shared use paths in Massachusetts, once determined. Although many sources provided relevant information about both methodology and relevant findings, some sources either did not include a full description of their methodology or used data sources that

were deemed to be irrelevant to our study. In these cases, the source was only referenced in the section where information relevant to our study was provided. This means that some sources are referenced in the methodology section and not the quantified impacts section, or visa versa.

Within the larger sections of methodology and quantified impact, the information is presented by the type of benefit that is being considered: economic, social, health, environmental, safety, and transportation. The following provides the table of contents for the document, to provide a better understanding of the document structure.

CONTENTS

METHODOLOGY REVIEW

The following sections summarize the reviewed methodologies for determining impacts of shared use paths and may inform the method used in Massachusetts. This includes a breakdown of the methodologies and metrics for economic-based measurements for determining different impacts from shared use paths from across the globe.

ECONOMIC IMPACT

The economic impacts of shared use paths can be measured using a variety of methods and tools. Although it may be difficult to obtain precise estimates on the economic impact of shared use paths, studies across the country have developed strategies that begin to measure and understand this impact. This section summarizes findings from studies that developed methodology to analyze the economic impacts of shared use paths and trails. The methodologies highlight impacts to property values, local business and employment, and taxes.

Property Values

- *North Carolina DOT: Evaluating the Economic Impact of Shared Use Paths in North Carolina (1)*
    - The study used buffer analysis to compare property values near and farther from the SUP.
    - Linear regression determined the effect of SUP proximity on property sales prices by controlling for neighborhood characteristics.
- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*
    - Study classified impacts into three types:
        - Type 1 small scale redevelopment as a direct result of the trail, serving the direct needs of trail users (e.g., bike shops, food, gift shops).
        - Type 2 small to mid-scale redevelopments in support of trail goals and principles; (e.g., properties that develop due to increased property values and desirability/increased food traffic).
        - Type 3 large scale redevelopment as market dictates but in support of trail goals and principles (e.g., apartments, grocery stores, offices, etc.).
- *Journal of Park and Recreation Administration: Property values, recreation values, and urban greenways (3)*
    - The study used a hedonic price method based on the theory that the value of public assets or goods are capitalized in values of nearby properties. Marginal effects can be isolated and estimated, controlling for other factors which affect value and prices.
        - Used GIS to identify sales within ½ mile of publicly accessible trails.
- *Headwaters Economics: Measuring Trails Benefit (4)*
    - This research compares and synthesizes findings from multiple trail studies. The analysis includes a combination of findings from around the country.
    - The analysis included statistical models to compare the price of homes identical in all ways except distance from the trail.
    - Additional research included surveying homeowners to gauge perceived property value impacts.

- *Pinal County, Arizona: The Economic Benefits of Open Space and Trails in Pinal County, Arizona (5)*
    - The study found that property values are primarily affected by the distance from and the quality of the park, trail, or open space.
    - Less attractive or poorly maintained parks or trails may have negative impacts to property values and might be perceived as dangerous and undesirable.

Businesses and Employment

- *Yellowstone-Grand Teton: Bicycle Pathway Estimated Economic Impact (6)*
    - The study used IMPLAN economic modeling software to identify the economic impact of the pathway.
    - A survey was used to collect average expenditures for locals and visitors.
    - Expenditures for visitors were calculated as per person per day values then multiplied to represent annual trail user spending.
    - The study used four evaluation methods for measuring economic impact:
        - Total output: value of industry output or contributions to state GDP
        - Labor income: impact on the amount of income earned, including employee compensation and proprietor income
        - Employment: estimates the number of jobs created and/or sustained from trail user spending
        - Value added: difference between value of a final good/service and cost of inputs to provide it

Tax Revenue

- *Headwaters Economics: Measuring Trails Benefit (4)*
    - This source includes a summary of findings from several trail studies around the country.
    - Analysis of multiple trail studies included tools IMPLAN and REMI.
    - The trail studies analyzed in this report used business impact studies to measure the total business revenue, jobs, and income attributable to the trail.
        - To measure business impact, studies estimated the number of trail visitors and visitor spending on and around the trail.
    - Economic impact studies measured new revenue in a community from non-local visitor spending. Economic impact studies often analyze change from a baseline condition.
        - "Local" spending can be defined in a variety of ways. Statewide studies categorized the entire state as "local" spending. Non-local spending included spending from visitors residing outside the state.
            - Studies were careful to distinguish between local and non-local spending.
        - Studies calculated a spending multiplier that quantified the effect of direct, indirect, and induced spending.
    - Studies measured the amount of new local, state, and federal funding allocated to the trail.
- *Schuylkill River Trail: User Survey and Economic Impact Analysis (7)*
    - Analysis included user surveys to determine purchased hard and soft goods and applied value equations to each type of good to determine overall economic impact.
- *North Carolina DOT: Evaluating the Economic Impact of Shared Use Paths in North Carolina (1)*

- The study calculated business benefits by estimating annual business output from the trail.
    - Business outputs included sales revenue at businesses along the shared use path, number of jobs supported annually through construction of the SUP, total estimated annual local and state tax collections resulting from trip expenditures, and total estimated business output from the construction of SUPs.
- To calculate the number of jobs, the analysis estimated the average cost of trail construction and maintenance per mile and multiplied the cost per total number of trail miles. This value was put into IMPLAN to estimate the total number of jobs created for trail construction and maintenance.
    - The number of jobs supported by the trail included direct jobs, indirect jobs, and induced jobs.

SOCIAL IMPACT

In addition to economic impacts, shared use paths have a social impact on surrounding cities, towns, and neighborhoods. Studies have used Census information, Geographic Information Systems (GIS) analysis, route modeling, user surveys, resident surveys, and more to begin to quantify the social impacts of shared use paths. Several studies are highlighted in the following section that focus on quantifying the societal impacts including quality of life, accessibility, and equity.

Quality of Life

- *Quequechan River Rail Trail Phase 2: Health Impact Assessment (8)*
    - The study gathered demographic and socioeconomic information from the Southeastern Regional Planning and Economic Development District (SPREDD) using Five Year Estimates from ACS and analyzed what populations were being served within a walking and biking distance to the trail.
- *Rails to Trails Conservancy: Reconnecting Milwaukee: A BikeAble Study of Opportunity, Equity, and Connectivity (9)*
    - The study selected socioeconomic and demographic variables at the census block group level to measure neighborhood inequality, including concentration of population living under the poverty line, population unemployed, population without a high school degree, zero-car households, and minority populations.
    - The BikeAble tool is a GIS modeling platform that was used to analyze the bicycle connectivity of a community to determine the best low-stress route for bicycling between set of origin and destination pairs.
- *Gallatin County, Montana: Benefit Analysis of the Proposed Belgrade-Bozeman Frontage Path (10)*
    - The study utilized findings based on research conducted by the Victoria Transport Policy Institute. The research quantified the economic value attributed to improved trail user experience. Research estimated that trail users benefit by $0.26 per non-motorized mile traveled along the trail. This benefit was attributed to improved social, physical, and health impacts.
    - Gallatin County's study estimated the average number of miles traveled by trail users and multiplied the established user-benefit value of $0.26 to estimate the combined annual social benefit to trail users.

  - The study conducted additional qualitative analysis to quantify benefits of socioeconomic opportunity and equity, as well as increased social cohesion.
    - Socioeconomic opportunity and equity were quantified by referring to research that shows the gap in mortality rates between income levels decreases with proximity to green space. Trails improved access and connectivity in areas by providing additional transportation options to users who might lack access to automobiles.
    - The study quantified improved social cohesion by assuming the trail would provide improved social connections and community gatherings. The trail was expected to promote social interaction between users and neighbors.

Accessibility/Equity

- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*
  - The study measured the following:
    - Improved access to schools, parks, transit stations, and bus stops for people surrounding the trail (within 2 miles)
    - The number of children from each school zone who live within biking/walking distance from the trail
    - The number of parks within the study area and how many people are connected to the parks via the trail
- *Headwaters Economics: Measuring Trails Benefits (4)*
  - The study measured equitable access to the path using a combination of the following:
    - GIS mapping of parks, trails, and recreation centers
    - User surveys to measure demographics, trail use, and perception of safety
    - Nearby resident surveys to understand the surrounding demographics, safety perceptions, property value perceptions, and trail use
  - These measures were used to determine which user groups benefit most from access to trails and which groups were underserved.
- *Quequechan River Rail Trail Phase 2 (8)*
  - The study used census demographic information and GIS to locate what demographic groups surround the trail. The study considers household income, educational attainment, and household number of vehicles and compared the results near the trail to the average of the city's distribution.
- *Journal of Park and Recreation Administration: Property Values, Recreation Values, and Urban Greenways (3)*
  - The study applies a monetary value to the benefits associated with trail equity and access.
  - Recreational benefits are quantified using travel cost method, based on the theory that the opportunity costs (time and travel people incur when using a recreational facility) are equal to the minimum price they would pay to use that facility.
  - The study calculated cost equivalence by summing:
    + Mean distance
    + Time to trail
    + Number of trail visits
    + Driving cost of $0.19/mile
    + Value of time approximately ½ annual wage rate ($0.15/min)

= Consumer surplus per zone

- The total value of benefits of the facility are the aggregate of people's willingness to pay based on the number of trips they make at different travel costs.
- Intercept studies were used to determine the frequency of trail use, including average distance and time travel to the trail, method of travel to the trail, and trail perceptions.

HEALTH IMPACT

The benefits of active transportation have been analyzed and well-known for decades. Walking, bicycling, skateboarding, jogging, and rollerblading are several modes of active transportation known to reduce risk of chronic illnesses and contribute to weight loss and healthy lifestyles. The studies in the following section assess the health impacts that can be attributed directly to shared use paths. Methodologies include data research and estimations, user surveys, scenario modeling, and several other tools and procedures. This section focuses on health impacts relating to increased physical activity and reduced medical costs.

Increased Physical Activity

- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*
  - The study used the Center for Disease Control's (CDC) estimate of $615 per year for an individual's lack of physical activity.
  - The study used data from the 2006 Community Health Survey to estimates total trail users and separated these users into new exercisers and habitual exercisers.
  - The study additionally separated assumptions into two scenarios:
    - Low – assumed the trail increases users' time spent exercising
    - High – assumed the trail provides access to additional park space, thus resulting in more users benefiting from exercise on the trail and additional access to parks and greenspace.
  - The study calculated the number of calories burned on the trail using two metrics:
    - The average amount of time spent on the trail
      - This information was gathered from a trail user survey.
      - The data showed the average weekly time spent on the trail was 180 minutes.
      - From this, the methodology included two categories for analysis: low duration (100 minutes per week) and high duration (200 minutes per week).
    - The type of exercise or activity used on the trail
      - The study referred to the Department of Health and Family Services from the State of Wisconsin to assign a number of calories burned for each physical activity for a 130-pound individual (low end) and 190-pound individual (high end). Activities included walking, bike riding, jogging, and skating.
    - The study then calculated calories burned on four scenarios:
      - Low scenario of new exercisers with a low duration of physical exercise
      - High scenario of new exercisers with a low duration of physical exercise

- Low scenario of new exercisers with a high duration of physical exercise
- High scenario of new exercisers with a high duration of physical exercise

	0%	25%	50%	75%	100%
Calories for LOW DURATION (100 Min)	0	131	261	392	522
Calories for HIGH DURATION (200 Min)	0	262	522	784	1044

Exhibit 1: Assumed number of calories burned for different path exercise scenarios during the Miami-Dade County Trail Benefits Study

  - This analysis calculated the total pounds lost per year but did not convert this to cost savings.

- *Pinal County, Arizona: The Economic Benefits of Open Space and Trails in Pinal County, Arizona (5)*
  - The research identified common medical problems associated with a lack of physical activity and conducted studies to determine the economic value to attribute to the annual medical cost difference between those who exercise regularly and those who don't ($350). This value was doubled for users above 65 years old.
  - The study used the CDC definition for "sufficient" amount of physical activity: 150 minutes of moderate activity per week or 75 minutes of vigorous activity per week.
  - The study interviewed users to determine type, duration, and frequency of activity.
    - The methodology filtered out low-heart rate activities and removed respondents who engaged in strenuous activities fewer than three times per week, as not meeting the criteria to gain measurable health benefits.
- *Gallatin County, Montana: Benefit Analysis of the Proposed Belgrade-Bozeman Frontage Path (10)*
  - The study referred to the County Health Rankings by the University of Wisconsin Population Health Institute for area statistics, including population and percentage of residents who don't have access to exercise opportunities.
  - The study gathered information from a trail user survey to estimate the percentage of inactive residents who increased their physical activity due to the construction of the trail.
  - The study used the Health Economic Assessment Tool (HEAT), which estimates the value of reduced mortality that results from specified amounts of walking or cycling. The tool values each "avoided premature death" with a "value of a statistical life" (VSL).
  - HEAT was used to quantify the expected mortality risk reduction and reduced health care expenses associated with residents who increase regular exercise due to the trail.
    - Health savings were calculated assuming trail users walk an additional two miles per week on the trail.
  - The research identified several limitations to the study, including underestimation by only including local county residents and not accounting for visitors of the trail from outside counties.
    - The study also identified potential underestimation by accounting only for residents using the pathway strictly for exercise and recreation, not commuting/transportation uses.

Reduced Medical Costs

- *Rails to Trails Conservancy: Quantifying the Benefits of Active Transportation (11)*
    - The study used the HEAT to estimate the value of reduced mortality that results from trail use (walking or bicycling).
        - The National Highway Traffic Safety Administration quantifies the value of a statistical life (VSL) at $9.1 million per person.
        - The tool aims to answer: if x number of people regularly walk or cycle an amount of y, what is the economic value of the health benefits that occur as a result of the reduction in mortality due to their physical activity?
    - The tool also considers health effects from road crashes, air pollution, and CO2.
- *Headwaters Economics: Measuring Trails Benefit (4)*
    - The studies summarized by Headwaters Economics measured the change in residents' levels of physical activity after a trail is built.
    - Studies surveyed random samples within populations to determine the proportion of residents who used a trail, instead of relying on intercept surveys.
    - Studies referred to existing research that measured the change in disease prevalence for sedentary individuals versus individuals with active lifestyles, concluding that active individuals have a lower risk of disease.
    - Studies then used the average cost of disease prevention and treatment to calculate the avoided health care costs attributed to active lifestyles.
    - Studies were cautious to include only the number of newly active residents using the trail.
    - The goal of this methodology was to assign an economic value to health savings attributed to trail use. This monetary benefit was then compared to the monetary cost of building and maintaining the trail, which resulted in a cost-effectiveness ratio.
- *Quequechan River Rail Trail Phase 2: Health Impact Assessment (8)*
    - The study gathered baseline health data from the Massachusetts Behavioral Risk Factor Surveillance System (BRFSS), Youth Risk Behavior Surveillance System (YRBSS) and 2010 Census data, which included data on health conditions, risk factors, and behaviors at the state level.
    - Additionally, the study reviewed literature on the connections between trails and physical activity, safety from collisions, crime, economic development, air quality, and social cohesion.
    - The methodology includes using GIS to map population groups who live within a certain distance from the trail. The study looks at area income levels, educational attainment, household vehicle ownership, etc.
    - The study uses these data sources and methods to determine the potential effects of proposed policies, plans, programs and projects on the health of the population and the distribution of the effects within a population.
- *Lincoln, Nebraska: A Cost-Benefit Analysis of Physical Activity Using Bike/Pedestrian Trails (12)*
    - The study calculated the direct health benefits by estimating the difference in medical costs for active individuals and inactive individuals.
    - The study developed a cost-benefit ratio by dividing the direct medial cost savings by the total trail costs to quantify the amount of health benefit achieved from $1 of investment in trail use.

- The study used the city's 1998 Recreational Trails Census Report to quantify the per capita annual cost of using the trails (combined construction, maintenance, equipment, and travel) and the per capita annual direct medical benefit of using the trails.
    - Additional cost information included surface types, date built, and length of each trail.
    - Trail use was calculated using volunteers to count the number and types of users on the trail on a single day.
    - The direct health benefit was calculated by estimating the difference in medical costs between active and inactive individuals.
        - Data from the National Medical Expenditure Survey reported that active persons spend an average of $330 less on medical care annually than inactive persons. The survey defined moderate physical activity as spending at least 30 minutes in moderate to strenuous physical activity three or more times per week.

ENVIRONMENTAL IMPACT

The following section highlights the potential environmental impacts of shared use paths. This section focuses on both local and global environmental impacts. The studies highlighted below use a variety of methodologies including assigning economic values to environmental benefits, measuring air quality, carbon emissions, vehicle miles traveled (VMT), and using the TIGER Cost-Benefit analysis resource guide.

Local Impact

- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*
    - The study quantified tree canopy benefits with the addition of the trail.
    - The trail design guidelines and standards required planting 1,050 shade trees.
    - The study used the United States Forest Service's estimates of a single shade trees' benefits, including the following (over a 50-year lifespan):
        - $32,812,500 oxygen value
        - $61,100,000 air pollution control value
        - $39,375,000 recycled water value
        - $32,812,500 soil erosion control value
        - Total: $170,100,000
    - Additionally: the US Forest Service reports that a single mature shade tree can provide enough oxygen to support two humans.
    - The US Forest Service reports that a single shade tree can store over 10,000 pounds of CO2 over an average lifespan.
        - The study applied this value multiplied by the number of trees provided by the trail to quantify the total number of CO2 sequestered.
    - The study utilized the online calculator provided by the University of Georgia Warnell School of Forestry and Natural Resource to estimate the total carbon sequestered by the trail corridor.
- *Quequechan River Rail Phase 2: Health Impact Assessment (8)*
    - The study quantified environmental impact by measuring air quality.

        - The study gathered data on baseline conditions and then used state and federally-approved worksheets to estimate the impact of the trail on changing air quality.
    - Data sources included:
        - Census demographic information
        - Transportation data from the Southeastern Regional Planning and Economic Development District (SPREDD)
        - Ozone level data from MassDEP
        - Air quality improvement data from MassDOT
    - The study utilized the MassDOT/FHWA Congestion Mediation and Air Quality Analysis Worksheet for bike facilities is used to calculate potential air quality improvements.

Global impact

- *Gallatin County, Montana: Benefit Analysis of the Proposed Belgrade-Bozeman Frontage Path (10)*
    - The study estimated the value of avoided carbon emissions from reduced VMT.
    - The study used the percentage of residents commuting by bicycle and estimated future bicycle commuter percentage after pathway construction, using the neighboring city's percentage where the pathway currently exists.
    - The study used the TIGER Benefit-Cost Analysis Resource Guide to estimate the amount of reduced emissions and social cost of carbon.

SAFETY IMPACT

Many studies have attempted to measure the safety impacts of shared use paths and trails. When analyzing safety impacts, it's important to distinguish between actual and perceived safety. Studies often conduct user and resident surveys to measure the perceived safety of areas surrounding trails and shared use paths. It is more challenging to quantifying the actual safety impacts directly related to shared use paths. The section below highlights several studies that assess the safety impacts of shared use paths as they relate to crime and crash mitigation.

Crime

- *Quequechan River Rail Phase 2: Health Impact Assessment (8)*
    - The study collected baseline data for crime from the FBI's 2010 Uniform Crime Reports.
    - Research included collecting specific and detailed crime data for one-mile radius around the trail from the local police department.
- *Omaha, Nebraska: Omaha Recreational Trails: Their Effects on Property Values and Public Safety (13)*
    - To measure property values and public safety, the study designed a survey that addressed property values, public safety, and trail use.
    - Residents living near the trail were surveyed by telephone and mail surveys.
    - The survey asked questions about trail impact on public safety, property values, and general neighborhood quality of life.

Crash Mitigation

- *Quequechan River Rail Phase 2: Health Impact Assessment (8)*
    - The study used MassDOT's Motor Vehicle Crash Database to collect data on collisions and injuries.
    - The study referred to Massachusetts Health and Human Services (HHS) for state level data for ped/bike related injuries.
    - The study collected speed and volume counts for the proposed trail crossings to gather background information about the trail corridors and understand crash and traffic patterns.
- *Cleveland, Ohio: Re-Connecting Cleveland: Pathways to Opportunity (Tiger Grant Application) (14)*
    - The study calculated crash statistics for bike/ped accidents within 1.5-mile buffer of the trail project.
    - The study scaled numbers using the formula provided by TIGER Benefit-Cost Analysis Resource Guide.
    - The study estimated the total value of bike/ped fatalities and injuries.
        - The study assumed that bike/ped chances of injury drops to 0 on SUP and that bikes/peds complete trips solely on SUP.
- *North Carolina DOT: Evaluating the Economic Impact of Shared Use Paths in North Carolina (1)*
    - The study quantified the safety benefits of trail use.
        - The study first conducted an intercept survey to measure the average time users spend on the trail, how frequently users visit the trail, and how far users travel to visit the trail.
        - The study then collected collision data for the study area and streets/areas parallel to the trail, which might serve as alternate routes.
        - The study combined information from the previous steps to estimate societal benefits that from avoided motorized transport collision costs.
            - The study used FHWA's statistical value of human life.
- *Gallatin County, Montana: Benefit Analysis of the Proposed Belgrade-Bozeman Frontage Path (10)*
    - The study used the USDOT guidance to estimate the impact of crashes using the value of a statistical life.
        - The USDOT defines this value at $10,176,000. The study used historical crash records to estimate the number of avoided crashes per year that result from the construction of the pathway.

TRANSPORTATION IMPACT

The construction of a shared use path undeniably modifies the transportation network of an area. By introducing a new transportation option, shared use paths impact the transportation patterns in surrounding areas. Shared use paths have shown both increases and decreases in surrounding automobile traffic. Additionally, shared use paths have been shown to increase active transportation in surrounding neighborhoods. The studies highlighted in the following section have developed methodologies for measuring the transportation impacts that shared use paths have on surrounding areas.

- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*

- The study quantified the trail's improved bicycle and pedestrian access to transit facilities.
  - The study used 2000 Census information to estimate the percentage of residents living within two miles of a transit station who use transit as their primary transportation mode. This percentage served as the baseline transit ridership, while two other areas in Miami were assigned as medium and high range transit ridership areas.
  - The study used the 2006 Community Health Survey to estimate the average percent of Miami-Dade County residents that use trails annually.
    - This percentage was applied to the number of commuters that will bike or walk to transit stations along the trail as their route, assuming that not all transit riders will use the trail as their route to the station.
  - The study calculated the following, which are presented in greater detail in Exhibit 2:
    - Number of people using transit pre-trail
    - Number of people using transit post-trail (low assumption)
    - Number of people using transit post-trail (medium assumption)
    - Number of people using transit post-trail (high assumption)
    - Vehicle trips reduced post trail development

Population that Uses Transit Pre-Trail [Population within 2 miles of transit] x [percent of population that used transit per 2000 Census data]
Population that will use Transit Post-Trail (Low) [Population within 2 miles of transit] x [percent of population that uses transit in baseline (5.3%)] x [2006 Community Survey data of trail users (40.7%)]
Population that will use Transit Post-Trail (Medium) [Population within 2 miles of transit] x [percent of population that uses transit in medium (8.3%) comparable] x [2006 Community Survey data of trail users (40.7%)]
Population that will use Transit Post-Trail (High) [Population within 2 miles of transit] x [percent of population that uses transit in high (12.2%) comparable] x [2006 Community Survey data of trail users (40.7%)]
Vehicle Trips Reduced Post Trail Development [[[Population that Uses Transit Post-Trail (for each scenario)] – [Population that Uses Transit Pre-Trail]] x [2(Trip to and from transit station)]] x [255 (workdays per year)]

Exhibit 2: The estimated number of transit users after addition of path from the Miami-Dade County Trail Benefits Study

- The study calculated transportation modes traveling to school.
  - The study estimated the following:
    - Number of students with walking access to schools pre-trail (within 2 miles)
    - Number of students with access to schools post-trail
    - Increase in student accessibility to schools
  - The study utilized Safe Routes to School studies to gather information about the percentage of students living within two mile of each school who arrive by vehicle.

- Safe Routes to School statistics showed that after a Safe Route to school was implemented, there was a 50% decrease in the number of students within two miles of each school who arrived by vehicle.

QUANTIFIED IMPACTS REVIEW

The following sections provide the impacts that shared use paths have had on communities around the globe. These impacts will be used to inform the types of benefits that are studied in Massachusetts and will be compared to the benefits determined in the Shared Use Paths Benefits Brochure.

ECONOMIC IMPACT

This section provides the quantified economic impacts to an area due to shared use paths. Specifically, the section focuses on the amount that paths affect property values based on proximity, the effect on business revenue and employment, and the subsequent effect on tax revenue.

Property Values

- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*
    - Based on an analysis of comparable trails from across the country, the presence of the Ludlam Trail is expected to increase property values within the Walkable Area (within ½ mile of a proposed public access point) at an annual pace of 0.32% to 0.73% faster than other properties throughout Miami-Dade County. This translates to a total property value increase over a 25-year period of $121-282 million.
- *Cleveland, Ohio: Re-Connecting Cleveland: Pathways to Opportunity (Tiger Grant Application) (14)*
    - In Cleveland, The Trust for Public Land, using a conservative 2% market value premium for homes within 500 feet of trails estimated for 2012 that $9.65 million in residential property exists because of proximity to trails.
- *Ohio: The Impact of the Little Miami Scenic Trail on Single Family Residential Property Values (23)*
    - The analysis suggests that each foot increase in distance away from the trail decreases the sale price of a sample property by $7.05. For example, a house a half mile away from the trail would sell, on average, for $18,612 less than a house that is identical in all other aspects but is adjacent to the trail. In addition to the statistical model, the author conducts a thorough literature review and notes that $7 is within the range of price premiums found in other studies.
- *San Antonio, Texas: The Relative Impacts of Trails and Greenbelts on Home Price (22)*
    - Trails, greenbelts, and trails with greenbelts (or greenways, I.e. trails with greenbelts) are associated with roughly 2, 4, and 5%, property price premiums, respectively.
- *Greenways and Greenbacks: The Impact of the Catawba Regional Trail on Property Values in Charlotte, North Carolina (15)*
    - The greenway coefficient for single family residential land implies a 0.03% premium on access to the greenway for every 1% decrease in distance from the greenway; the premium for multi-family property is only 0.0013% and the effects on commercial land are about half that of single family property.
    - In all three cases, the maximum benefit from the greenway occurs within 1,000 ft (i.e., a little less than ¼ mi) of the greenway, although benefits are not completely exhausted until about 5,000 ft (or approximately one mile) from the greenway.

Mecklenburg County	Real Estate Premium	Median Price	Change in value from being within 5,000 ft
Single family	−0.0312	$104,000	$107,245
Multifamily	−0.0013	$178,000	$178,231
Commercial	−0.0172	$260,000	$264,472

Note: Real estate premium is % change in sales price due to 1% increase in distance from greenway.

Exhibit 3: Summary of estimated real estate premiums due to shared use paths, according to *Greenways and Greenbacks: The Impact of the Catawba Regional Trail on Property Values in Charlotte, North Carolina*

Businesses and Employment

- *North Carolina DOT: Evaluating the Economic Impact of Shared Use Paths in North Carolina (1)*
  - Increase in business revenue and employment due to retail

Shared Use Path	Year	Annual Number of Trips	Type of Business Benefit	Business Output	Employment (No. of Jobs)	Labor Income
American Tobacco Trail	3-Yr Ave*	480,800	Direct	$3,000,000	59	$1,370,000
			Indirect	$1,202,000	8	$375,000
			Induced	$1,466,000	11	$465,000
			Total	**$5,668,000**	**78**	**$2,211,000**
Brevard Greenway	3-Yr Ave*	76,000	Direct	$831,000	16	$380,000
			Indirect	$331,000	2	$105,000
			Induced	$404,000	3	$129,000
			Total	**$1,566,000**	**21**	**$614,000**
Little Sugar Creek Greenway	2016	382,600	Direct	$2,783,000	56	$1,280,000
			Indirect	$1,112,000	7	$345,000
			Induced	$1,366,000	10	$433,000
			Total	**$5,261,000**	**73**	**$2,059,000**
Duck Trail	2016	145,700	Direct	$3,643,000	66	$1,614,000
			Indirect	$1,518,000	10	$492,000
			Induced	$1,770,000	13	$562,000
			Total	**$6,931,000**	**89**	**$2,668,000**

Exhibit 4: The summary of economic contribution from direct expenditures of path uses, according to *Evaluating the Economic Impact of Shared Use Paths in North Carolina*

Shared Use Path	Output Supported per Trip	Employment Supported per Trip	Labor Income Supported per Trip
American Tobacco Trail	$12	0.0002	$5
Brevard Greenway	$21	0.0003	$8
Little Sugar Creek Greenway	$14	0.0002	$5
Duck Trail	$48	0.0006	$18

Exhibit 5: The estimated amount of benefit to businesses per trip on a shared use path, according to *Evaluating the Economic Impact of Shared Use Paths in North Carolina*

  - Increase in business revenue and employment due to construction

Shared Use Path	SUP Length in Miles*	Type of Construction Benefit	Business Output	Employment (No. of Job Years**)	Labor Income
American Tobacco Trail	17.5	Direct	$14,900,000	155	$5,600,000
		Indirect	$5,600,000	50	$2,100,000
		Induced	$6,700,000	95	$2,100,000
		Total	**$27,200,000**	**300**	**$9,800,000**
Brevard	4.82	Direct	$4,100,000	40	$1,500,000
		Indirect	$4,100,000	15	$600,000
		Induced	$1,800,000	25	$600,000
		Total	**$7,500,000**	**80**	**$2,700,000**
Little Sugar Creek Greenway	6	Direct	$2,600,000	25	$1,000,000
		Indirect	$1,000,000	10	$400,000
		Induced	$1,200,000	15	$400,000
		Total	**$4,700,000**	**50**	**$1,800,000**
Duck Trail	3	Direct	$5,100,000	55	$1,900,000
		Indirect	$1,900,000	15	$700,000
		Induced	$2,300,000	35	$700,000
		Total	**$9,300,000**	**100**	**$3,300,000**

Exhibit 6: Summary of the economic impact of shared use path construction, according to *Evaluating the Economic Impact of Shared Use Paths in North Carolina*

- *Rails-To-Trails Conservancy: Advancing the Smart Growth Agenda (16)*
  - Economic activity of the Ghost Town Trail (Pennsylvania) supported 4.7 jobs in the region based on the 66,000 annual visitors to the trail.
- *Moab, Utah: Estimating the Recreation Demand and Economic Value of Mountain Biking in Moab, Utah: An Application of Count Data Models (17)*
  - Multi-use trails create 9.6 jobs for every $1 million spent on infrastructure. In contrast, road infrastructure only projects only create 7.75 jobs per $1 million spent.
- *Pennsylvania: The Great Allegheny Passage Economic Impact Study (20)*
  - One-quarter (25.5%) of gross revenue for businesses along the trail was directly attributed to trail users. About one-third (32.4%) of businesses said that they have expanded or plan to expand their business operations because of the trail.
- *Pennsylvania: Ghost Town Trail 2009 Survey and Economic Impact Analysis (21)*
  - 88.4% of respondents indicated they had purchased "hard goods" in the past year in conjunction with their use of the trail. The majority of these purchases were bicycles and bike supplies that resulted in an average expenditure of $357.63.
  - 72% of respondents indicated they had purchased some form of "soft goods" while visiting the trail, with an average dollar amount of $13.62 spent per visit.
  - 12% of respondents indicated they had stayed overnight in conjunction with their visit; they spent an average of $78.04 per night on their lodging.

Tax Revenue

- *North Carolina DOT: Evaluating the Economic Impact of Shared Use Paths in North Carolina (1)*

Shared Use Path	Year	Employee Compensation	Tax on Production & Imports	Households	Corporations	Total
American Tobacco Trail	Annual average*	$2,000	$169,300	$41,800	$6,600	$219,700
Brevard Greenway	Annual average*	$700	$43,900	$8,100	$700	$53,400
Little Sugar Creek Greenway	2016	$1,600	$132,700	$38,400	$6,300	$179,000
Duck Trail	2016	$3,500	$176,900	$44,400	$7,000	$231,800
All 4 SUPs	**Annual Estimated**	**$7,800**	**$522,800**	**$132,700**	**$20,600**	**$683,900**

**Based on the average annual tax collections from 2015-2017*

Exhibit 7: Summary of annual local and state tax collections resulting from shared use path trip expenditures, according to *Evaluating the Economic Impact of Shared Use Paths in North Carolina*

- 5: *Miami, Florida: Miami-Dade County Trail Benefits Study Miami-Dade County Trail Benefits Study (2)*
    - Miami-Dade County is expected to receive between $31,900 and $80,000 in sales tax from trail related expenditures while the State of Florida is expected to receive between $191,400 and $480,000 annually in sales tax.
- *Greenways and Greenbacks: The Impact of the Catawba Regional Trail on Property Values in Charlotte, North Carolina (15)*
    - Nearly $600,000 in additional property tax revenue is expected annually due to the Catawba Regional Trail in Mecklenburg County, about 81% of which is due to increases in the value of commercial land.

SOCIAL IMPACT

Walking, jogging, biking, or doing other activities along shared use paths can improve wellbeing and provide those who live or work nearby access to nearby residences, jobs, schools, commercial areas, and greenspace. Although the social impact that shared use paths can have on neighbors is difficult to quantify, the Victoria Transport Policy Institute also was able to estimate the financial impact of improved quality of life, which is applied by other trail benefit studies, summarized below. It is also possible to estimate the number of people of different backgrounds that will gain access to various destinations.

Quality of Life

- *Gallatin County, Montana: Benefit Analysis of the Proposed Belgrade-Bozeman Frontage Path (10)*
    - Annual trail use is expected to increase by approximately 3,216 new users. Research from the Victoria Transport Policy Institute estimates that improved trail user experience is worth $0.26 per non-motorized mile traveled due to improved social experiences and physical and mental health. Assuming the new users travel 10 miles round trip—roughly half the path length, we estimate the annual benefits to new users will be $8,040. The net present value of benefits discounted at seven percent during the next 20 years is approximately $81,000.

Accessibility/Equity

- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*
    - The development of the Ludlam Trail is expected to enhance overall accessibility to schools, parks, transit stations, and bus stops for as many as 30,500 people living within two miles of the trail.
    - 261 students will gain access to area schools; 6,389 residents will gain access to parks; 186 residents will gain access to bus stops; 23,900 residents will gain access to transit stations.
- *Rails to Trails: Reconnecting Milwaukee: A BikeAble Study of Opportunity, Equity, and Connectivity (9)*
    - The methodology examines the connectivity of a specific subset of neighborhoods to trail access points within two miles. Neighborhood inequality is defined by concentrations of population living under poverty line, unemployment, population without a high school degree, zero-car households, and minority populations. The method uses a series of hot-spot analyses to visualize areas that have a clustering of the six inequality variables
        1. 8% of Milwaukee residents live within a half-mile of a trail (maximum distance people are generally willing to walk), and 3% of neighborhoods experiencing inequality.
        2. Analysis shows that adding two new pieces of trail infrastructure, along with extensions of existing trails, will increase access to 14% for residents citywide and 11% for residents in targeted areas
        3. Today, 24% of residents live within 2 miles of the trail and 8% of neighborhoods experiencing inequality live within 2 miles (distance willing to bike) of the trail
            - Trail extensions would increase these trail access percentages to 59% of citywide residents and 66% of residents in targeted areas

HEALTH IMPACT

The following section outlines the amount of increased physical activity, due to shared use paths. The estimated reduced medical costs due to this increase in physical activity are also presented below.

Increased Physical Activity

- *North Carolina DOT: Evaluating the Economic Impact of Shared Use Paths in North Carolina (1)*
    - Trail users are estimated to spend 929,000 hours (enough for 7,416 people to meet the CDC's recommended weekly active minutes) each year on the Brevard Greenway, 4,394,000 hours (enough for 33,800 people) on the Little Sugar Creek Greenway and 58,000 (enough for 400 people) on the Duck Trail.
- *Missouri: Promoting Physical Activity in Rural Communities: Walking Trail Access, Use and Effects (24)*
    - Among persons with access to walking trails, 38.8% used the trails. Among persons who used the trails, 55.2% reported they had increased their amount of walking since they began using the trail. Women and persons with a high school education or less were more than

twice as likely to have increased the amount of walking since they began using the walking trails.

- *Quequechan River Rail Trail Phase 2 Health Impact Assessment (8)*
    - The health of Fall River's adult residents is consistently poorer than that of the residents of the state. The literature shows that there is evidence that the availability of trails, trail usage, and trail promotion promotes physical activity. The report predicts a positive impact to this population through increased access to physical activity resources (trail, open space), particularly within a mile radius of the QRRT.

Reduced Medical Costs

- *North Carolina DOT: Evaluating the Economic Impact of Shared Use Paths in North Carolina (1)*
    - The American Tobacco Trail is estimated to reduce one death a year through a decreased risk of chronic disease. The trail is estimated to collectively provide its users with 23.9 additional years of "healthy life" and medical cost savings of $1,437,000 per year.
    - The physical activity on the other three trails translates into a healthcare cost savings of $51,000 for Brevard Greenway, $243,000 for Little Sugar Creek Greenway and $2,000 for Duck Trail.
- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*
    - The development of the Ludlam Trail will save the community between $1.68 million and $2.25 million annually in direct medical costs related to lack of physical exercise.
- *Gallatin County, Montana: Benefit Analysis of the Proposed Belgrade-Bozeman Frontage Path (10)*
    - The pathway is assumed to facilitate increased physical activity among 639 residents. Using the Health Economic Assessment Tool, the value of the expected mortality risk reduction and reduced health care expenses associated with 639 residents walking two additional miles per week is $64,713 per year. The net present value of these benefits during 20 years at seven percent discount rate is approximately $625,000.
- *Lincoln, Nebraska: A Cost-Benefit Analysis of Physical Activity Using Bike/Pedestrian Trails (12)*
    - Per capita annual cost of using the trails was $209.28. Per capita annual direct medical benefit of using the trails was $564.41. Every dollar invested in trails for physical activity led to $2.94 in direct medical benefit.

ENVIRONMENTAL IMPACT

Increasing the amount of biking and walking can decrease the number of motorized vehicle trips, and shared use paths can provide opportunities to grow trees or other vegetation. This section focuses on both the local environmental impact of shared use paths, including the local air and water quality benefits, and the global environmental impact of shared use paths due to reduced greenhouse gas emissions.

Local Impact

- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*

  - With the reduction of approximately 860,700 vehicle trips per year due to the trail, the following vehicle emissions will be reduced annually:
    - 5,308 fewer lb of hydrocarbons
    - 39,622 fewer lb of carbon monoxide
    - 2,635 fewer lb of NOx
  - New tree canopy plantings associated with the Ludlam Trail amenities will provide the surrounding community with over $170 million in pollution control savings over the life span of a typical urban tree (50 years). This breaks-down into the following pollution control savings:
    - $32.8 million in fresh oxygen (equivalent to the needs of 2100 humans)
    - $65.1 million in air pollution control
    - $39.4 million in recycled water
    - $32.8 million in soil erosion control
- *Quequechan River Rail Trail Phase 2 Health Impact Assessment (8)*
  - The potential VMT reductions from this project and subsequent emissions reductions can be quantified using the FHWA/MassDOT CMAQ Air Quality Analysis Worksheet. This worksheet was completed for the QRRT by SRPEDD and demonstrates the following changes to VMT and vehicle emissions:
    1. Reduction in VMT of 53.5 miles per day or 10,704 miles per year
    2. Reduction in Summer VOC of 2.5 kg/year
    3. Reduction in Summer NOx of 1.9 kg/year
- *Rail-To-Trails: Trails and Greenways: Advancing the Smart Growth Agenda (16)*
  - The City of Seattle found that one vehicle trip is eliminated for every two bicycle commute trips or five non-commute bicycle trips. For every vehicle trip avoided, the air quality impacts are reductions of 5 grams/mi of hydrocarbons, 42.48 grams/mi of CO and 3.58 grams/mi of NOx.

Global Impact

Reduced Green House Gas Emissions

- *North Carolina DOT: Evaluating the Economic Impact of Shared Use Paths in North Carolina (1)*

	Baseline Estimates		
	Brevard Greenway	Little Sugar Creek Greenway	Duck Trail
Annual Reduced CO_2 Emissions (lbs)	4,952,000	48,397,000	266,000
Annual Reduced Other Motor Vehicle Emissions (lbs)	99,000	582,000	5,000
Annual Environmental Cost Savings	$102,000	$600,000	$5,000

Exhibit 8: Estimated environmental benefits for three North Carolina paths, according to *Evaluating the Economic Impact of Shared Use Paths in North Carolina*

- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*
  - With the reduction of approximately 860,700 vehicle trips per year due to the trail, 394 fewer tons of CO_2 will be emitted.
- *Vancouver, Canada: Effects of New Urban Greenways on Transportation Energy Use and Greenhouse Gas Emissions (25)*
  - The daily transportation greenhouse gas emissions decreased by 20.90% for residents living near the Comox-Helmcken Greenway (Vancouver, Canada) after the greenway's construction.
- *Cardiff, Penarth, Kenilworth, Southampton, UK: Evaluating the Impacts of New Walking and Cycling Infrastructure on Carbon Dioxide Emissions from Motorized Travel: A Controlled Longitudinal Study (26)*
  - There was found to be no significant effect on of path usage on CO_2 emissions despite heavy use of the new paths because the trail is mostly used for recreational purposes.
- *Gallatin County, Montana: Benefit Analysis of the Proposed Belgrade-Bozeman Frontage Path (10)*
  - Based on average fuel consumption and fair-weather working days per year under average climatic conditions, it is estimated that the proposed path will avoid 34,545 metric tons of CO^2 emissions during the next 20 years. Using the current and projected social cost of carbon, the net present value of these savings discounted at seven percent is approximately $978,000.
- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*
  - New tree canopy plantings associated with the Ludlam Trail amenities will provide for the sequestration of between 3,120 and 4,200 tons of carbon within 25 years and 5,250 tons of carbon over a 50-year life span.

SAFETY IMPACT

This section focuses on the impact that shared use paths have on safety. Shared use paths are known to affect crime, and providing an off-street location for people to bike, walk, jog, or do other activities can reduce the risk of crashes between motor vehicles and pedestrians or bicyclists.

Crime

- *Rail-To-Trail Conservancy: Rail-Trails and Safe Communities (27)*
    - Only 3% of the trails reported any crimes against persons (assaults, muggings, rape, and murder). Crime against persons on rural trails was negligible.
    - In 1996, the national rate of muggings in urban areas was 335 for each 100,000 inhabitants. Only one of 36 urban trails reported muggings, giving rail trails a rate of 15 muggings per 5 million users. In the suburbs, muggings occurred at a rate of 102 per 100,000 people. Only one mugging was reported among the 14 million people who used suburban trails in 1996.
    - Burglary near trails was found to be extremely rare, more so than other crimes. Only four burglaries were reported in homes adjacent to 7,000 miles of rail trails in 1996, three of which were reported in rural areas. There is no evidence that these four crimes were a result of the nearby trail.
    - Minor crimes were reported on trails, but less frequently than in the rest of the landscape: 4% of trails reported trespassing; 14% reported graffiti; 24% reported littering; and 18% had unauthorized motorized use.
- *Omaha, Nebraska: Omaha Recreational Trails: Their Effect on Property Values and Public Safety (13)*
    - The majority (>90%) of residents did not increase home security due to a nearby trail. Experiences with trail-related theft (4.0%) and property damage (4.7%) were reported infrequently by respondents and most of these incidents were of relatively minor nature.

Crash Mitigation

- *North Carolina DOT: Evaluating the Economic Impact of Shared Use Paths in North Carolina (1)*
    - The American Tobacco Trail brings the following benefits due to reduced risk of road traffic injuries: a reduction in 1 death every 2 years or an annual increase of 16.6 additional years of “healthy life”. This is equivalent to $913,000 per year.
    - The estimated annual benefits due to reduced vehicle crash costs are $670,000 from Brevard Greenway, $3,943,000 from Little Sugar Creek Greenway and $36,000 from Duck Trail.
- *Quequechan River Rail Trail Phase 2 Health Impact Assessment (8)*
    - Currently, most crashes in Fall River involving bicyclists and pedestrians occur within one mile of the proposed location for the Quechechan River Rail Trail, according to the study. Bicyclists have the greatest potential to see a reduction in crashes with motor vehicles when using the Quechechan River Rail Trail as an alternative route to downtown Fall River. The Quechechan River Rail Trail will most likely decrease motor vehicle crashes involving bicyclists and pedestrians by offering a separated and safe path in which to travel with less interaction with motor vehicles.
- *Gallatin County, Montana: Benefit Analysis of the Proposed Belgrade-Bozeman Frontage Path (10)*
    - Based on historical crash records, the pathway will help avoid an average of one crash per year. The US DOT sets the value of a statistical life at $10,176,000 and those of non-fatal injuries discounted in proportion to injury severity. Therefore, the pathway would result in $2,205,648 in avoided costs per year. During the project lifespan, this equates to a net present value discounted at 7% of $21,305,000 through 18 crashes avoided over the expected lifespan of the project.

TRANSPORTATION IMPACT

Providing a shared use path for people to use for active transportation purposes can reduce the number of vehicle miles traveled on parallel roadways. This reduction can not only reduce the effect on the environment and number of crashes, but it can also reduce the amount of congestion on the roadway, reduce the amount of necessary roadway maintenance, and reduce personal costs of owning and operating a motor vehicle. This section highlights the impact that shared use paths can have on transportation.

- *North Carolina DOT: Evaluating the Economic Impact of Shared Use Paths in North Carolina (1)*
    - The estimated annual vehicle miles traveled reduced are 3,043,000 from Brevard Greenway, 17,924,000 from Little Sugar Creek Greenway and 163,000 from Duck Trail.
- *Miami, Florida: Miami-Dade County Trail Benefits Study (2)*
    - The development of the Ludlam Trail is expected to lead to reduced vehicle trips within the Ludlam Trail Study Area by 860,700 per year. The breakdown is as follows:
        - 262,929 trips to transit stations
        - 136,080 trips to area schools
        - 2,773 trips to parks
        - 458,918 trips for miscellaneous errands
    - The reduction in 860,700 vehicle trips translates into an annual savings in fuel consumption of approximately 36,625 gallons or the equivalent of 4 tanker trucks. Community fuel savings equals $101,450 per year.
- *Rail-To-Trail Conservancy: Trails and Greenways: Advancing the Smart Growth Agenda (16)*
    - Weekday user surveys on the Burke-Gilman Trail (Seattle), the Pinellas Trail (Tampa) and several trails in Washington DC show that 35-45% of weekday trail users are making a trip. This translates to 1,000-2,000 trips each day. Similar levels (36%) of users have been found to be making a trip on the Iron Horse Trail (San Francisco).
    - The same surveys found that commuters used the trail more than three times/week in Washington DC and up to five times/week on the Pinellas Trail.
    - The Burke-Gilman trail opened in 1980. A 1985 user survey found that 6% of trail users were making commuter trips. In 2000, a similar survey found that 32% were commuting and another 6% were shopping.
- *North Carolina DOT: Evaluating the Economic Impact of Shared Use Paths in North Carolina (1)*
    - The estimated annual benefits due to reduced traffic congestion costs are $365,000 from Brevard Greenway, $2,151,000 from Little Sugar Creek Greenway and $19,000 from Duck Trail.
    - The estimated annual benefits due to reduced road maintenance costs are $456,000 from Brevard Greenway, $2,689,000 from Little Sugar Creek Greenway and $25,000 from Duck Trail.
    - The estimated annual benefits due to reduced household vehicle operation costs are $1,735,000 from Brevard Greenway, $10,216,000 from Little Sugar Creek Greenway and $93,000 from Duck Trail.

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APPENDIX B: SURVEY QUESTIONNAIRES

massDOT
Massachusetts Department of Transportation

Shared Use Path User Survey
Survey Date: _____
Trail Name:_____

1. **How often do you visit this path?**
- ☐ This is my first time
- ☐ Daily
- ☐ 1-3 times/week
- ☐ 4+ times/week
- ☐ Several times/month
- ☐ Monthly
- ☐ Several times per year
- ☐ Other: _____

2. **How did you travel to the path today?**
- ☐ Walked
- ☐ Biked
- ☐ Drove
- ☐ Carpooled
- ☐ Public transportation
- ☐ Taxi/Uber
- ☐ Other: _____

3. **Which of these activities best describes your use of the path today (choose 1)?**
- ☐ Walking
- ☐ Jogging
- ☐ Skateboard/Rollerblades
- ☐ Scooter
- ☐ Biking
- ☐ Backpacking
- ☐ Other: _____

4. **If the path didn't exist, would you still participate in this activity elsewhere today?**
- ☐ Yes
- ☐ No
- ☐ Unsure

5. **How long do you plan to stay on the path today? Number of minutes/hours: _____**

6. **What is your primary purpose for using the path?**
- ☐ Recreation
- ☐ Health/Exercise
- ☐ Commuting/Traveling
- ☐ Other: _____

7. **Indicate the number of your dependents on the path or others on the path with you who are not taking this survey that fit into the following age groups. Do not include yourself:**
- ☐ 0-12_____
- ☐ 13-18_____
- ☐ 19-30_____
- ☐ 31-50_____
- ☐ 51 +_____

8. **Do you think the path has affected crime rates in the area?**
- ☐ Yes- Less crime
- ☐ Yes- More crime
- ☐ No- Crime is unaffected
- ☐ Unsure

9. **Has the path influenced your purchase of:**
- ☐ Bikes
- ☐ Bike equipment
- ☐ Shoes/Clothing
- ☐ Outdoor equipment
- ☐ Other:_____

10. **We are trying to assess the path's local economic impact. As a result of your trip today, how much money are you and your dependents/others in your group each spending on :**
- ☐ $_____Restaurants
- ☐ $_____Fuel
- ☐ $_____Retail stores (rentals)
- ☐ $_____Lodging
- ☐ $_____Museums, Parks, Zoos
- ☐ $_____Other

11. **What is your home zip code? _____**

Optional: Background Information

- ☐ Ethnicity/Race:_____
- ☐ Age: _____
- ☐ Gender: _____
- ☐ Estimated Household Income: _____
- ☐ Level of Education: _____

Additional comments:

_____

_____

Thank you for completing this survey. For questions about this study, please contact Caitlin at cmildner@kittelson.com

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1. ¿Con qué frecuencia visitas este camino?
€ Esta es mi primera vez
€ Daily
€ 1-3 veces / semana
€ 4+ veces / semana
€ Varias veces / mes
€ Mensual
€ Varias veces al año
€ Otro: _____

2. ¿Cómo viajaste al camino hoy?
€ Caminé
€ Biked
€ Condujo
€ Carpoolado
€ Transporte público
€ Taxi / Uber
€ Otro: _____

3. ¿Cuál de estas actividades describe mejor su uso de la ruta hoy?
€ Caminando
€ Jogging
€ Skateboard / Rollerblades
€ Scooter
€ Ciclismo
€ Mochilero
€ Otro: _____

4. Si el camino no existiera, ¿aún participaría en esta actividad en otro lugar hoy?
€ Sí
€ No
€ Inseguro

5. ¿Cuánto tiempo planeas permanecer en el camino hoy? Número de minutos / horas: _____

6. ¿Cuál es tu propósito principal para usar el camino?
€ Recreación
€ Salud / Ejercicio
€ Viajar / Viajar
€ Otro: _____

7. Indique la cantidad de personas en el grupo de las que es responsable y que se ajustan a los siguientes grupos de edad:
€ 0-12 _____
€ 13-18 _____
€ 19-30 _____
€ 31-50 _____
€ 51 + _____

8. ¿Crees que el camino ha afectado las tasas de criminalidad en el área?
€ Sí- Menos crimen
€ Sí- Más crimen
€ No, el crimen no se ve afectado

9. ¿Ha influido la ruta en su compra de:
€ Bicicletas
€ Equipamiento de bicicleta
€ Zapatos / Ropa
€ Equipo al aire libre
€ Otro: _____

10. Estamos tratando de evaluar el impacto económico local de la ruta. Como resultado de su viaje de hoy, cuánto dinero gastan usted y sus dependientes en:
€ $ _____ Restaurantes
€ $ _____ Combustible
€ $ _____ Tiendas minoristas (alquileres)
€ $ _____ Alojamiento
€ $ _____ Museos, Parques, Zoológicos
€ $ _____ Otro

11. Por favor, indique el código postal de su casa: _____

Opcional: Información de fondo
€ Etnia / Raza: _____
€ Edad: _____
€ Género: _____
€ Ingreso familiar estimado: _____
€ Nivel de educación: _____
€ Comentarios adicionales:
_____
_____
_____
_____
_____
_____
_____
_____

Gracias por completar esta encuesta. Si tiene preguntas sobre este estudio, comuníquese con Caitlin en cmildner@kittelson.com.

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1. 请填写您的家庭邮政编码:_____
2. **您多久探访这条路?**

€ 第一次
€ 每天
€ 每周1-3次
€ **每周4次以上**
€ 每月3次以上
€ 每月
€ 每年3次以上
€ 其他：_____
€ **3.您是如何到达这条路?** 步行
€ 骑自行车
€ 开车
€ 顺风车
€ 公共交通
€ 出租车或优步
€ 其他: _____

3. **以下哪个选项最能体现您今天在这里的活动？**

€ 步行
€ 慢跑
€ 滑滑板
€ 滑滑板车
€ 骑车
€ 徒步
€ 其他: _____

4. **如果没有这条路，您还会在其他地方进行这项活动么？If the path didn't exist, would you still participate in this activity elsewhere today?**

€ 是
€ 否
€ 不确定

5. **您计划在这里停留多久？ 时长（分钟或小时）：_____**
6. **您来这里的主要目的是？**

€ 休闲
€ 保持健康或运动健身
€ 通勤或旅游
€ 其他: _____

7. **请填写与您同行的所有人在每个年龄阶段的人数？**

€ 0至12岁_____
€ 13至18岁_____
€ 19至30岁_____
€ 31至50岁_____
€ 51岁 以上_____

8. **您认为这天路是否会影响本区域的犯罪率？**

€ 是，减少犯罪
€ 是，增多犯罪
€ 否，犯罪率不会受影响

9. **这条路是否对您购买以下物品产生了影响？**

€ 自行车
€ 自行车用品
€ 服饰
€ 户外装备
€ 其他:_____

10. **我们希望通过这个调查了解这条路对当地经济的影响。请问，为了今天的出行，您和您的家庭共花费了多少钱在以下的各项活动上？：**

€ $_____餐饮
€ $_____汽油
€ $_____零售商店
€ $_____住宿
€ $_____博物馆，公园，动物园
€ $_____其他

选填：背景信息

€ 种族：
€ 年龄: _____
€ 性别: _____
€ 预计年收入: _____
€ 教育等级: _____
€ 其他的建议: _____
_____
_____

感谢您参与本次调研！如果您有任何与本次调研有关的问题，欢迎联系Caitlin

cmildner@kittelson.com

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1. **Mã vùng nhà của bạn (zip code):**
   _____
2. **Bạn có thường xuyên ghé thăm con đường này không?**
€ Đây là lần đầu tiên của tôi
€ Hằng ngày
€ 1-3 lần một tuần
€ 4+ lần một tuần
€ Vài lần một tháng
€ Mỗi tháng
€ Vài lần một năm
€ Khác: _____
3. **Bạn đã đi đến con đường này ngày hôm nay như thế nào ?**
€ Đi bộ
€ Xe đạp
€ Lái xe
€ Đi chung xe
€ Xe buýt
€ Xe tắc xi/Uber
€ Khác: _____
4. **Hoạt động nào trong số những hoạt động này là tốt nhất miêu tả sử dụng con đường này hôm nay cho bạn?**
€ Đi bộ
€ Chạy bộ
€ Ván trượt
€ Xe tay ga
€ Xe đạp
€ Backpacking
€ Khác: _____
5. **Nếu đường dẫn này không tồn tại, bạn vẫn sẽ tham gia vào hoạt động này ở nơi khác hôm nay không?**
€ Có
€ Không
€ Không chắc chắn
6. **Bạn nghĩ bạn ở lại con đường này bao lâu hôm nay? Bao nhiêu phút/giờ:**
   _____
7. **ý định của bạn sử dụng đường này là gì?**
€ Sự giải trí
€ Sức khỏe/Tập thể dục
€ Giao hoán/đi vòng quanh
€ Khác: _____
8. **Bao nhiêu người trong nhóm bạn có thể chịu trách nhiệm cho phù hợp với các nhóm tuổi này:**
€ 0-12_____
€ 13-18_____
€ 19-30_____
€ 31-50_____
€ 51 +_____
9. **Bạn có nghĩ rằng con đường đã ảnh hưởng đến tỷ lệ tội phạm trong khu vực này không?**
€ Có - tội phạm nhiều hơn
€ Có - ít tội phạm hơn
€ Không - tội phạm không bị ảnh hưởng
10. **Con đường này có ảnh hưởng đến việc bạn mua:**
€ Xe đạp
€ Đồ cho xe đạp
€ Quần áo/giày
€ Đồ cho ở ngoài
€ Khác:_____
11. **Chúng tôi đang cố gắng đánh giá tác động kinh tế địa phương của con đường này. Kết quả của chuyến đi hôm nay của bạn, bạn và các bạn của bạn xài bao nhiêu tiền cho:**
€ $_____ Nhà hàng
€ $_____ Ga
€ $_____ Cửa hàng cho thuê đồ
€ $_____ Chỗ ở
€ $_____Bảo tàng, công viên, vườn thú
€ $_____Other

Tùy ý: thông tin lai lịch

€ Dân tộc:
   _____
€ Tuổi:
   _____
€ Nam/ Nữ:
   _____
€ Gia đình của bạn làm bao nhiêu tiền
   _____
€ Cấp độ đi học: _____
€ Ý kiến khác:
   _____
   _____

Cảm ơn bạn đã tham gia khảo sát này.
Câu hỏi về nghiên cứu này, vui lòng liên hệ Caitlin at cmildner@kittelson.com

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