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What’s Behind Recent Transit Ridership Trends in the Bay Area? Volume II: Trends among Major Transit Operators

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16. Abstract

Transit ridership in the San Francisco Bay Area is falling. Yet some operators, areas, times, directions, routes, modes, and services have fared better than others. These differences help reveal the causes of the Bay Area's overall ridership slump and inform policy and service decisions that aim to restore Bay Area transit use. To investigate these temporal and spatial trends, we analyze ridership on the eight largest Bay Area transit operators in considerable detail in Volume II of our report.

Overall, we find a significant level of "peaking." Ridership losses at off-peak hours, on weekends, on outlying routes, in non-commute directions, and on smaller operators account for a large and disproportionate share of the whole region's patronage decline. Downtown San Francisco and commute-oriented rail lines like Caltrain have gained ridership as less central, lower-service routes have lost patronage. These patterns match our statistical modeling of BART ridership, on which station-area jobs had the greatest influence, one that has grown over time. The most significant exceptions to the Bay Area's peaking problem are operators in urban cores, like Muni and AC Transit, where residential and employment density throughout the network have blunted peaking, though not necessarily overall losses.

Absolute patronage declines and peaking are intertwined but distinct problems, with cross-cutting divisions. Yet on all agencies, we see at least some evidence of peaking. The resulting dependence on peak trips both incurs high costs and depresses passenger satisfaction.

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Disclaimer

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What's Behind Recent Transit Ridership Trends in the Bay Area?

Volume II: Trends among Major Transit Operators

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Executive Summary

Executive Summary: Trends among Major Transit Operators

ES.1. Introduction

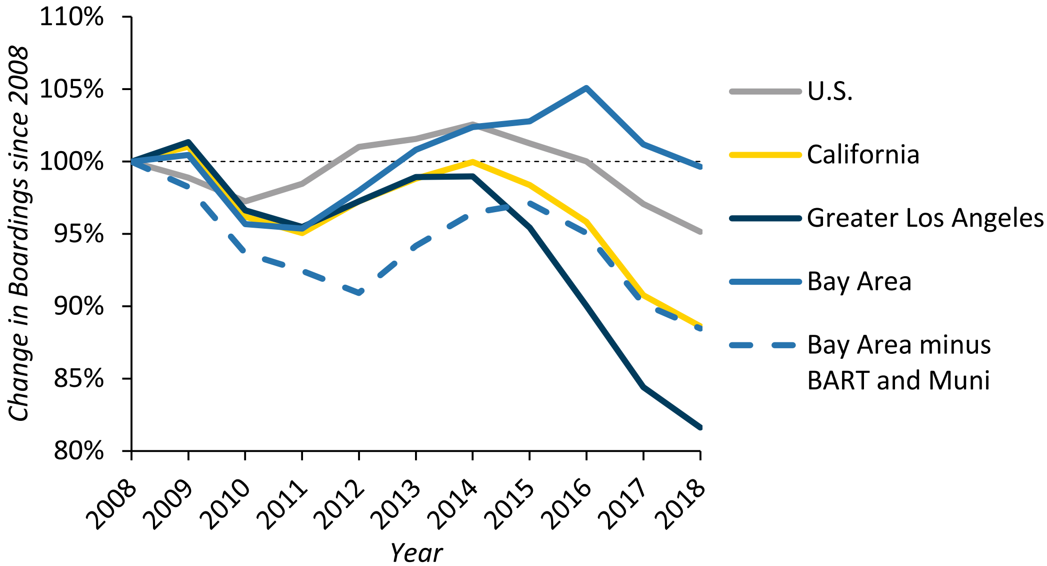
Transit ridership in the San Francisco Bay Area is falling. In just two years, 2017 and 2018, the nine-county Metropolitan Transportation Commission (MTC) region lost 27.5 million boardings, 5.2 percent of its total trips (FTA, 2019). While the situation may not be as dire as in other parts of the U.S., Bay Area operators have begun to shed patronage, some dropping faster and faster each year. Yet some operators, areas, times, directions, routes, modes, and services have fared much better than others. Far from trivial distinctions, these differences help reveal the causes of the Bay Area's overall ridership slump, highlight the similarities and differences between the Bay Area and other American metropolitan areas, and inform policy and service decisions that aim to restore Bay Area transit use.

To investigate temporal and spatial similarities and differences in ridership trends, we analyze ridership trends on the eight largest San Francisco Bay Area transit operators in considerable detail: San Francisco Municipal Transportation Agency (Muni or SFMTA), Bay Area Rapid Transit District (BART), Alameda-Contra Costa Transit District (AC Transit), Santa Clara Valley Transportation Authority (VTA), Peninsula Corridor Joint Powers Board (Caltrain), San Mateo County Transit District (SamTrans), Golden Gate Bridge, Highway, and Transportation District (Golden Gate Transit or GGT), and Central Contra Costa Transit Authority (County Connection). Together, these top eight carried 96 percent of the region's transit trips in 2018 (FTA, 2019).

ES.2. Bay Area Ridership Trends

Bay Area transit ridership trends present a "good news/bad news" story. The good news is in how the region differs from the rest of the U.S. While it may seem that the Bay Area's losses are yet another symptom of a nationwide plague of declining transit ridership, the region's patronage trends differ from elsewhere in timing and magnitude. Figure ES-1 shows how absolute ridership in the U.S., California, Greater Los Angeles, and the Bay Area has changed since 2008. The first three peaked in 2014 and have declined ever since, steepening every year. In contrast, Bay Area transit patronage continued to climb until 2016, only falling thereafter. This delay suggests that causes of ridership losses elsewhere—auto access increases in the Los Angeles Area (Manville, Taylor, and Blumenberg, 2018), service cut "death spirals" in D.C. (Aratani, 2016), etc.—are not major factors in the Bay Area. Rather, the region's tremendous job growth has sustained its transit ridership for longer, and a unique or uniquely strong set of factors, like changing residential locations in relation to employment, have now brought its patronage down.

Figure ES-1. Delayed Ridership Losses in the Bay Area, Particularly on BART and Muni



Data source: FTA, 2019

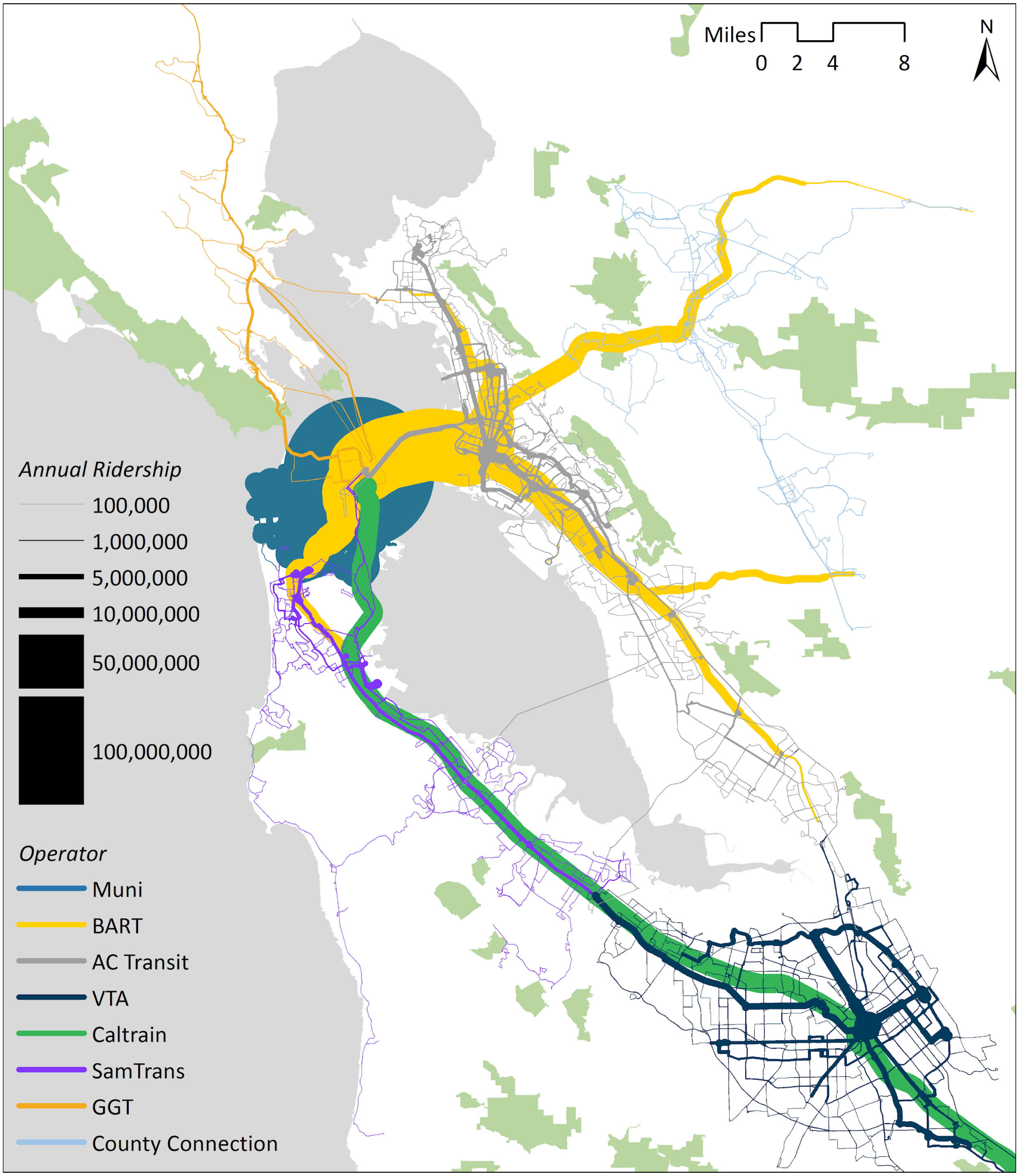
The bad news, though, is that the fundamentals of the region's ridership were weak long before it began to fall in absolute terms in 2017. For one, Bay Area ridership failed to keep pace with regional population growth, which has run above the national average (U.S. Census Bureau, 2011, 2019a): per capita ridership essentially flattened from 2013 to 2016, despite a healthy post-Great-Recession economic recovery. At no point since the start of the Great Recession has per capita ridership come close to its 2008 high. Productivity—measured here as the number of boardings per hour of service—dropped in the Bay Area beginning in 2014, as service increased without any growth in patronage, portending the decline in overall ridership to come (FTA, 2019).

The other warning sign was ridership on smaller operators. For context, the region's two largest transit operators, Muni and BART, carry over seven in ten Bay Area boardings (FTA, 2019) and most of those trips are on downtown San Francisco routes and the Transbay Tube (SFMTA, 2018 and BART, 2019e). Figure ES-2 dramatically demonstrates these concentrations,[1] with line widths corresponding to annual ridership along each route.[2] Market Street and the Transbay Tube dwarf the thin routes crossing most of the rest of the region. But it is beyond these transit hotspots on smaller operators that patronage has fallen most.

1. In Figures ES-2, ES-5, and ES-6, due to data availability, each individual route is depicted with the same ridership along its length—except on BART, whose origin-destination matrices allow for ridership to be shown between each pair of stations. However, where multiple routes of the same operator run on the same street, the line width for that segment reflects the sum of those routes.

2. In Figure ES-2, routes with annual ridership of under 500,000 boardings were rounded up for visibility. Ridership data reflect either calendar year 2018 or Fiscal Year 2018, depending on the operator.

Figure ES-2. Bay Area Ridership by Line, 2018 or Fiscal Year 2018

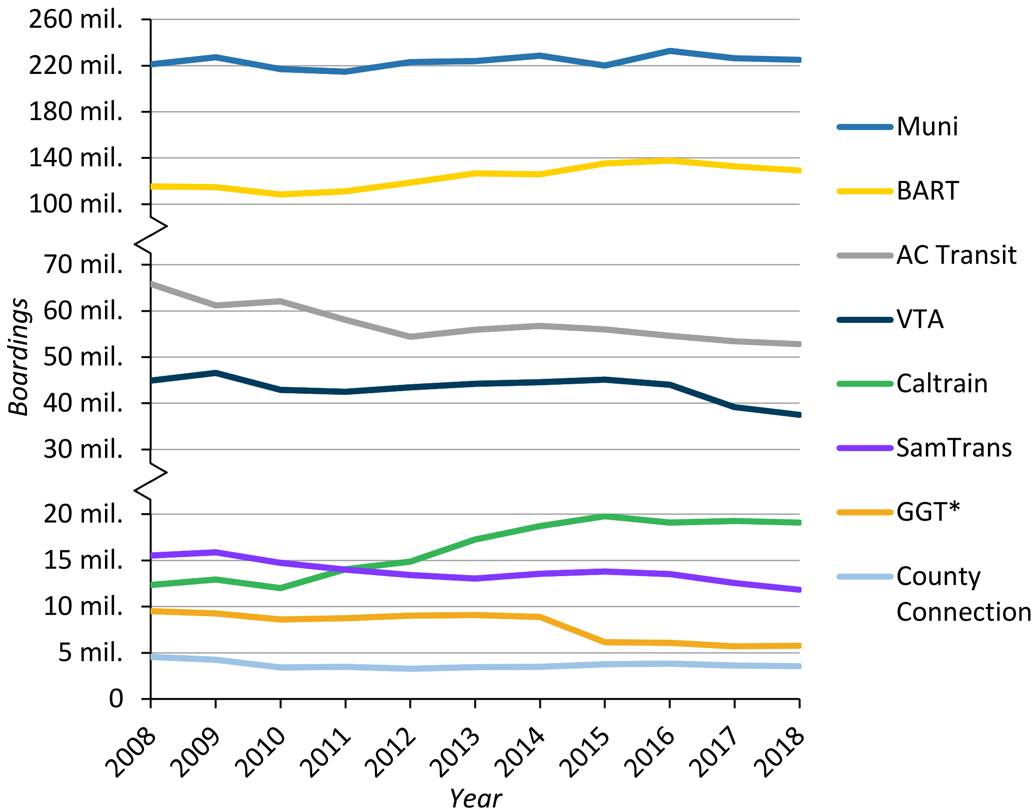


Data source: SFMTA, 2013, 2018; BART, 2019c, 2019e; AC Transit, 2019b, 2018; VTA, 2019b, 2018; Caltrain, 2019, 2018a; SamTrans, 2019b, 2019b, 2019a; GGBHTD, 2019a, 2019b; County Connection, 2019a, 2019b; U.S. Census Bureau, 2019b; CaliDetail, n.d.; and Esri, 2010

We highlight in Volume I, Chapter 3 that ridership gains on Muni and BART during most of the 2010s have in many ways masked longer-run patronage losses on the other Bay Area operators. As Figure ES-1 shows, without Muni and BART, the Bay Area's ridership trends look more like those of the nation overall. So these differences between the two largest agencies and the rest of the region's operators are not new. The recent patronage decline may have drawn these contrasts to the fore, but ridership trends have systematically differed among Bay Area agencies for the past decade.

Figure ES-3 shows trends in annual boardings over the past decade; note the discontinuous axis to allow for comparison among larger and smaller operators on one graph. Since 2008, Muni ridership has remained at roughly the same level—albeit with some noticeable year-to-year jumps, and without overall growth despite San Francisco's expanding population. BART, meanwhile, grew its patronage significantly and steadily, gaining 22 million additional annual boardings between 2008 and its 2016 peak (subsequently falling more recently). Increases on BART over that period and on Muni between 2011 and 2015 account for essentially all of the region's ridership growth over the past decade. These gains have masked stagnant or slipping ridership on most other operators. Ridership on VTA, for instance, remained virtually flat for the past decade before falling in 2017. AC Transit, the region's third busiest operator, lost over 13 million annual trips since 2008, the most of any agency region-wide. Its ridership suffered severely from the Great Recession and never recovered. The exception is Caltrain, whose route on a key commute corridor between downtown San Francisco and Silicon Valley has seen major ridership growth.

Figure ES-3. Annual Boardings by Bay Area Operator



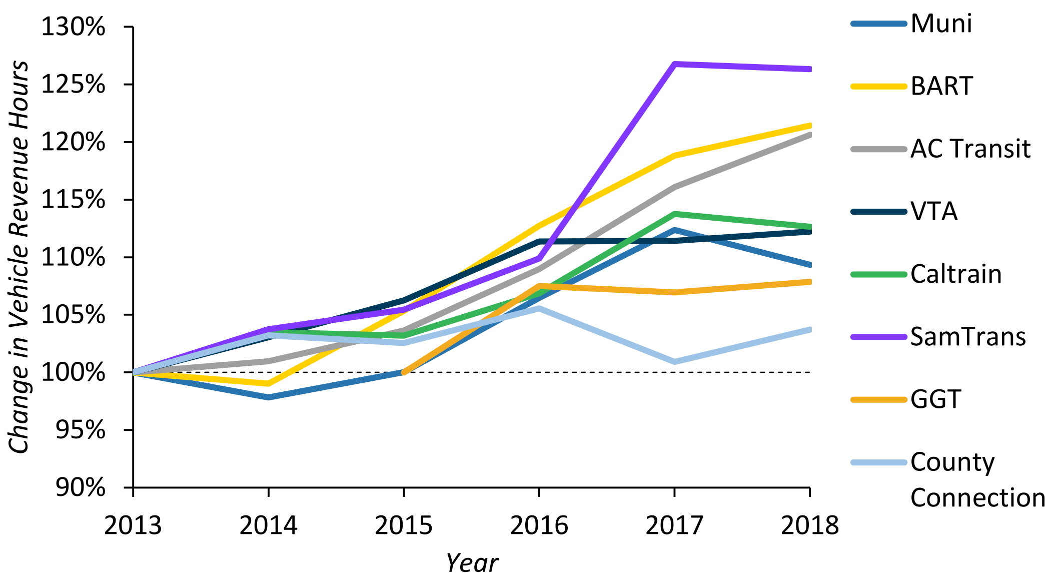
** In FY 2014-2015, Marin Transit began reporting a number of lines that were previously counted under GGT (Downing, 2020).*

Data source: FTA, 2019

We see little evidence that individual operators have reduced service across the board and in turn shed riders. Figure ES-4 shows changes in vehicle revenue hours of service in the past six years;[3] vehicle revenue mile trends look similar. For all of the top eight operators, service is up, in SamTrans' case by over 25 percent. Ridership has stubbornly fallen all the same. Indeed, two of the top three operators by percentage service-hour increase, SamTrans and AC Transit, have seen sharp downwards ridership trends, steeper than the region overall. To be sure, operators have scaled back service on certain modes and routes, but agency-wide service cuts cannot be the cause of the recent ridership decline simply because they have not occurred on most operators.

3. The past four years for GGT, as a major service reclassification in FY14-15 prevents apples-to-apples before-and-after comparison

Figure ES-4. Major Bay Area Operators Have Added Service Recently



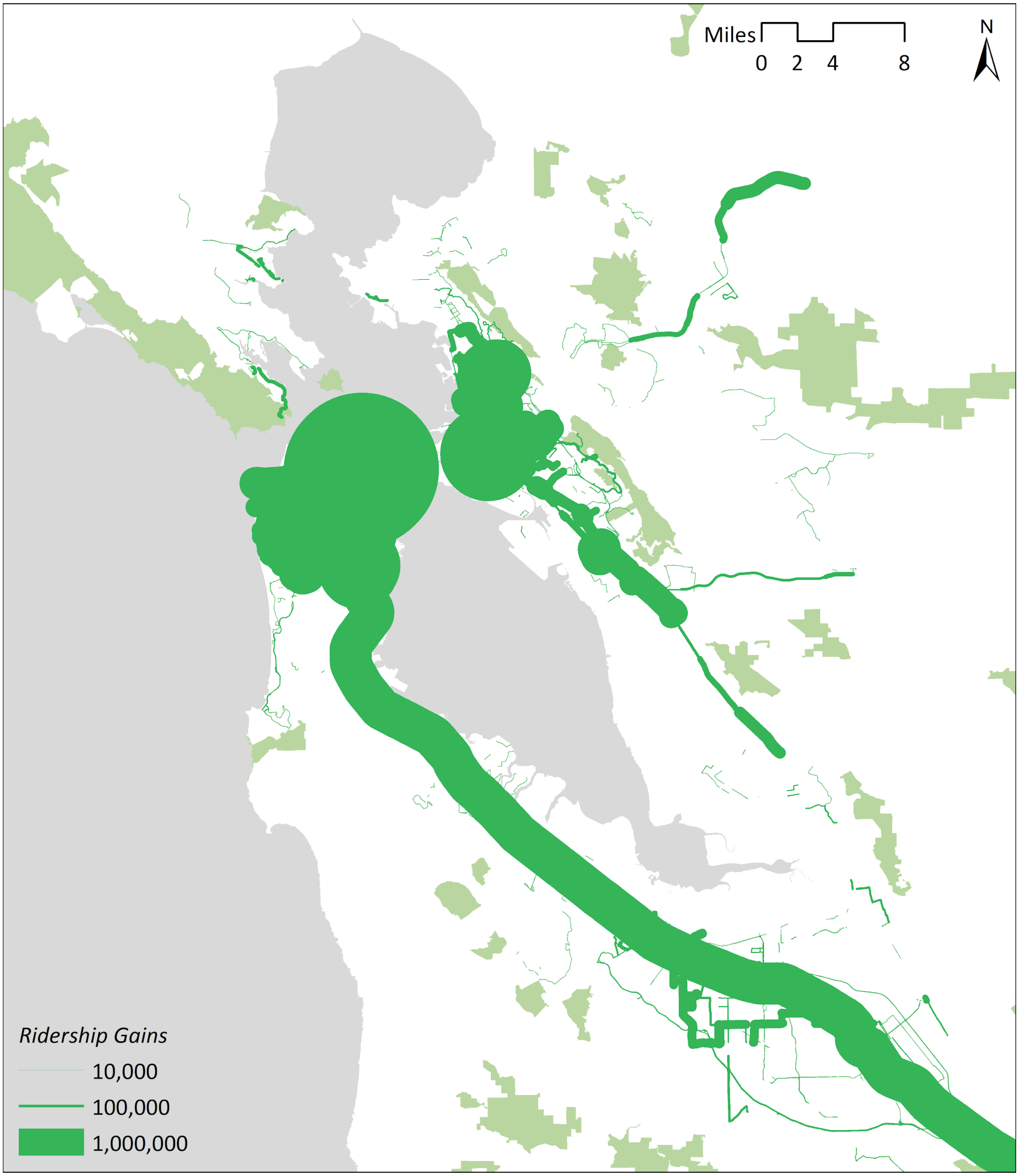
Data source: FTA, 2019

What we do find evidence for is "peaking." Peaking refers to the concentration of riders at peak times, in core areas, in commute directions, etc. Peaking can occur because peak transit use is growing as off-peak use is flat, because peak transit use is flat as off-peak use is falling, or—as is the case on a number of Bay Area operators—both are declining, but off-peak use is falling faster than peak use. As discussed further in the conclusion (Chapter 10), peaking can be an expensive problem and can depress rider satisfaction.

Overall, we find a significant level of peaking on major Bay Area transit operators. In other words, ridership losses at off-peak hours, on weekends, on outlying routes, in non-commute directions, and on smaller operators account for a large and disproportionate share of the whole region's patronage decline (Wasserman, 2019). Figures ES-5 and ES-6 lay out the geography of the region's peaking problem:[4] downtown San Francisco and commute-oriented rail lines have gained ridership as more outlying, lower-service routes have lost patronage. The most significant exceptions to the Bay Area's peaking problem are operators in urban cores, like Muni and AC Transit, where residential and employment density throughout the network have blunted peaking, though not necessarily overall losses. We discuss this and other nuances of the region's ridership and peaking issues in the chapters that follow.

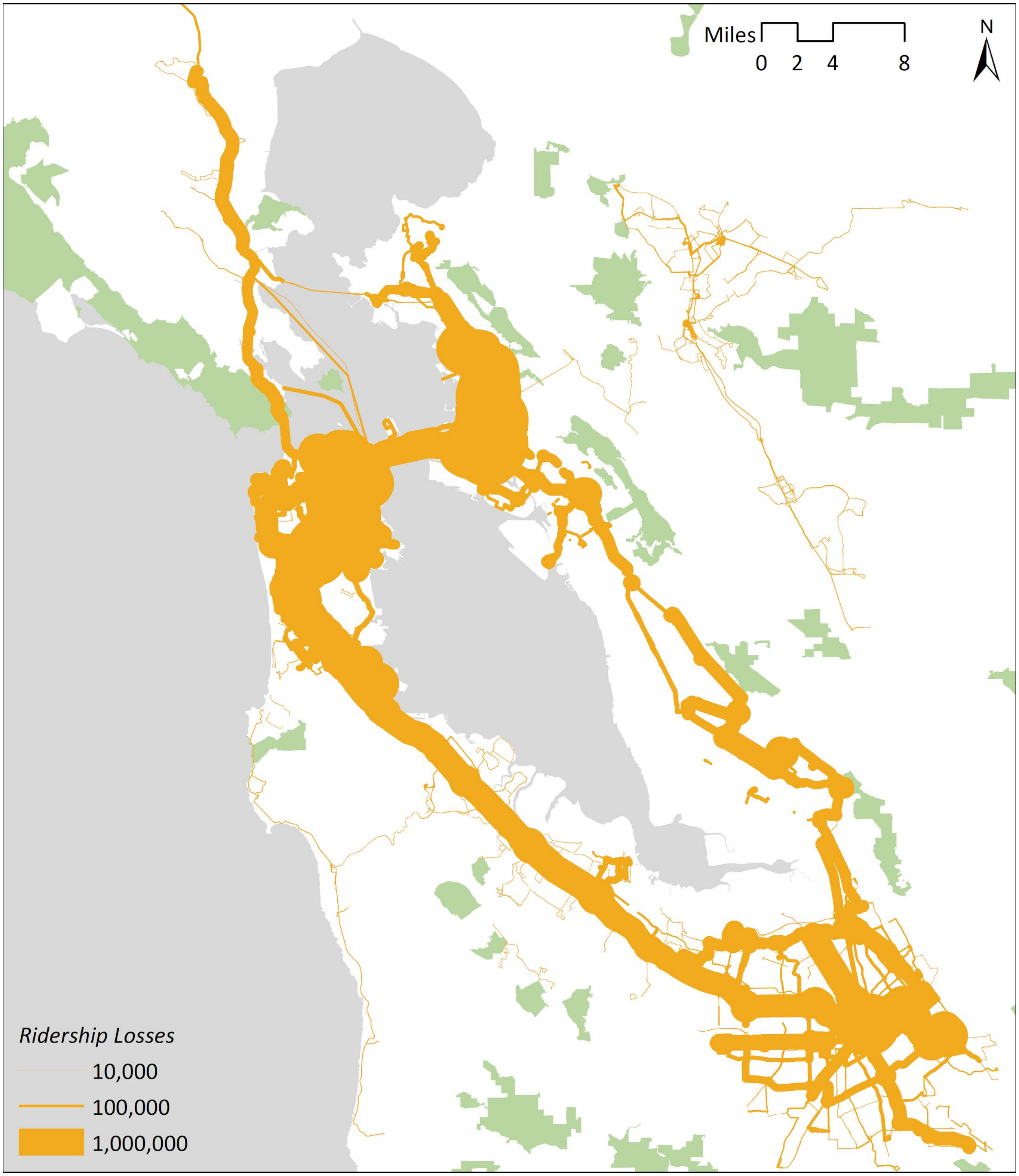
4. In Figures **ES-5** and **ES-6**, routes with a gain or loss in annual ridership, respectively, of under 20,000 boardings were rounded up for visibility. Ridership data reflect either the change between calendar years 2015 and 2018 or the change between Fiscal Years 2015 and 2018, depending on the operator.

Figure ES-5. Ridership Gains by Line, from 2015 to 2018 or from Fiscal Year 2015 to Fiscal Year 2018



Data source: SFMTA, 2013, 2018; BART, 2019c, 2019e; AC Transit, 2019b, 2018; VTA, 2019b, 2018; Caltrain, 2019, 2018a; SamTrans, 2019b, 2019b, 2019a; GGBHTD, 2019a, 2019b; County Connection, 2019a, 2019b; U.S. Census Bureau, 2019b; CaliDetail, n.d.; and Esri, 2010

Figure ES-6. Ridership Losses by Line, from 2015 to 2018 or from Fiscal Year 2015 to Fiscal Year 2018



Data source: SFMTA, 2013, 2018; BART, 2019c, 2019e; AC Transit, 2019b, 2018; VTA, 2019b, 2018; Caltrain, 2019, 2018a; SamTrans, 2019b, 2019b, 2019a; GGBHTD, 2019a, 2019b; County Connection, 2019a, 2019b; U.S. Census Bureau, 2019b; CaliDetail, n.d.; and Esri, 2010

ES.3. Muni Ridership Trends

Muni, the region's largest transit agency, has simultaneously shed ridership in one of the most transit-favorable areas in America and has retained patronage better than most other national operators. Muni lost 7.8 million annual riders between 2016 and 2018—6.6 million in 2017 alone—with even steeper losses on a per capita basis (FTA, 2019). But unlike BART, AC Transit, and VTA, it gained significant ridership in 2016 and has generally had volatile ridership fluctuations from year to year. Recently, Muni has seen significant ridership shifts to lines with more frequent service and modes with more dedicated rights of way (SFMTA, 2018). Between Fiscal Years 2015 and 2018, weekday local bus boardings fell three percent, while Rapid bus patronage rose 24 percent and light rail six percent. Indeed, many of the lines with the largest losses are the local routes along the same corridors as Rapids, which have seen some of the largest gains. Meanwhile, weekday ridership on lines with peak frequencies of ten minutes or less grew three percent, while less frequent routes carried two percent fewer trips. Overall, Muni has experienced some degree of peaking, especially by mode, but the high density of its entire operating environment has helped it avoid the acute peaking problems and sharp total losses of other agencies.

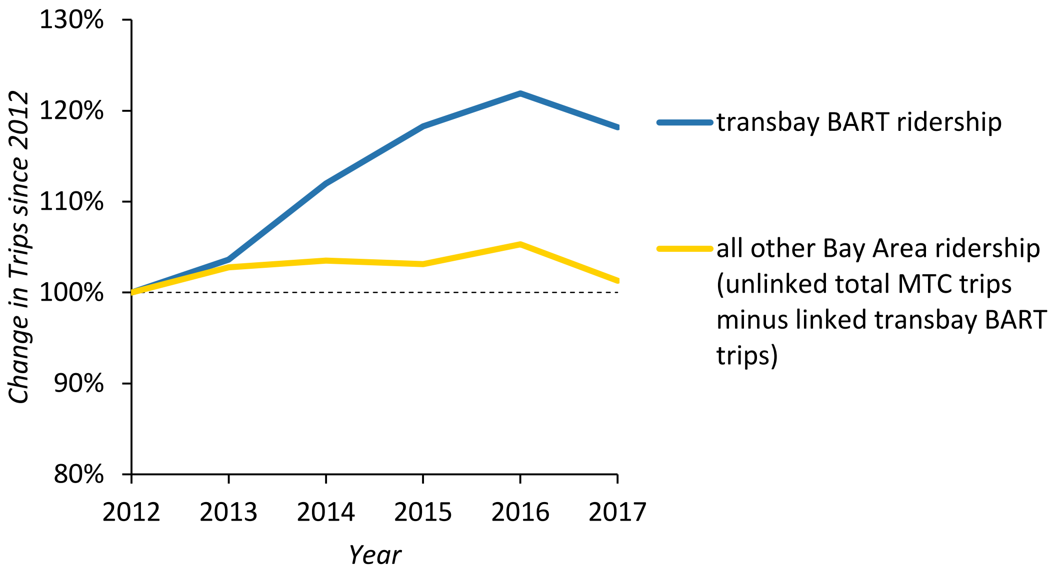
ES.4. BART Ridership Trends

BART, the Bay Area's regional heavy-rail system and its second-most-ridden operator, has experienced a growing divergence between peak and off-peak ridership trends. But despite a recent decline in trips, BART's patronage growth also sustained the region's ridership in the years prior to the Bay Area's overall decline.

Between 2015 and 2018, trip counts at peak hours were almost identical, while trips at all other times fell 11 percent. Weekday ridership dropped four percent, compared to a 16 percent reduction on Saturdays and a 17 percent reduction on Sundays. Ridership into or out of downtown San Francisco, a huge job cluster, dipped only slightly, while trips to and from all other stations account for over half of the system's ridership losses over the same period, though they represent just 34 percent of all trips. Measured slightly differently, transbay trips between the relatively housing-rich East Bay and the relatively jobs-rich San Francisco Peninsula have remained healthy, while trips that did not cross San Francisco Bay account for 86 percent of system losses but less than half of system ridership. By any measure, BART's peaking problem is acute. But its peak trip growth has also propped up the whole Bay Area: BART transbay trips alone accounted for 43 percent of the *entire region's* ridership growth from 2012 to 2015, despite making up only 15 percent of 2015 patronage[5] (See Figure ES-7) (BART, 2019e and FTA, 2019).

5. Admittedly a rough estimate, as the internal BART data on transbay trips count linked trips, while the regional NTD data count unlinked trips

Figure ES-7. Transbay BART Trips Accounted for Much of the Bay Area's Overall Ridership Growth



Data source: BART, 2019e and FTA, 2019

To determine the most influential factors driving the trends above, we look at the determinants of BART ridership using a multivariate statistical model. We find that station-area jobs are, by far, the most important factor explaining BART ridership in both 2011 and 2015. Moreover, their influence has grown over time. The influence of employment even outweighs the headways at a station (as measured by the number of lines), which are often among the most important predictors of transit use. In an alternate set of models requiring more estimation, we could not establish that station cleanliness, police presence, or homeless counts were having significant, independent effects on BART ridership, public debates about these issues notwithstanding.

ES.5. AC Transit Ridership Trends

AC Transit has simultaneously lost a substantial share of its ridership but avoided the peaking problems of other agencies like BART. AC Transit has lost ridership across its route types, days of the week, and lines (AC Transit, 2018). Like Muni, AC Transit operates in a relatively dense service area; however, its Oakland service area lacks the explosive job growth of downtown San Francisco (U.S. Census Bureau, n.d.), likely contributing to AC Transit's deeper ridership drops. Indeed, AC Transit lost the third-most boardings of all Bay Area operators between 2015 and 2018 (FTA, 2019).

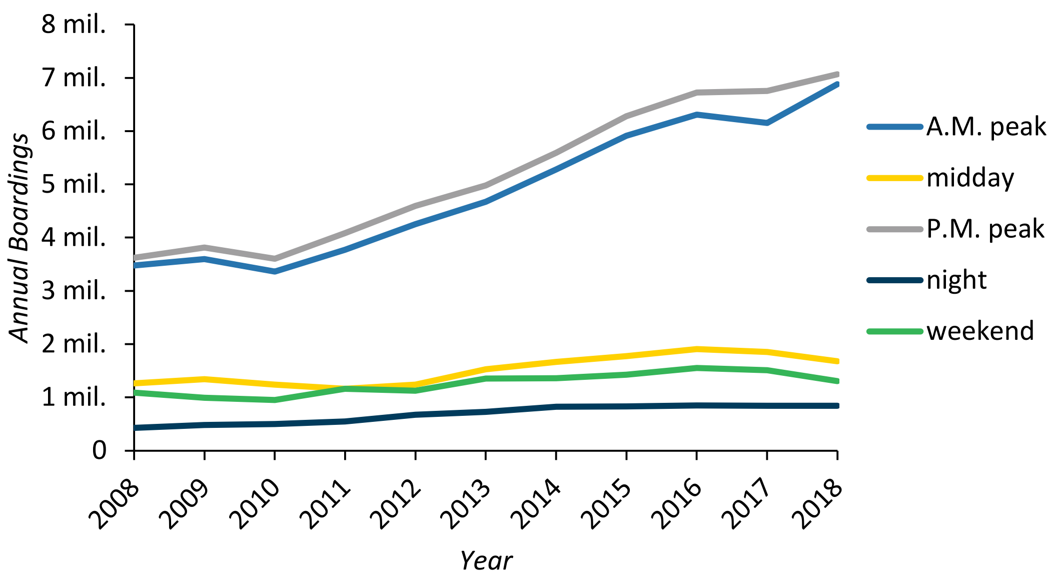
ES.6. VTA Ridership Trends

VTA's ridership trajectory looks more like that of the U.S. than the Bay Area overall. VTA has experienced some ridership declines across modes and lines, but with particular losses off-peak (VTA, 2018). While rush-hour ridership jumped ten percent between April 2015 and April 2018, off-peak patronage dipped 18 percent—and dragged the agency's topline ridership number down with it. Light rail routes and outlying bus services have, respectively, suffered some of the agency's largest absolute and relative losses over the same period. Broadly, VTA's steepest losses come from its most-patronized lines.

ES.7. Caltrain Ridership Trends

If any agency in the Bay Area represents a ridership success story, it is Caltrain. Coming off over a dozen years of nearly uninterrupted ridership growth, Caltrain connects the Bay Area's two largest cities, San Francisco and San José, and its two largest job centers, downtown San Francisco and Silicon Valley. Potentially for the same reasons as its ridership has grown, its peaking problem is acute: weekday ridership, and rush-hour patronage in particular (See Figure ES-8), each account for almost all of the agency's ridership growth (Caltrain, 2018a). Meanwhile, trip counts are beginning to slide on local trains and in off-peak directions.

Figure ES-8. Annual Caltrain Ridership by Time of Day



Data source: Caltrain, 2018a

ES.8. SamTrans Ridership Trends

Ridership trends on SamTrans in some ways complicate the story we tell of other operators' patronage trends. SamTrans' service area has experienced substantial job growth (U.S. Census Bureau, n.d.), which, elsewhere, has sustained peak but not off-peak ridership on BART, GGT, and VTA. But on SamTrans, boardings have fallen across the board, dropping at similar rates across geographic sub-areas, route types, and days of the week (SamTrans, 2019a). With housing growth failing to keep up with job growth in San Mateo County (U.S. Census Bureau, 2019a, n.d.), the internal ridership data suggest that job growth alone has failed to support ridership on relatively short trips within the service area (SamTrans, 2019a).

ES.9. GGT Ridership Trends

Like BART and Caltrain, commute-oriented Golden Gate Transit's off-peak ridership trends have diverged starkly from its peak trends. Boardings on weekdays, at rush hour, on ferries, and on peak-only routes have declined only slightly, while trips on weekends, in the evening, on buses, and on all-day services have plunged (GGBHTD, 2019b). But unlike BART and Caltrain, GGT's overall patronage has dropped as its peaking problems have sharpened. Yet, while GGT faces the same employment-driven peaking pressures as other large Bay Area operators, wildfires, service reclassifications, and competing transit options offer explanations for these trends unique to GGT.

ES.10. County Connection Ridership Trends

County Connection, the eighth-largest operator in the Bay Area by 2018 boardings, was selected to represent the roughly dozen and a half smaller transit operators in the region. While the largest of these small operators, County Connection is likely emblematic: placing between the small operators that have gained patronage and those that have lost it, County Connection had nearly the same total ridership in 2017 as in 2014 (FTA, 2019). Serving largely suburban and exurban communities in Central Contra Costa County, County Connection is only one of the eight agencies profiled herein without any service in the three largest Bay Area cities (San José, San Francisco, and Oakland (U.S. Census Bureau, 2019a)). Unlike the largely intra-urban operators like Muni and AC Transit, on which declines have occurred relatively evenly across the system, and commuter systems like BART and GGT, on which declines are focused at peak times and in commute directions, County Connection has seen moderate peaking (County Connection, 2019b).

ES.11. Conclusion

Bay Area ridership faces two intertwined but distinct problems: absolute patronage losses and peaking. These issues are correlated, and many of the same causes, like changing residential locations, are behind both. Yet in surveying the ridership landscape of the top eight Bay Area transit agencies, we see cross-cutting divisions.

Caltrain, for instance, has experienced over the past decade both tremendous growth (56% growth, the highest relative growth of the operators profiled herein) and acute peaking. Despite some worrisome overall trip losses in the past two years, BART also falls into this category. Its patronage growth propped up the whole region in the years after the Great Recession, even as its ridership increasingly concentrated on weekday transbay commute trips.

Meanwhile, Muni, SamTrans, and AC Transit have experienced little peaking, with ridership trends on weekends and low-frequency lines tracking relatively closely. To be sure, even these operators have seen some peaking by various measures, but not nearly to the degree of BART or Caltrain. Yet their overall ridership trends differ dramatically. Muni's ridership is bumpy but high, as riders likely shifting within the agency from local services and slower modes to express services and faster modes. SamTrans ridership, though, has fallen, both recently and over the past decade; AC Transit's trip counts have dropped even more steeply.

Finally, VTA and GGT have experienced both peaking and ridership losses. Even here, though, there is nuance: VTA's ridership is growing at peak times, but not on its busiest lines. GGT, meanwhile, represents the only clear-cut case of an agency-wide decrease in revenue service hours and miles, as ridership has also plunged. Amidst all this, low-ridership operators like County Connection have seen only moderate peaking and only moderate ridership losses.

Job growth and its relation to urban form may explain these differences. While not a perfect classification, the three most clearly commute-oriented operators—Caltrain, BART, and GGT—have witnessed the most severe peaking. As other pressures depress off-peak trip-making on these operators, employment growth has sustained or even increased their ridership at their peak hours and on their faster services. Thanks to BART's rich origin-destination data, our statistical models show that station-area jobs do indeed have the greatest influence on ridership on BART, an influence that has grown over time.

Though they certainly also carry commuters, agencies like Muni and AC Transit also bear many short, non-work trips as well, given their location in the region's urban cores. This may explain why their peaking has been less acute. However, employment growth in San Francisco has outpaced growth in the parts of the East Bay that AC Transit serves—explaining in part why, despite neither having sharp peaking, AC Transit has lost a far greater share of its ridership than Muni. Lacking a clear commuter orientation and a large urban center, operators like County Connection have not experienced extremes of either peaking or ridership change.

Yet on all agencies, we see at least some evidence of peaking. All told, off-peak and non-commute trip types account for a disproportionate share of the region's losses. The resulting dependence on peak trips both incurs high costs—procuring vehicles and hiring workers needed only for peak periods is inefficient (Taylor, Garrett, and Iseki, 2000)—and depresses passenger satisfaction—due to overcrowding and other such issues. Expanding capacity to address the problems caused by peaking is also neither easy nor cheap. For instance, to better handle peak-hour crush loads, BART is presently working to upgrade capacity in the Transbay Tube, with the goal of increasing peak-period frequencies from the current 23 trains per hour to 30 trains per hour. Current detailed cost estimates peg the price of the project at $3.5 billion (Watry, 2019). In addition, longer-term plans are underway to add an additional tube under San Francisco Bay; preliminary estimates for this project range from $5 to $12 billion (MTC, 2017). Other operators may not be planning such large projects, but the same fiscal realities apply.

Introduction

1. Introduction

1.1. Study Purpose

Transit ridership in the San Francisco Bay Area is falling. In just two years, 2017 and 2018, the nine-county Metropolitan Transportation Commission (MTC) region lost 27.5 million boardings, 5.2 percent of its total trips (FTA, 2019). While the situation may not be as dire as in other parts of the U.S., Bay Area operators have begun to shed patronage, some dropping faster and faster each year. Yet some operators, areas, times, directions, routes, modes, and services have fared much better than others. Far from trivial distinctions, these differences help reveal the causes of the Bay Area's overall ridership slump, highlight the similarities and differences between the Bay Area and other American metropolitan areas, and inform policy and service decisions that aim to restore Bay Area transit use.

This volume is a detailed supplement to the UCLA Institute of Transportation Studies' (UCLA ITS) broader study of transit use trends, commissioned by the Metropolitan Transportation Commission and presented in Volume I. The introduction (Chapter 1), discussion of region-wide transit trends (Chapter 3), list of key terms and definitions (Appendix A), and list of major data sources (Appendix B) in Volume I will help to orient, explain, and contextualize this volume.

1.2. Operators and Data

To investigate temporal and spatial similarities and differences in ridership trends, we analyze ridership trends in this volume on the eight largest San Francisco Bay Area transit operators in considerable detail:

1. San Francisco Municipal Transportation Agency (Muni or SFMTA)
2. Bay Area Rapid Transit District (BART)
3. Alameda-Contra Costa Transit District (AC Transit)
4. Santa Clara Valley Transportation Authority (VTA)
5. Peninsula Corridor Joint Powers Board (Caltrain)
6. San Mateo County Transit District (SamTrans)
7. Golden Gate Bridge, Highway, and Transportation District (Golden Gate Transit or GGT)
8. Central Contra Costa Transit Authority (County Connection)

Together, these top eight carried 96 percent of the region's transit trips in 2018 (FTA, 2019). The following chapters offer a thorough analysis of ridership trends on each of them, ordered, as above, by their number of boardings in 2017. The introductions to each of these chapters describes the operator's size and scale, service area, and topline ridership changes, followed by a more comprehensive analysis of agency patronage.

Each of these operators graciously provided UCLA ITS with a dataset of their ridership and, in many cases, service levels in recent years. Collectively, these datasets paint a detailed picture of Bay Area transit use trends. For each operator, we examine ridership trends broken down in as many salient ways as each dataset allows. The datasets are not precisely congruent across operators—for instance, some report boardings by calendar year, others by fiscal year—but we conduct a number of similar analyses of each operator that can, to varying degrees, be compared across agencies.

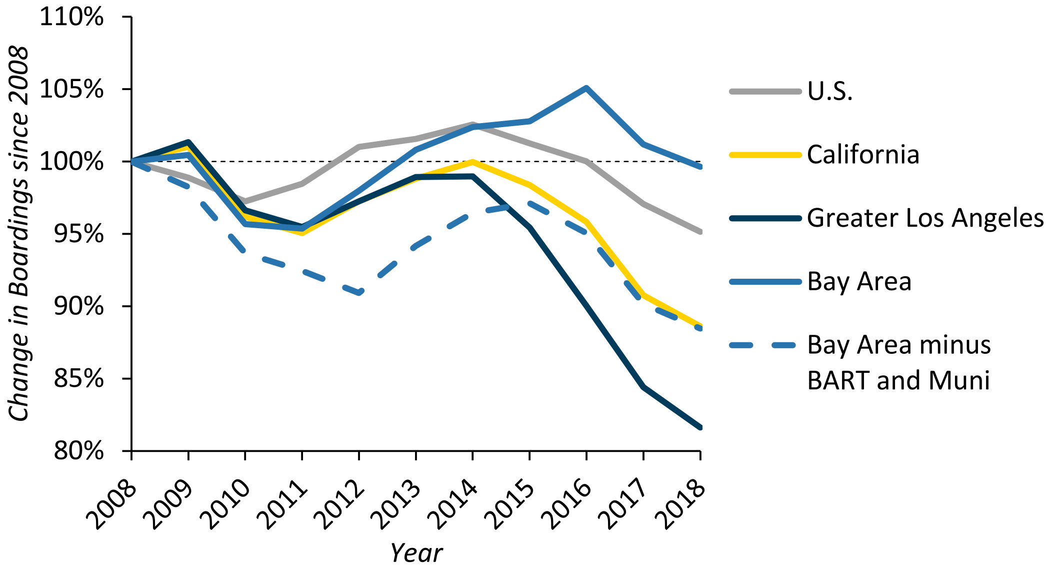
To further aid in cross-agency (and cross-regional) contrasts, we draw on the National Transit Database (NTD),[1] the Federal Transit Administration's (FTA) repository of ridership, service, and financial statistics for transit operators nationwide (FTA, 2019). Operators' internal datasets and NTD submissions do vary somewhat, to degrees discussed in the chapters below. But overall, the NTD and operator internal data complement each other, with the latter providing greater detail and the former allowing better comparisons.

1.3. Bay Area Ridership Trends

Bay Area transit ridership trends present a "good news/bad news" story. The good news is in how the region differs from the rest of the U.S. While it may seem that the Bay Area's losses are yet another symptom of a nationwide plague of declining transit ridership, the region's patronage trends differ from elsewhere in timing and magnitude. Figure 1-1 shows how absolute ridership in the U.S., California, Greater Los Angeles, and the Bay Area has changed since 2008. The first three peaked in 2014 and have declined ever since, steepening every year. In contrast, Bay Area transit patronage continued to climb until 2016, only falling thereafter. This delay suggests that causes of ridership losses elsewhere—auto access increases in Greater Los Angeles (Manville, Taylor, and Blumenberg, 2018), service cut "death spirals" in D.C. (Aratani, 2016), etc.—are not major factors in the Bay Area. Rather, the region's tremendous job growth has sustained its transit ridership for longer, and a unique or uniquely strong set of factors discussed in Volume I, like changing residential locations in relation to employment, have now brought its patronage down.

1. The NTD reports statistics by year, which are labeled in the dataset as calendar years but are actually the aggregate of each operator's fiscal year (whose start and end dates vary between operators). Following the lead of other scholarly publications, we reference annual NTD data by calendar year in graphs and text.

Figure 1-1. Delayed Ridership Losses in the Bay Area, Particularly on BART and Muni



Data source: FTA, 2019

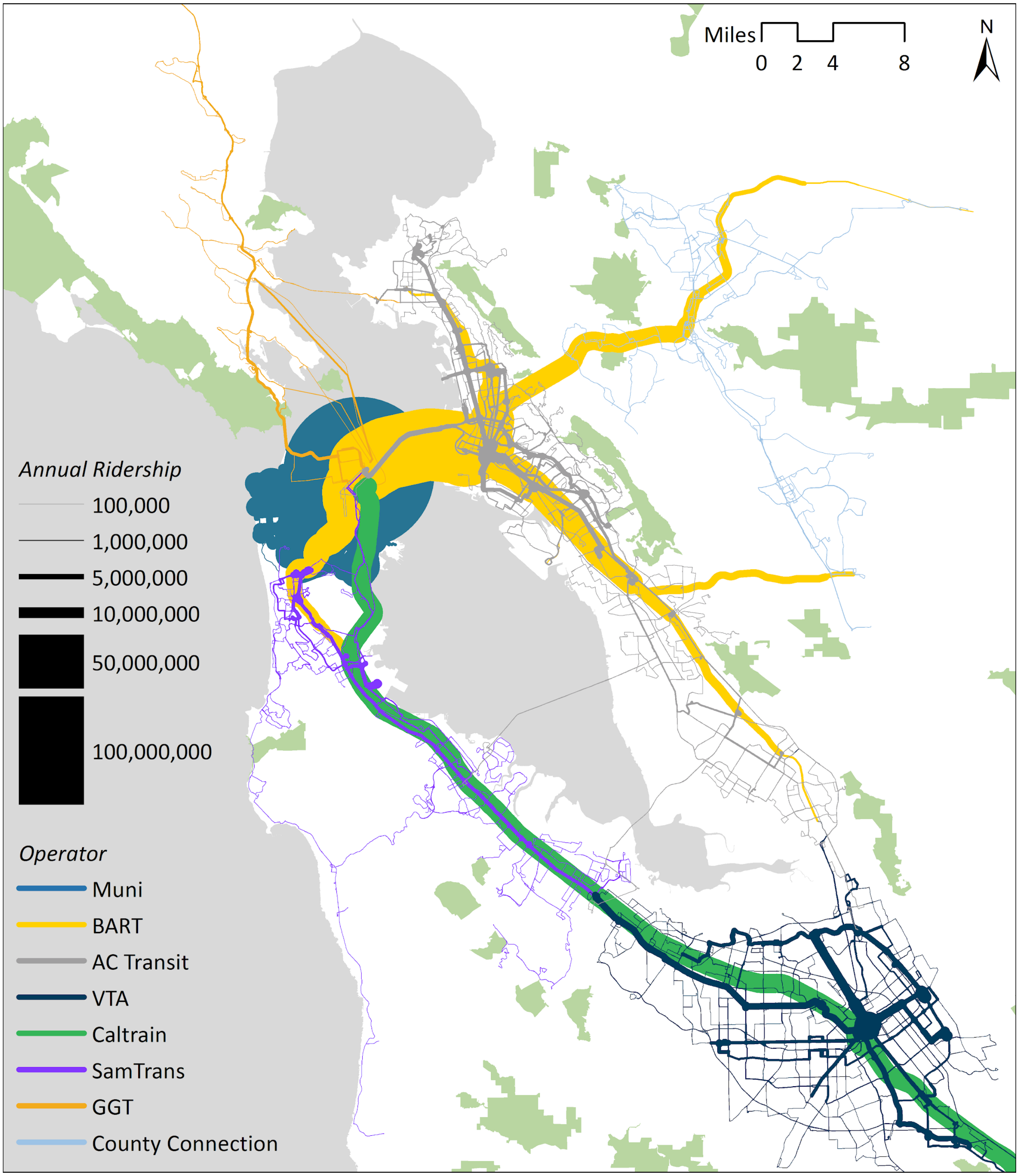
The bad news, though, is that the fundamentals of the region's ridership were weak long before it began to fall in absolute terms in 2017. For one, Bay Area ridership failed to keep pace with regional population growth, which has run above the national average (U.S. Census Bureau, 2011, 2019a): per capita ridership essentially flattened from 2013 to 2016, despite a healthy economic recovery post-Great-Recession. At no point since the start of the Great Recession has per capita ridership come close to its 2008 high. Productivity—measured here as the number of boardings per hour of service—dropped in the Bay Area beginning in 2014, as service increased without any growth in patronage, portending the decline in overall ridership to come (FTA, 2019).

The other warning sign was ridership on smaller operators. For context, the region's two largest transit operators, Muni and BART, carry over seven in ten Bay Area boardings (FTA, 2019) and most of those trips are on downtown San Francisco routes and the Transbay Tube (SFMTA, 2018 and BART, 2019e). Figure 1-2 dramatically demonstrates these concentrations,[2] with line widths corresponding to annual ridership along each route.[3] Market Street and the Transbay Tube dwarf the thin routes crossing most of the rest of the region. But it is beyond these transit hotspots on smaller operators that patronage has fallen most.

Figure 1-2. Bay Area Ridership by Line, 2018 or Fiscal Year 2018

2. In Figures 1-2, 1-5, and 1-6, due to data availability, each individual route is depicted with the same ridership along its length—except on BART, whose origin-destination matrices allow for ridership to be shown between each pair of stations. However, where multiple routes of the same operator run on the same street, the line width for that segment reflects the sum of those routes.

3. In Figure 1-2, routes with annual ridership of under 500,000 boardings were rounded up for visibility. Ridership data reflect either calendar year 2018 or Fiscal Year 2018, depending on the operator.

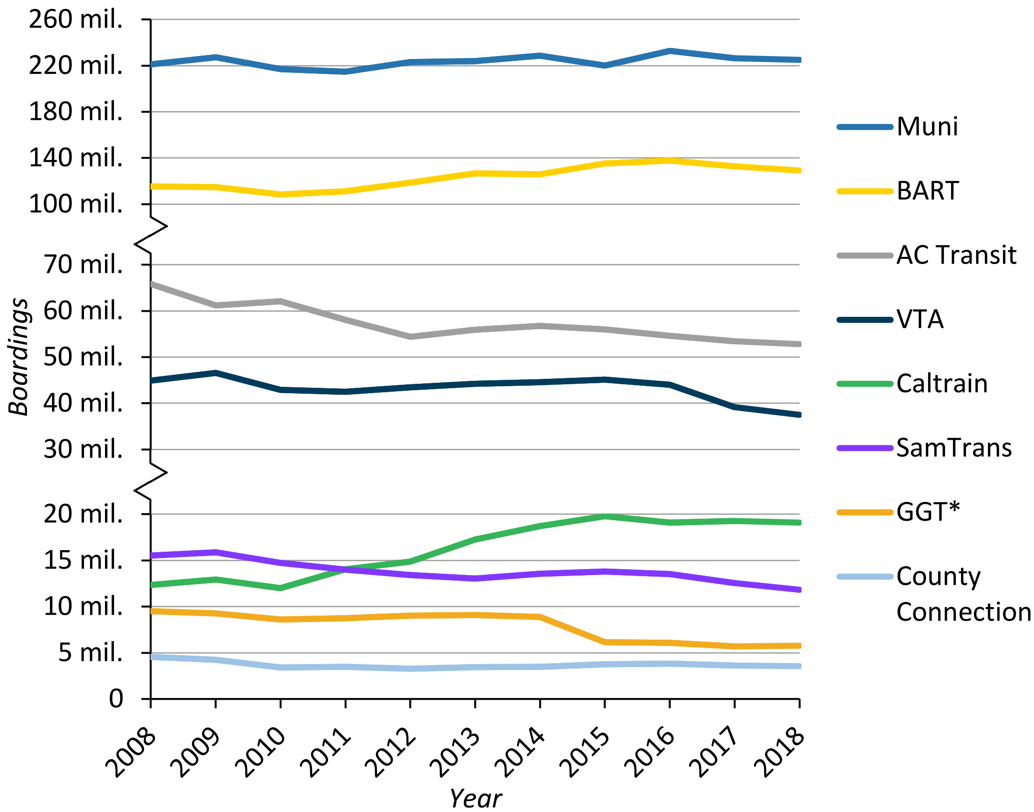


Data source: SFMTA, 2013, 2018; BART, 2019c, 2019e; AC Transit, 2019b, 2018; VTA, 2019b, 2018; Caltrain, 2019, 2018a; SamTrans, 2019b, 2019b, 2019a; GGBHTD, 2019a, 2019b; County Connection, 2019a, 2019b; U.S. Census Bureau, 2019b; CaliDetail, n.d.; and Esri, 2010

We highlight in Volume I, Chapter 3 that ridership gains on Muni and BART during most of the 2010s have in many ways masked longer-run patronage losses on the other Bay Area operators. As Figure 1-1 shows, without Muni and BART, the Bay Area's ridership trends look more like those of the nation overall. So these differences between the two largest agencies and the rest of the region's operators are not new. The recent patronage decline may have drawn these contrasts to the fore, but ridership trends have systematically differed among Bay Area agencies for the past decade.

Figure 1-3 shows trends in annual boardings over the past decade; note the discontinuous axis to allow for comparison among larger and smaller operators on one graph. Since 2008, Muni ridership has remained at roughly the same level—albeit with some noticeable year-to-year jumps, and without overall growth despite San Francisco's expanding population. BART, meanwhile, grew its patronage significantly and steadily, gaining 22 million additional annual boardings between 2008 and its 2016 peak (subsequently falling more recently). Increases on BART over that period and on Muni between 2011 and 2015 account for essentially all of the region's ridership growth over the past decade. These gains have masked stagnant or slipping ridership on most other operators. Ridership on VTA, for instance, remained virtually flat for the past decade before falling in 2017. AC Transit, the region's third busiest operator, lost over 13 million annual trips since 2008, the most of any agency region-wide. Its ridership suffered severely from the Great Recession and never recovered. The exception is Caltrain, whose route on a key commute corridor between downtown San Francisco and Silicon Valley has seen major ridership growth.

Figure 1-3. Annual Boardings by Bay Area Operator



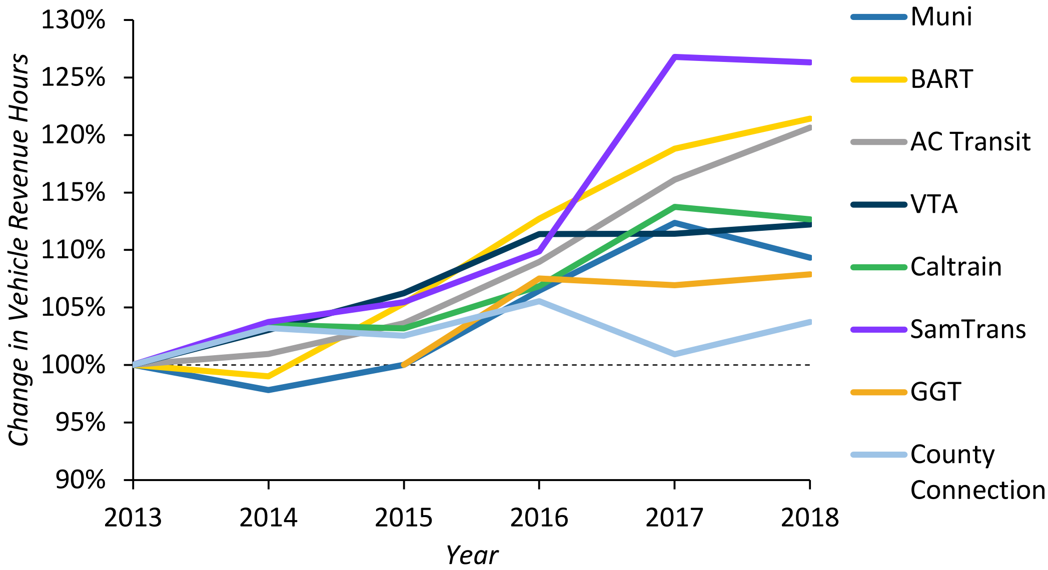
** In FY 2014-2015, Marin Transit began reporting a number of lines to the NTD that were previously counted under GGT (See Chapter 8, Section 1) (Downing, 2020).*

Data source: FTA, 2019

Just as we rule out service cuts as an explanation for falling ridership region-wide (See Volume I, Chapter 3), we also see little evidence that individual operators have reduced service across the board and in turn shed riders. Figure 1-4 shows changes in vehicle revenue hours of service in the past six years;[4] vehicle revenue mile trends look similar. For all of the top eight operators, service is up, in SamTrans' case by over 25 percent. Ridership has stubbornly fallen all the same. Indeed, two of the top three operators by percentage service-hour increase, SamTrans and AC Transit, have seen sharp downwards ridership trends, steeper than the region overall. To be clear, our analysis says nothing about whether service cuts depressed ridership in the past. Over the past two decades, agencies like VTA have faced criticism from advocates for reducing the hours and geographic spread of their routes (Silicon Valley Transit Users, 2019). But agency-wide service cuts cannot be the cause of the recent ridership decline simply because they have not occurred on most operators. To be sure, operators have scaled back service on certain modes and routes, the specific effects of which are discussed in relevant chapters following.

Figure 1-4. Major Bay Area Operators Have Added Service Recently

4. The past four years for GGT, as a major service reclassification in FY14-15, discussed in Chapter 8, Section 1, prevents apples-to-apples before-and-after comparison



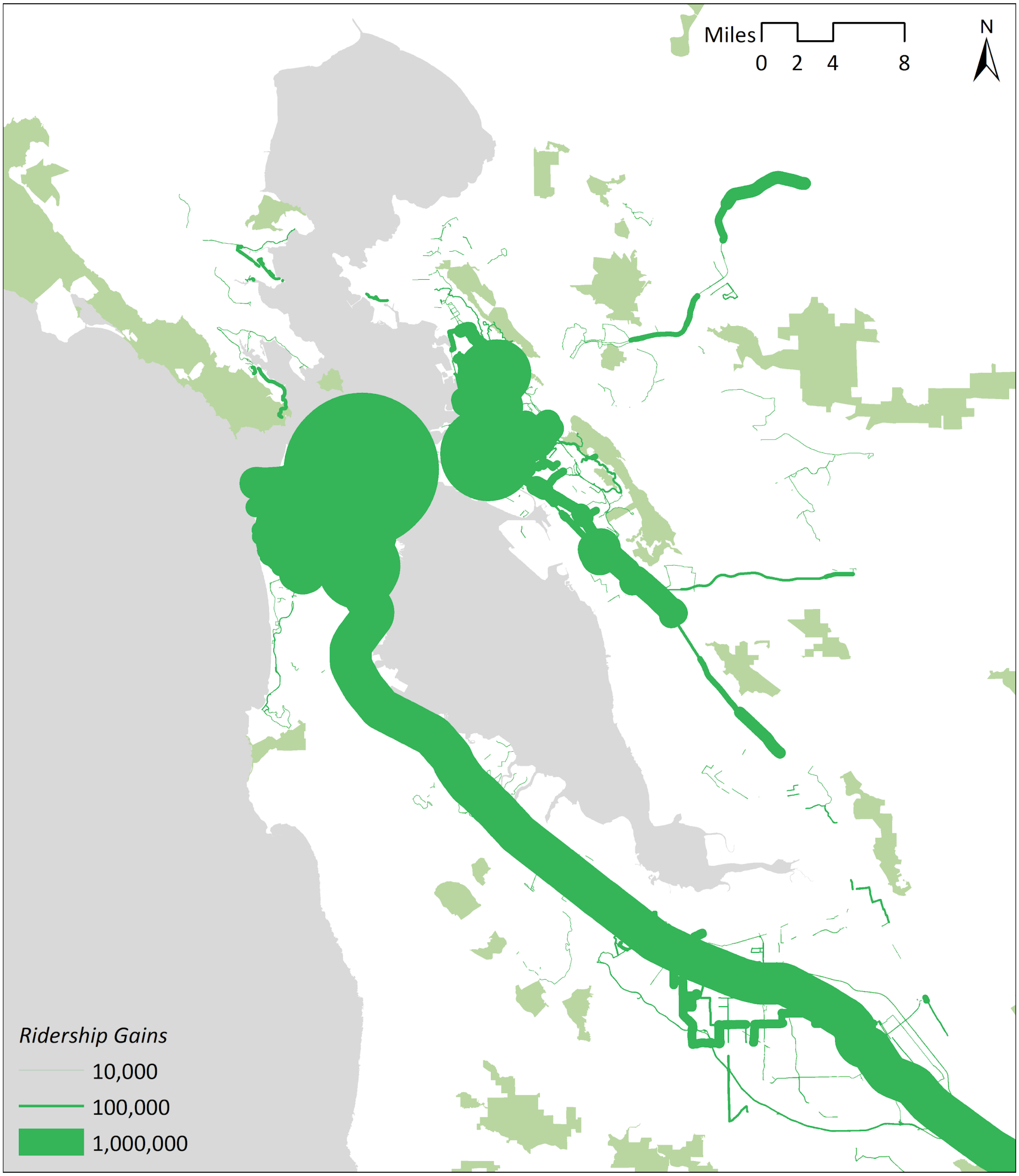
Data source: FTA, 2019

What we do find evidence for is "peaking." Peaking refers to the concentration of riders at peak times, in core areas, in commute directions, etc. Peaking can occur because peak transit use is growing as off-peak use is flat, because peak transit use is flat as off-peak use is falling, or—as is the case on a number of Bay Area operators—both are declining, but off-peak use is falling faster than peak use. As discussed further in the conclusion (Chapter 10), peaking can be an expensive problem and can depress rider satisfaction.

Overall, we find a significant level of peaking on major Bay Area transit operators. In other words, ridership losses at off-peak hours, on weekends, on outlying routes, in non-commute directions, and on smaller operators account for a large and disproportionate share of the whole region's patronage decline (Wasserman, 2019). Figures 1-5 and 1-6 lay out the geography of the region's peaking problem:[5] downtown San Francisco and commute-oriented rail lines have gained ridership as more outlying, lower-service routes have lost patronage. The most significant exceptions to the Bay Area's peaking problem are operators in urban cores, like Muni and AC Transit, where residential and employment density throughout the network have blunted peaking, though not necessarily overall losses. We discuss this and other nuances of the region's ridership and peaking issues in the chapters that follow.

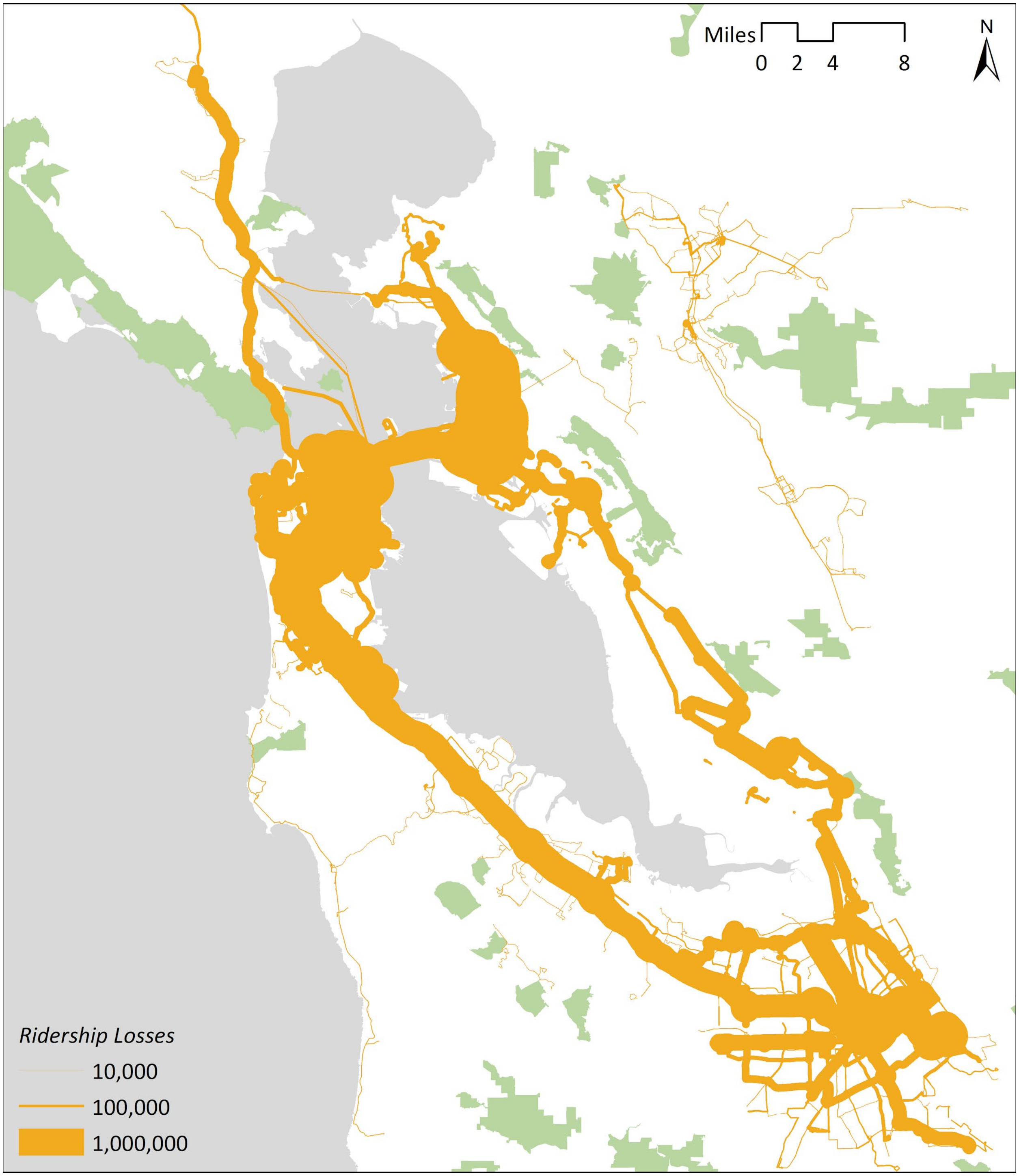
5. In Figures 1-5 and 1-6, routes with a gain or loss in annual ridership, respectively, of under 20,000 boardings were rounded up for visibility. Ridership data reflect either the change between calendar years 2015 and 2018 or the change between Fiscal Years 2015 and 2018, depending on the operator.

Figure 1-5. Ridership Gains by Line, from 2015 to 2018 or from Fiscal Year 2015 to Fiscal Year 2018



Data source: SFMTA, 2013, 2018; BART, 2019c, 2019e; AC Transit, 2019b, 2018; VTA, 2019b, 2018; Caltrain, 2019, 2018a; SamTrans, 2019b, 2019b, 2019a; GGBHTD, 2019a, 2019b; County Connection, 2019a, 2019b; U.S. Census Bureau, 2019b; CaliDetail, n.d.; and Esri, 2010

Figure 1-6. Ridership Losses by Line, from 2015 to 2018 or from Fiscal Year 2015 to Fiscal Year 2018



Data source: SFMTA, 2013, 2018; BART, 2019c, 2019e; AC Transit, 2019b, 2018; VTA, 2019b, 2018; Caltrain, 2019, 2018a; SamTrans, 2019b, 2019b, 2019a; GGBHTD, 2019a, 2019b; County Connection, 2019a, 2019b; U.S. Census Bureau, 2019b; CaliDetail, n.d.; and Esri, 2010

Ridership Trends by Transit Agency

2. Muni Ridership Trends

2.1. Overview

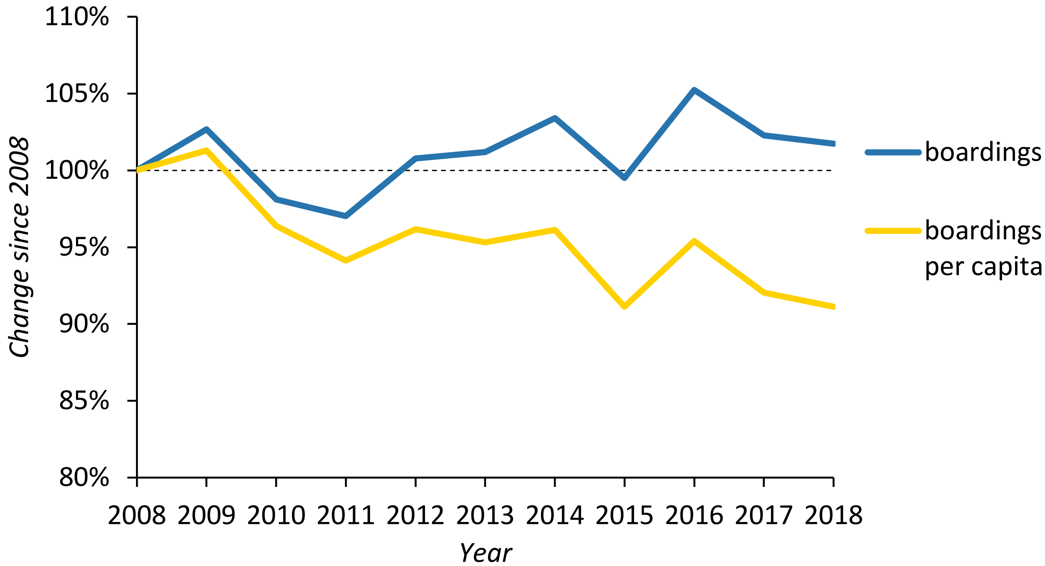
San Francisco Muni has simultaneously shed ridership in one of the most transit-favorable areas in America and has retained patronage better than most other national operators. To explore these trends, Muni staff have provided a spreadsheet of average daily boardings from Fiscal Year 1998 to Fiscal Year 2018, broken down by fiscal year (July 1st-June 30th) and line (SFMTA, 2018). These data come from automated passenger counters on vehicles and fareboxes and faregates, with some degree of agency estimation. From information on SFMTA's website, we matched these data with information on the peak frequency, mode, etc. of each line (SFMTA, 2019b).

The SFMTA, whose transit service is called Muni, carries the most riders of any transit agency in the Bay Area, bearing 45 percent of trips in 2018 (See Figure 1-3). Confined almost exclusively to the compact, 47-square-mile City and County of San Francisco, Muni enjoys the benefit of operating in the densest service area of any Bay Area operator—or, in fact, of any transit agency in the state. San Francisco is the second-densest city in America of 100,000 people or more (U.S. Census Bureau, 2019a), meaning that if transit can succeed anywhere beyond New York, it would be San Francisco. And indeed, with 255 boardings per capita in 2018, Muni does boast impressive ridership and mode share.

However, Muni has lost riders in recent years all the same. Figure 2-1 shows change in absolute boardings and boardings per capita on SFMTA, from the NTD. Muni's overall ridership trend is far bumpier than its next-largest peer agency, BART, with relatively substantial changes year to year. Patronage fell in 2015, only to recover in 2016 roughly back to where it would have been if its growth had proceeded evenly since 2012. Ridership again dropped in 2017, this time by 6.6 million annual riders, and in 2018 as well, but in light of Muni's 2016 recovery, the agency may be better positioned to recover than other transit agencies. If other agencies profiled below represent a sharp case of peaking problems across a regional network, Muni presents a less even and less clear decline.

As for ridership per capita, Muni's trends are more worrisome. Boardings per capita have never recovered from the effects of the Great Recession, staying flat until 2014 and then jaggedly falling again. San Francisco's population has grown quite a bit, but Muni ridership has failed to keep pace.

Figure 2-1. Muni Ridership Bumpy and Not Keeping Pace with Population Growth



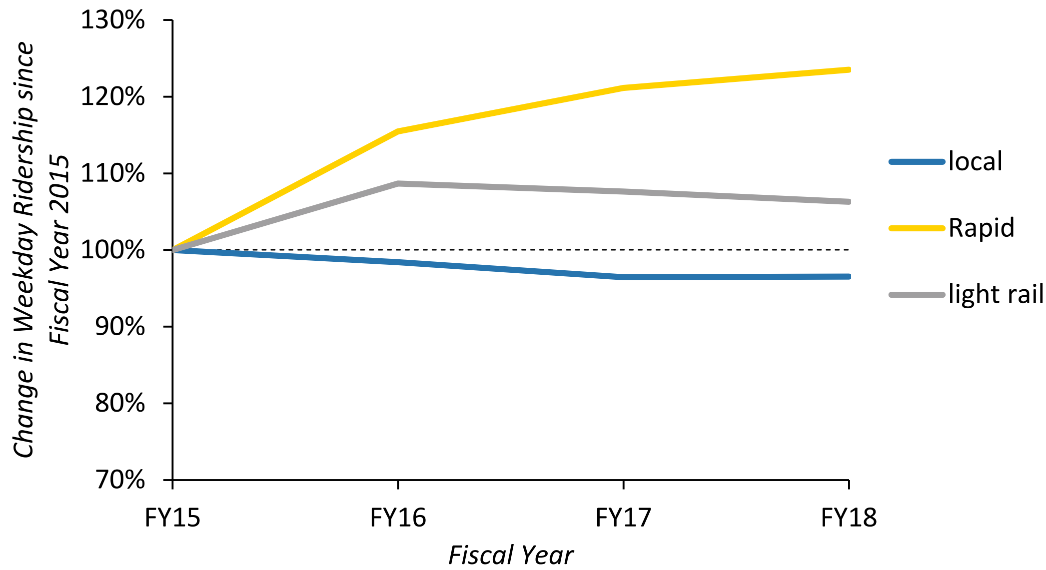
Data source: FTA, 2019 and U.S. Census Bureau, 2011, 2019a

2.2. Breakdown by Mode and Frequency

How do these trends vary temporally and spatially? To answer this, we reviewed data provided by Muni staff, breaking down ridership by mode, and route (SFMTA, 2018). Like most other agencies nationwide, Muni riders only need to pay a fare upon entry, so their exits are not tracked. Even so, important differences in the data reveal a waxing peaking problem on Muni as well, albeit one muted by the high density of its entire operating environment.

One facet of Muni's peaking issues is that ridership has concentrated on certain modes. Beyond bus versus rail, SFMTA operates many different modes. Per the NTD, only four agencies nationwide operate more transit modes than SFMTA (FTA, 2019). Muni runs motorbuses, trolleybuses, light rail, historic streetcars, (contracted) paratransit, and the only cable car fleet in the country. Furthermore, Muni also categorizes bus lines as Rapid, Express, Owl, etc. based on their service pattern. To sort through this, Figure 2-2 breaks down three core categories of Muni service: light rail (excluding the more tourist-oriented cable cars and streetcars), local bus (excluding peak-only expresses), and Rapid bus (a network of limited-stop lines, some of which have features of bus rapid transit, that saw a rebranding and service increase in April 2015) (SFMTA, 2015). Since Fiscal Year 2015, weekday ridership on light rail is up six percent, and weekday patronage on Rapids has jumped 24 percent. Over the same period, local bus trips—over half of the agency's total boardings—have fallen three percent on weekdays. Whether the same passengers are changing mode or whether different passengers are riding locals less and rail and Rapids more is unclear, though evidence from specific lines below points toward the former. Either way, these trends show a slightly different peaking problem than on other agencies—a modal peaking problem.

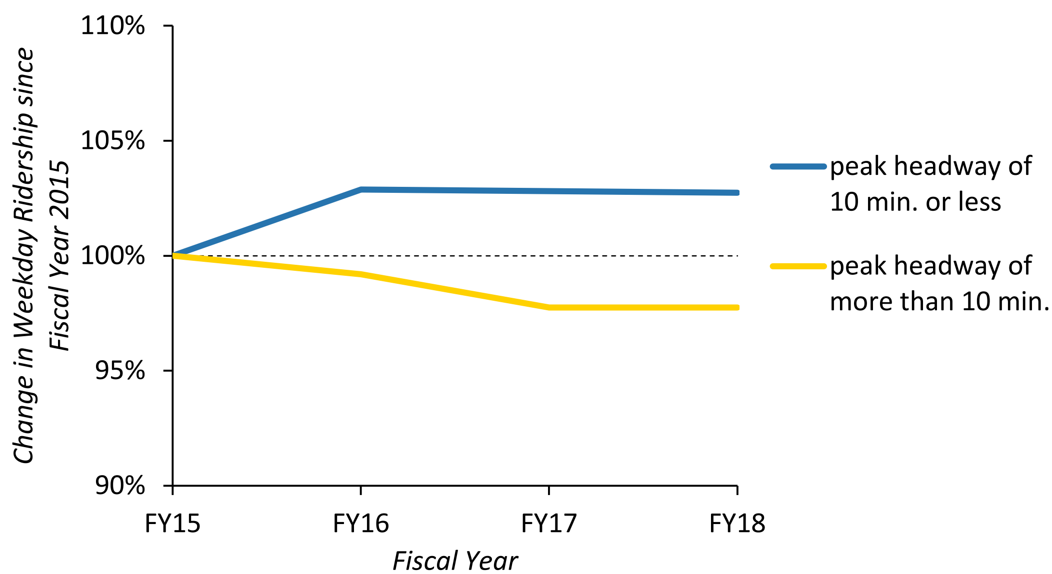
Figure 2-2. Muni's Local Buses Losing Ridership as Rapid Buses and Light Rail Grow



Data source: SFMTA, 2018

Divergent patterns likewise emerge when ridership is broken down by route frequency. On routes with peak weekday headways of 10 minutes or less, weekday ridership is up three percent from Fiscal Year 2015, while on routes with longer peak weekday headways, ridership is down two percent (See Figure 2-3). These changes are relatively small, but their different directions nevertheless indicate that busier routes are getting busier and the converse.

Figure 2-3. Ridership Growth on High-frequency Lines and Losses on Low-frequency Lines on Muni



Data source: SFMTA, 2018, 2019b

2.3. Breakdown by Line

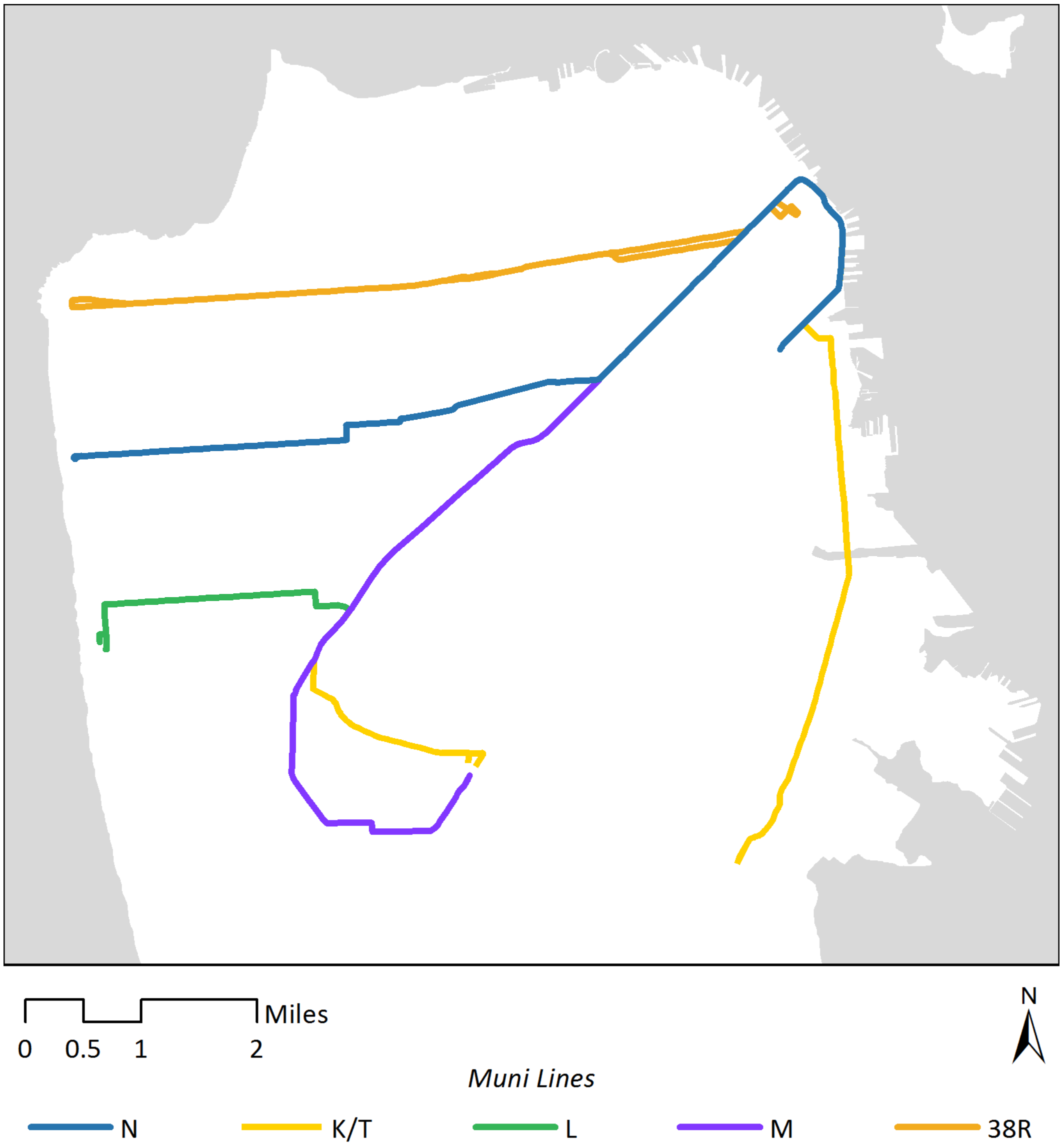
Unlike on operators like VTA, Muni's most patronized routes have seen the greatest absolute ridership gains (See Table 2-1 and Figure 2-4). Four of the agency's light rail lines topped the list of routes with the highest Fiscal Year 2017 ridership, and the Geary Rapid rounds out the top five—a route that, along with its local counterpart, are among "the busiest bus lines west of the Mississippi and carry almost as many riders as Caltrain's entire daily service," as the *San Francisco Examiner* put it (Fitzgerald Rodriguez, 2018). These lines all also rank in the top ten in terms of gains since Fiscal Year 2015, roughly when the Bay Area's region-wide ridership slump began. These busy lines are carrying more and more trips, causing crowding and necessitating high amounts of service and a number of planned improvements to give them priority lanes (Fitzgerald Rodriguez, 2018).

Table 2-1. Muni Lines with the Most Boardings, Fiscal Year 2018

LINE	DAILY BOARDINGS, FISCAL YEAR 2018	ABSOLUTE CHANGE IN DAILY BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018	
N (light rail)	48,152	+2,027	8th out of 76
K/T (light rail)	41,609	+4,493	3rd out of 76
L (light rail)	32,302	+1,746	9th out of 76
M (light rail)	29,907	+2,059	7th out of 76
38R (Rapid bus)	29,484	+4,649	1st out of 76

Data source: SFMTA, 2018

Figure 2-4. Muni Lines with the Most Boardings, Fiscal Year 2018



Data source: SFMTA, 2013, 2018 and CaliDetail, n.d.

Notably, some of Muni's most ridership-gaining lines are Rapid buses, while some of its most ridership-losing lines are the local buses along the same corridors. Table 2-2 lists the five corridors with Rapid bus routes[6] and compares the change in boardings since Fiscal Year 2015 on each. The local buses have all lost significant ridership, with three of the five placing in the bottom five by absolute change. Meanwhile, the Rapids have all markedly grown in patronage, with three placing in the top five by absolute change. The 38 and 38R on Geary Boulevard exemplify the group, with the former losing six percent of its riders and ranking 71st and the latter gaining 19 percent and ranking first. Among lines that lost riders since Fiscal Year 2015, the five local routes in Table 2-2 account for just over a quarter of their total losses, while the

6. The five corridors with Rapid bus routes today, to be specific. The 7R, discontinued in August 2017, is not included (SFMTA, 2017).

five Rapid routes account for 39 percent of total gains among lines that increased in patronage. While these data do not directly indicate that the same individual passengers have switched from locals to Rapids, the weight of these statistics makes this scenario very likely. To be sure, Muni has suffered outright losses on other lines that are pulling the system's numbers down. But it also is shifting riders onto faster service options, which, despite the risk of crowding and expense, represents a positive outcome for the agency.

Table 2-2. Ridership Change on Muni Locals versus Rapids

LINES	LOCAL: ABSOLUTE CHANGE IN DAILY BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018		RAPID: ABSOLUTE CHANGE IN DAILY BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018	
5 / 5R	-1,567	72nd out of 76	+1,053	13th out of 76
9 / 9R	-2,740	75th out of 76	+4,575	2nd out of 76
14 / 14R	-1,242	68th out of 76	+2,692	5th out of 76
28 / 28R	-462	54th out of 76	+2,254	6th out of 76
38 / 38R	-1,429	71st out of 76	+4,649	1st out of 76

Data source: SFMTA, 2018

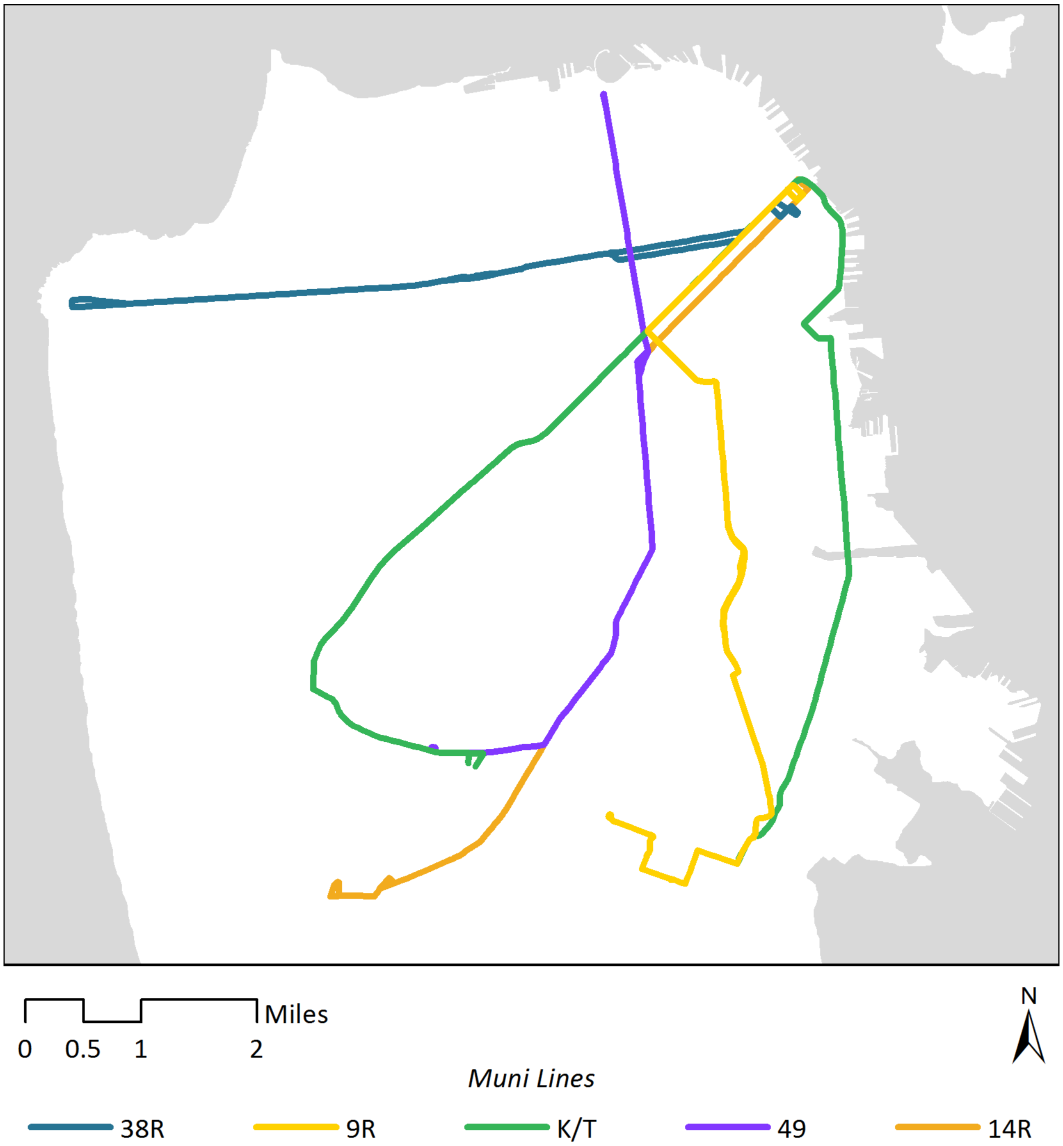
Looking at the agency overall, the lines that have gained the most riders lie along major transit corridors: three Rapid lines, the longest light rail line, and a major local, trunk-line bus (See Table 2-3 and Figure 2-5). By percent change, the biggest gainers include a few significant north-south routes and few local buses in rapidly developing areas like Park Merced (See Table 2-4 and Figure 2-6). Overall, the lines that already had high ridership have grown.

Table 2-3. Muni Lines with the Largest Absolute Gains, Fiscal Year 2015-Fiscal Year 2018

LINE	ABSOLUTE CHANGE IN DAILY BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018
38R (Rapid bus)	+4,649
9R (Rapid bus)	+4,575
K/T (light rail)	+4,493
49 (local bus)	+2,703
14R (Rapid bus)	+2,692

Data source: SFMTA, 2018

Figure 2-5. Muni Lines with the Largest Absolute Gains, Fiscal Year 2015-Fiscal Year 2018



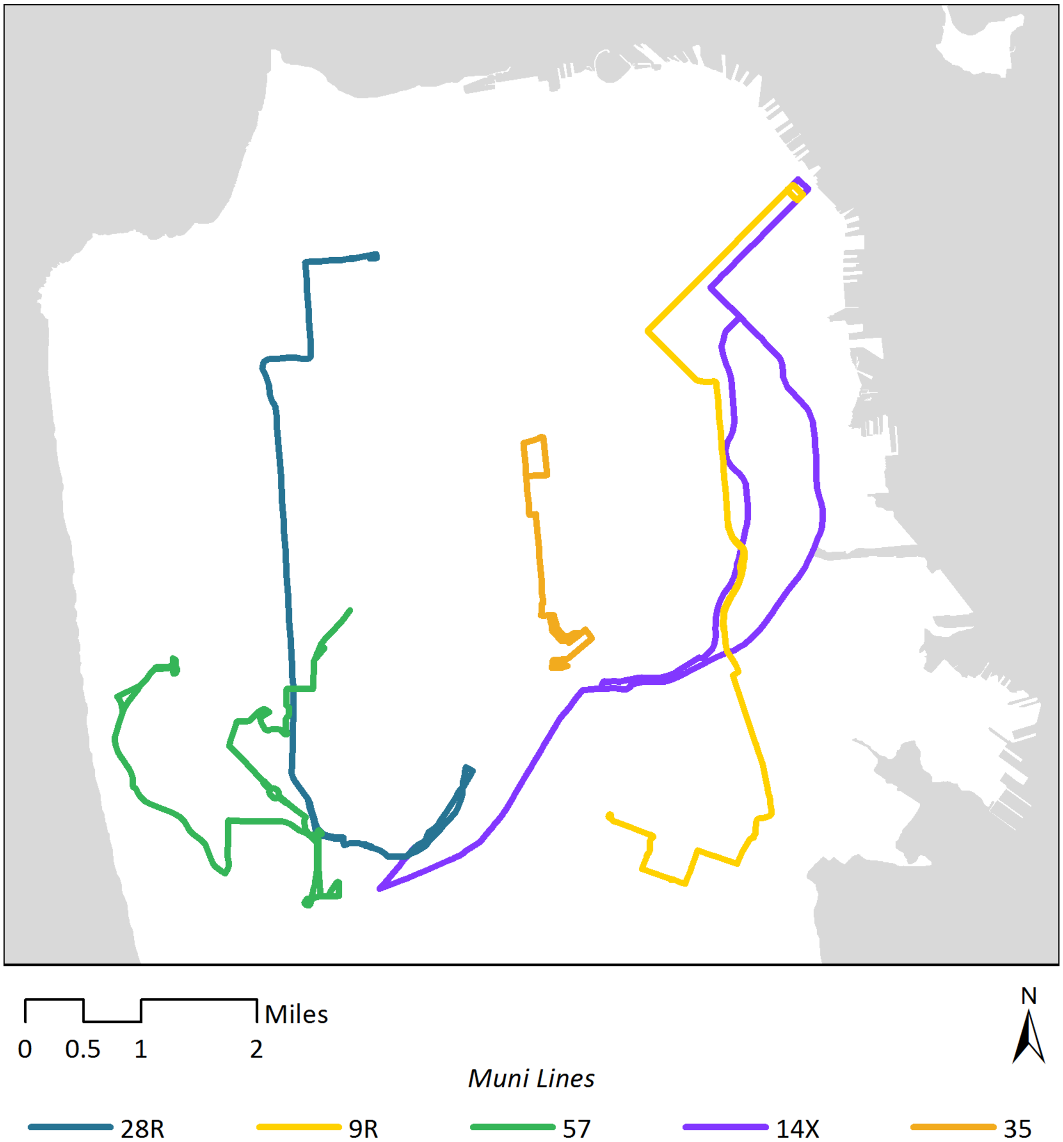
Data source: SFMTA, 2013, 2018 and CaliDetail, n.d.

Table 2-4. Muni Lines with the Largest Percentage Gains, Fiscal Year 2015-Fiscal Year 2018

LINE	PERCENT CHANGE IN DAILY BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018
28R (Rapid bus)	+103%
57 (local bus)	+89%
9R (Rapid bus)	+65%
14X (express bus)	+59%
35 (local bus)	+39%

Data source: SFMTA, 2018

Figure 2-6. Muni Lines with the Largest Percentage Gains, Fiscal Year 2015-Fiscal Year 2018



Data source: SFMTA, 2013, 2018 and CaliDetail, n.d.

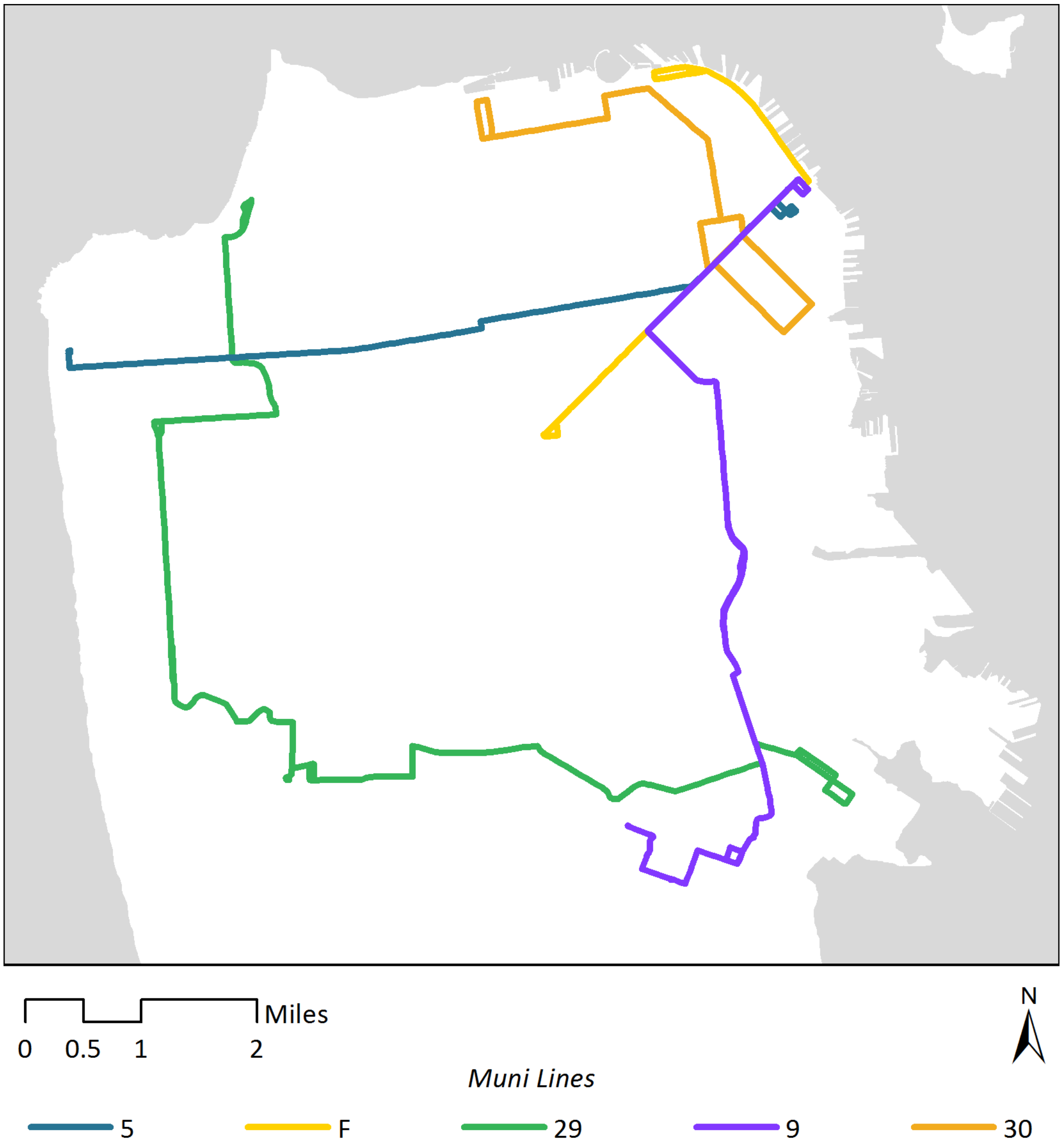
Meanwhile, the lines that have shed the most riders include a number of long local routes (again, some of whose riders may be switching to Rapids) and the F historic streetcar (See Table 2-5 and Figure 2-7). The F's ridership decline is more bad news for an already troubled line facing an operator shortage due to personal safety concerns among operators (Fitzgerald Rodriguez, 2016). The five lines that have seen the largest percentage losses include another set of local buses and two commuter-focused express services (See Table 2-6 and Figure 2-8).

Table 2-5. Muni Lines with the Largest Absolute Losses, Fiscal Year 2015-Fiscal Year 2018

LINE	ABSOLUTE CHANGE IN DAILY BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018
5 (local bus)	-1,567
F (streetcar)	-1,653
29 (local bus)	-1,695
9 (local bus)	-2,740
30 (local bus)	-3,498

Data source: SFMTA, 2018

Figure 2-7. Muni Lines with the Largest Absolute Losses, Fiscal Year 2015-Fiscal Year 2018



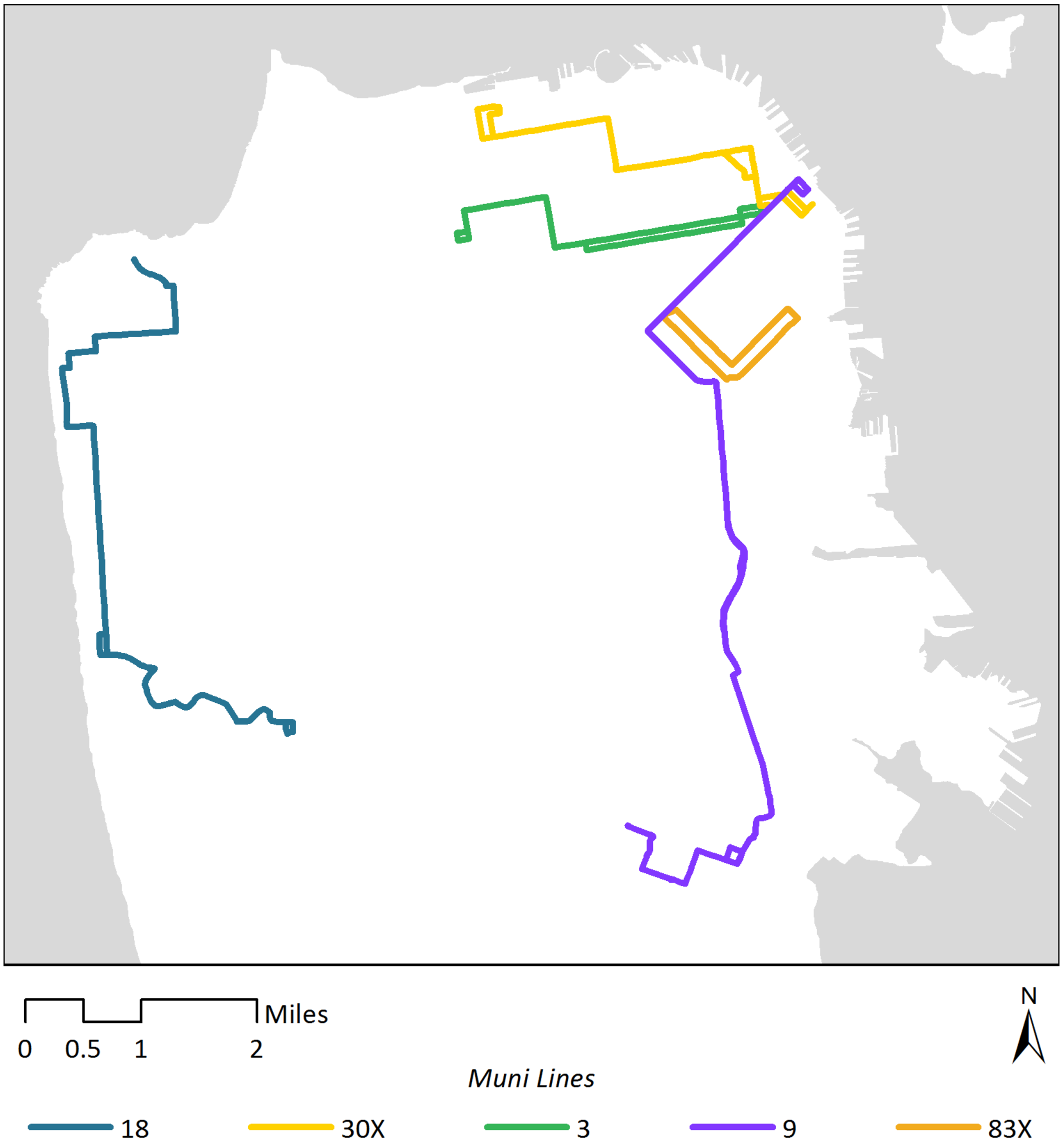
Data source: SFMTA, 2013, 2018 and CaliDetail, n.d.

Table 2-6. Muni Lines with the Largest Percentage Losses, Fiscal Year 2015-Fiscal Year 2018

LINE	PERCENT CHANGE IN DAILY BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018
18 (local bus)	-21%
30X (express bus)	-21%
9 (local bus)	-22%
3 (local bus)	-34%
83X (express bus)	-37%

Data source: SFMTA, 2018

Figure 2-8. Muni Lines with the Largest Percentage Losses, Fiscal Year 2015-Fiscal Year 2018



Data source: SFMTA, 2013, 2018 and CaliDetail, n.d.

3. BART Ridership Trends

3.1. Overview and Data Validation

Bay Area Rapid Transit, the Bay Area's regional heavy-rail system and its second-most-ridden operator, has experienced severe demand peaking problems and a growing divergence between peak and off-peak ridership trends. The fifth-busiest heavy rail system in the U.S. (FTA, 2019) and the third-most extensive by track miles (Freemark, 2019), BART serves an expanding variety of jurisdictions and land uses across the Bay Area. But the system straddles a sometimes awkward dual role: frequent, fast commuter rail in the suburbs at the ends of its branches and high-frequency subway in and among San Francisco, Oakland, and Berkeley at the core of its system.

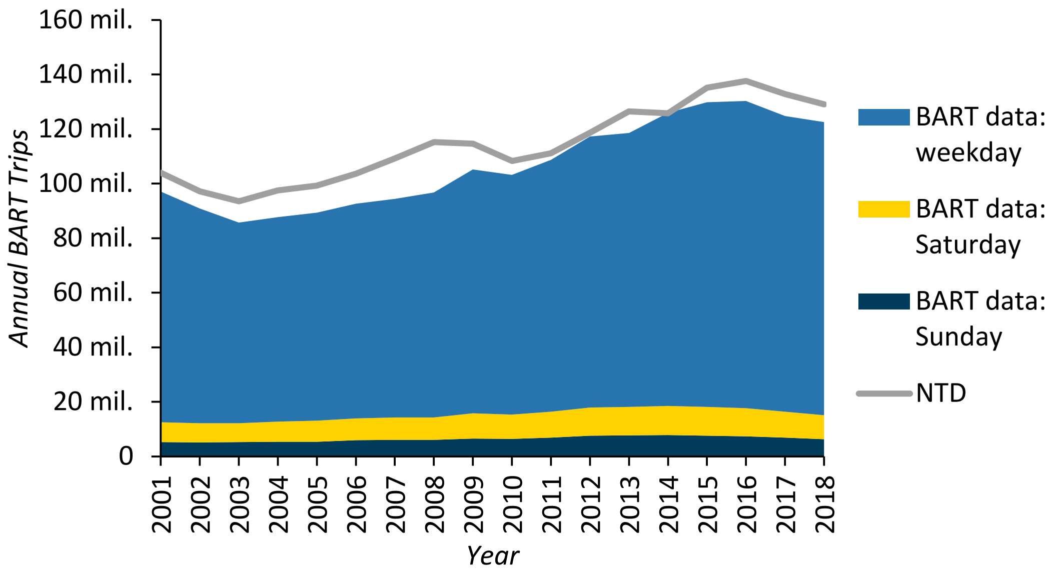
As BART becomes more reliant on peak-hour, commute-direction ridership, its rider satisfaction has dropped. While BART's ridership has remained among the most resilient in the region—belying surveyed "quality of ride" factors as a major cause of the patronage decline—these passenger trends are concerning nonetheless. As discussed in Volume I, Chapter 9, passenger satisfaction fell from 74 percent in 2014 to 56 percent in 2018, with high negative ratings and particularly steep drops for factors like security and safety, cleanliness, crowding, and presence of people experiencing homelessness (BART, 2019a). To be sure, these data do not distinguish important nuances, such as the fact that the presence of police, one surveyed factor, make some riders feel more safe and some less. But if anything, these surveys demonstrate the pressures that peaking applies to an agency like BART.

Whatever the causes, BART's ridership slump and its waxing demand peaking are hurting the agency. Even as overall trip counts have fallen, surveys show trains becoming so overcrowded at peak hours in peak directions that perhaps, to paraphrase master of paradox Yogi Berra, no one rides anymore—it's too crowded (BART, 2019a; Barmann, 2017; and Houston, 2015). And as discussed in Volume I, Chapter 11, all the while, BART's costs have risen.

To investigate these trends, we explore BART's rich ridership datasets. Unlike most other transit agencies, BART charges a distance-based fare and therefore requires customers to tag their farecards both when entering and exiting. Thus, BART has origin *and destination* data on every paying rider, tabulated from data on the faregates. Agency staff publishes two products from these data: 1) a monthly matrix of aggregate average daily trips between every pair of stations, divided into weekday, Saturday, and Sunday spreadsheets and 2) an annual matrix of ridership between every pair of stations, broken down by date and by hour band (BART, 2019e). The latter we use in our causal analysis later in this section, the former for the descriptive analysis immediately below.

To test the validity of BART's monthly matrixes, we multiplied out the daily ridership figures to annual totals and compared them to the NTD (See Figure 3-1) (BART, 2019e and FTA, 2019). Overall, the numbers are fairly close, with year-over-year changes in each mostly consistent with one another. The NTD numbers are slightly higher, because they represent BART estimates of unlinked trips, as opposed to the linked trips tracked in BART's matrices. Indeed, throughout the analyses and figures in this section, "trips" refers to linked trips from BART internal data.

Figure 3-1. BART Annual Ridership: NTD versus Internal BART Origin-destination Matrices



Data source: BART, 2019e and FTA, 2019

3.2. BART's Peaking Problem

These data reveal a long period of steady ridership growth for BART, followed by a more recent downswing. BART experienced steady growth between 2003 and 2015, gaining around 3.7 million riders on average every year and weathering the Great Recession better than most American transit agencies (BART, 2019e). Since 2016, though, BART ridership has dropped noticeably. Over these two years, BART lost around 8 million annual riders, six percent of their 2016 ridership. This decline returned BART to its ridership numbers from around 2013, erasing the three years of growth (BART, 2019e and FTA, 2019).

Over this period of decline, one issue appeared again and again: a severe peaking problem. Since 2015, riders have continued packing onto peak trains but abandoning off-peak trips in droves. Meanwhile, both on weekends and in off-commute directions, trains are becoming emptier and emptier. A detailed look at the geography of the system's declines reveals some clues about why these two trends have diverged.

As more jobs are concentrating in downtown San Francisco (U.S. Census Bureau, n.d.), ridership into and out of its four BART stations—the system's busiest—has held up far better than other trip types. Trips that begin or end in downtown San Francisco[7] account for a huge share of ridership—66 percent in 2018—compared to 24 percent that begin or end in downtown Oakland[8] and 21 percent that begin and end elsewhere.[9] Figure 3-2 shows just how important downtown San Francisco trips have been for BART and how they have changed since 2003. Especially since 2015, ridership has declined most heavily in trips outside of downtown San Francisco (See Figure 3-3). All other trip types besides those starting or ending in downtown San Francisco account for over half (56%) of system losses. As discussed below, these losses

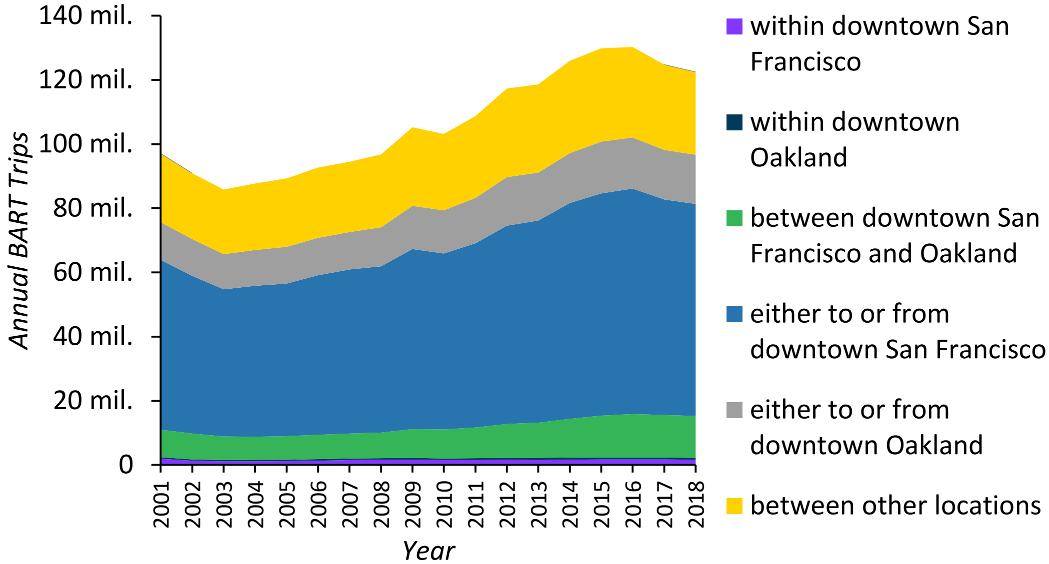
7. Defined by BART as Embarcadero, Montgomery Street, Powell Street, and Civic Center Stations (BART, 2019e).

8. Defined by BART as MacArthur, 19th Street/Oakland, 12th Street/Oakland City Center, West Oakland, and Lake Merritt Stations (BART, 2019e).

9. Percentages do not add to 100 percent because trips between downtown San Francisco and downtown Oakland are double-counted.

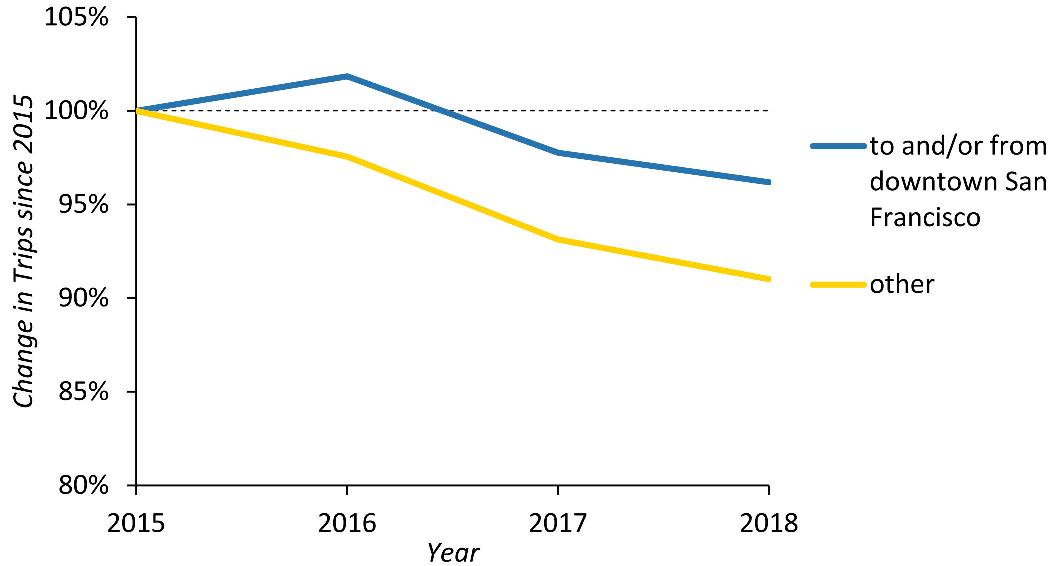
have particularly come from trips starting and ending south of downtown San Francisco and from trips between the north and south halves of the East Bay. While trips to the four Market Street stops together have also fallen, all other trip types have dropped off even more (See Figure 3-3).

Figure 3-2. Trips to or from Downtown San Francisco Dominate BART Ridership



Data source: BART, 2019e

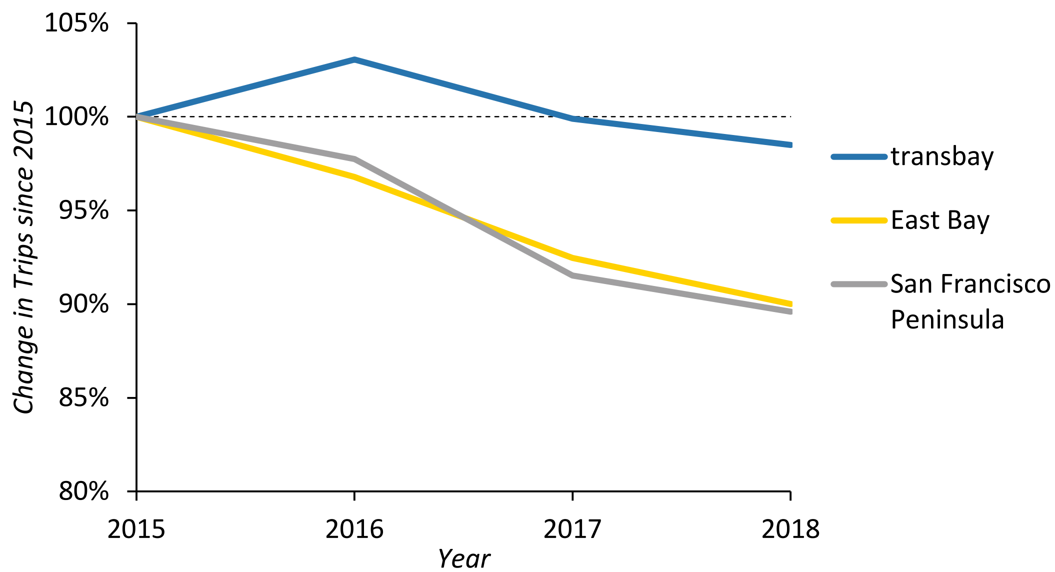
Figure 3-3. Trips to and/or from Downtown San Francisco Have Lost Less Ridership



Data source: BART, 2019e

Ridership changes on either side of the San Francisco Bay are even more skewed (See Figure 3-4). Transbay trips—those that cross San Francisco Bay—made up 55 percent of rides in 2018 but accounted for only 14 percent of 2015-2018 ridership loss. Meanwhile, trips wholly on the east side of the Bay (East Bay) and wholly on the San Francisco Peninsula together represented 45 percent of 2018 trips but an astonishing 86 percent of BART's patronage decline.

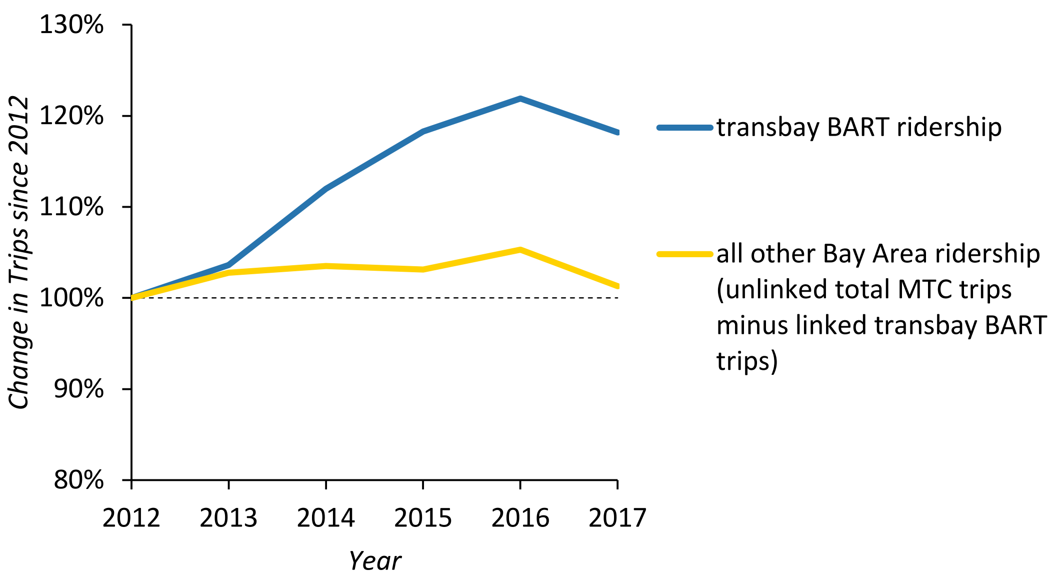
Figure 3-4. Change in Annual BART Ridership by Geography



Data source: BART, 2019e

This spatial skew in patronage has affected BART long before 2015-2018. Much as BART's overall ridership gains prior to 2015 propped up the whole region's ridership total, BART's transbay ridership propped up the whole system's ridership total. From 2012 to 2015, transbay trips accounted for *all* of the growth in system ridership, while East Bay and San Francisco Peninsula trips remained almost perfectly flat. In fact, transbay BART trips accounted for 43 percent of the *whole region's* ridership growth during that period, despite making up only 15 percent of 2015 patronage[10] (See Figure 3-5). In other words, BART and the region overall have been dependent on BART's transbay trips to prop up ridership for most of the past decade. This presents a significant problem for BART, as the Transbay Tube is operating at capacity and construction of a second tunnel is many years away (BART, 2018b).

Figure 3-5. Transbay BART Trips Accounted for Much of the Bay Area's Overall Ridership Growth

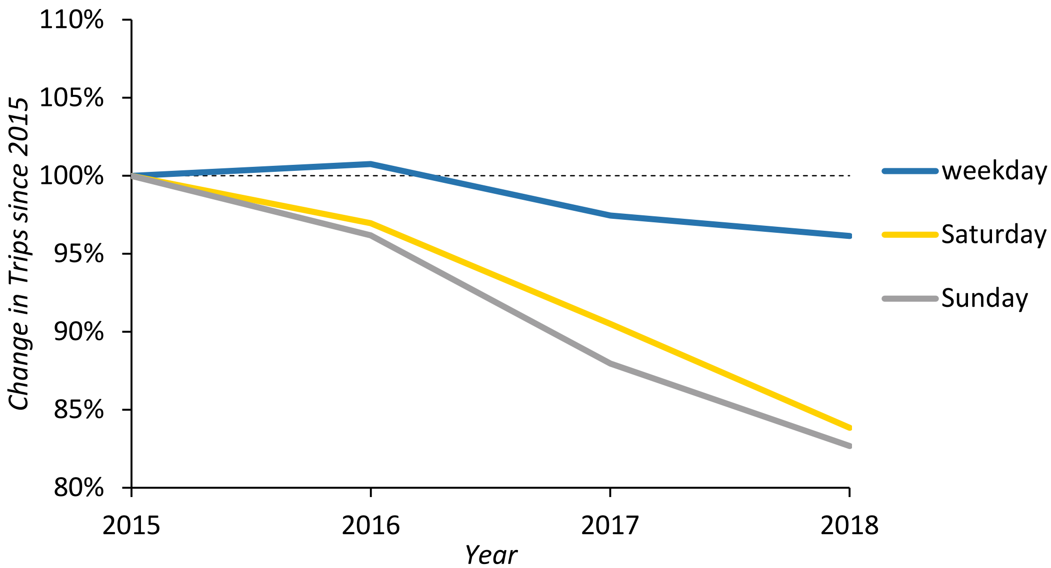


Data source: BART, 2019e and FTA, 2019

A similar trend is occurring by day of the week. As with transit use nationwide, BART ridership is highest during the traditional work week: around 412,000 riders per weekday in 2018, compared to 172,000 per Saturday and 124,000 per Sunday. But between 2015 and 2018, weekday ridership only fell four percent, compared to a 16 percent drop on Saturdays and a 17 percent drop on Sundays (See Figure 3-6). Weekday jobs have sustained ridership on BART, while weekend ridership has plummeted.

10 . Admittedly a rough estimate, as the internal BART data on transbay trips count linked trips, while the regional NTD data count unlinked trips

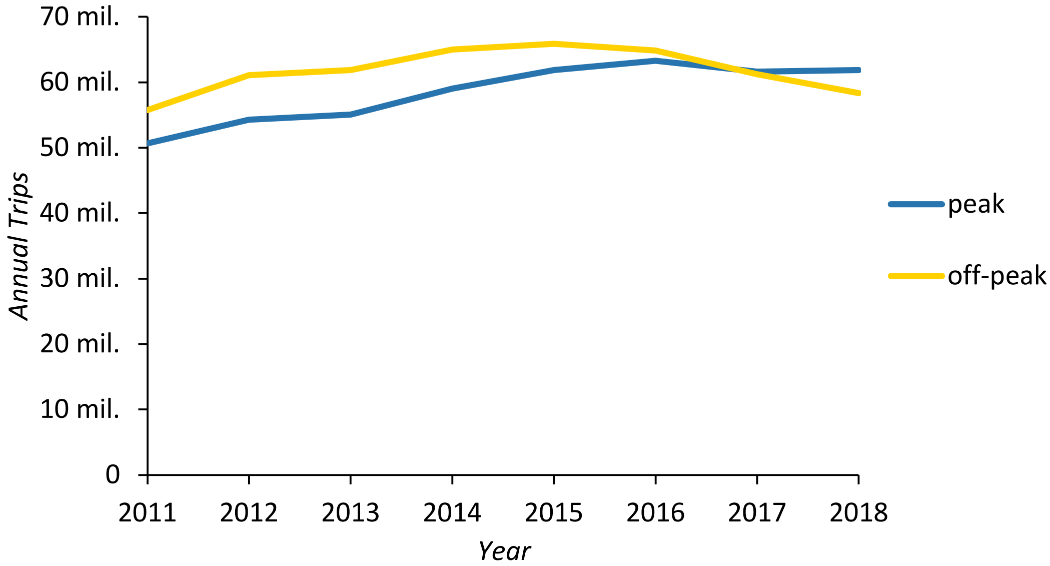
Figure 3-6. Change in Annual BART Ridership by Geography



Data source: BART, 2019e

Indeed, at rush hour, ridership remains more resilient than at off-peak times. Figure 3-7 plots the number of annual trips taken on weekdays at the six busiest hours (7 A.M. to 10 A.M. and 4 P.M. to 7 P.M.) versus at all other times (weekends and weekdays outside of rush hour). Since 2012, peak-hour patronage has grown faster than off-peak and has increased its share of the agency's overall ridership, cresting 50 percent in 2017. More than half of all BART trips, in other words, happen within these six weekday hours. Since 2015, rush-hour ridership has dropped only slightly. Meanwhile, off-peak ridership fell over 11 percent, at an increasingly steep rate of descent nearly every year. BART has become a primarily rush-hour service. In so doing, BART is spending more and more on delivering expensive peak service, potentially endangering its financial bottom line.

Figure 3-7. Annual BART Ridership by Time of Day



Data source: BART, 2019e

3.3. Detailed Geographic Analysis

The effects of increased peaking have played out geographically across the BART system by intensifying the passenger load at the busiest stations and on the busiest track segments. For instance, among the 48 stations in the BART network, Table 3-1 lists the top ten stations by number of combined entries and exits in 2018. They are, as one might expect, mostly in job-rich areas like downtown San Francisco, Oakland, and Berkeley (See Figure 3-8). More than that, though, these busy stations have tended to weather the recent ridership declines the best. As shown in the last column of Table 3-1, three of these busiest stations are among the ten best-performing stations by percent change in entries and exits between 2015 and 2018; five are among the top 15. The busiest stations have gotten busier, or at least retained their crowds. On the other hand, three of the busiest stations are among the ten worst-performing stations by percent change in entries and exits between 2015 and 2018. Nevertheless, two of the three, Downtown Berkeley and Balboa Park, are outside of BART's core areas (downtown San Francisco and Oakland).

Table 3-1. BART Stations with the Most Combined Entries and Exits, 2018

STATION	ANNUAL COMBINED ENTRIES AND EXITS, 2018	PERCENT CHANGE IN ANNUAL COMBINED ENTRIES AND EXITS, 2015-2018	
Embarcadero	25,539,142	+1.7%	5th out of 45
Montgomery Street	24,711,292	-0.4%	7th out of 45
Powell Street	18,154,191	-13.5%	40th out of 45
Civic Center	14,018,068	-4.9%	13th out of 45
12th Street/ Oakland City Center	7,845,980	-4.9%	12th out of 45
16th Street Mission	7,637,341	-9.5%	26th out of 45
19th Street/ Oakland	7,601,917	+1.0%	6th out of 45
24th Street Mission	7,558,706	-9.9%	29th out of 45
Downtown Berkeley	7,083,270	-17.2%	43rd out of 45
Balboa Park	6,468,168	-14.1%	42nd out of 45

Data source: BART, 2019e

Figure 3-8. BART Stations with the Most Combined Entries and Exits, 2018

Data source: BART, 2018a, 2019e

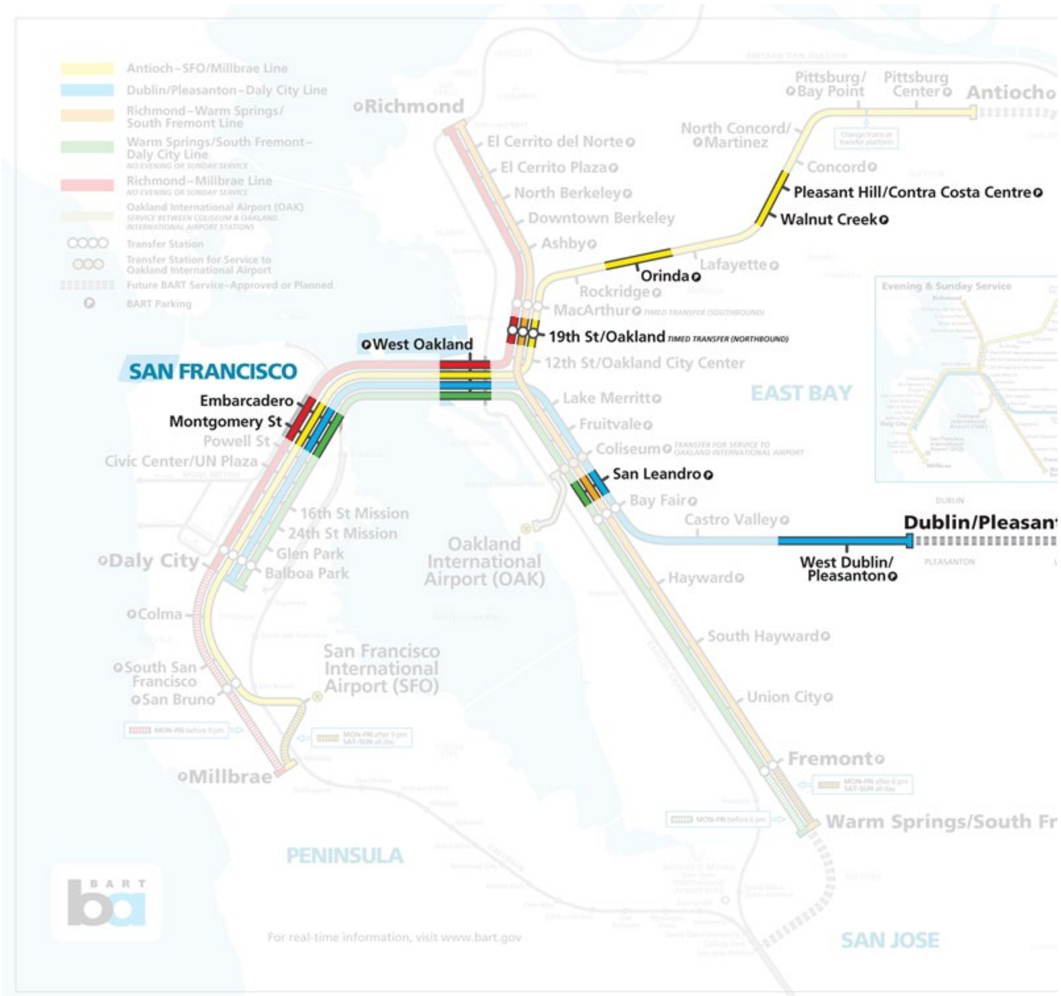
From the list of best-performing stations by 2015-2018 change in entries and exits (See Table 3-2 and Figure 3-9), perhaps the most striking takeaway is that only six of the 45 stations open during the whole period gained riders. The stations that have gained ridership or dipped only slightly are clustered on either side of the Transbay Tube, in inland Contra Costa County, and in the Tri-Valley. As discussed below, the Contra Costa and Tri-Valley branches have retained riders by percentage, though they carry few riders in absolute terms.

Table 3-2. BART Stations with the Largest Percentage Gains, 2015-2018

STATION	PERCENT CHANGE IN ANNUAL COMBINED ENTRIES AND EXITS, 2015-2018
Pleasant Hill	+4.3%
West Oakland	+3.9%
Dublin/Pleasanton	+3.4%
San Leandro	+1.9%
Embarcadero	+1.7%
19th Street/Oakland	+1.0%
Montgomery Street	-0.4%
Orinda	-1.9%
West Dublin/Pleasanton	-3.0%
Walnut Creek	-4.6%

Data source: BART, 2019e

Figure 3-9. BART Stations with the Largest Percentage Gains, 2015-2018



Data source: BART, 2018a, 2019e

On the other hand, many of the stations that have lost the most entries and exits from 2015 to 2018 (See Table 3-3 and Figure 3-10) lie south of downtown San Francisco and near Berkeley. The two stations with the largest percentage losses get a pass, though—they used to be their line's terminus, until the Warm Springs/South Fremont and East Contra Costa "eBART" extensions opened in March 2017 and May 2018, respectively (Rudick, 2017 and BART, 2019b). The bottom performers do not necessarily paint a clear picture in which all downtown stations are growing and all suburban stations are declining, but they do show that certain outlying areas have seen significant drops.

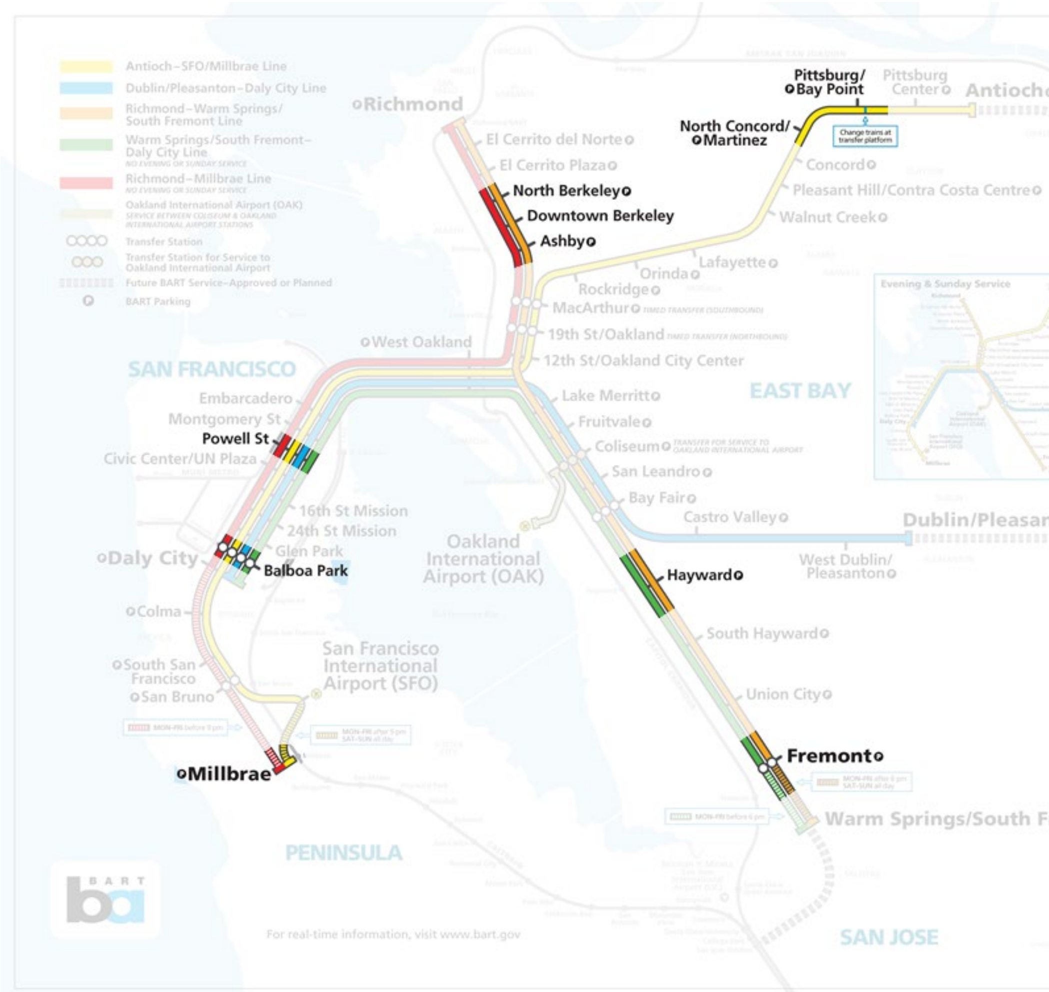
Table 3-3. BART Stations with the Largest Percentage Losses, 2015-2018

STATION	PERCENT CHANGE IN ANNUAL COMBINED ENTRIES AND EXITS, 2015-2018
Millbrae	-11.0%
Hayward	-12.2%
North Berkeley	-12.5%
Ashby	-13.4%
Powell Street	-13.5%
North Concord/Martinez	-13.7%
Balboa Park	-14.1%
Downtown Berkeley	-17.2%
Pittsburg/Bay Point*	-21.7%
Fremont*	-29.3%

** Ridership losses likely due to the opening of extensions beyond these previously terminal stops during the comparison period*

Data source: BART, 2019e, 2019b and Rudick, 2017

Figure 3-10. BART Stations with the Largest Percentage Losses, 2015-2018



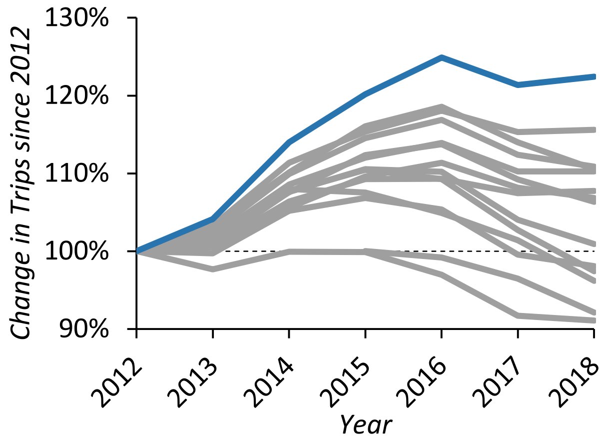
Data source: BART, 2018a, 2019e

Analyzing BART ridership by track segment reveals a similar geographic distribution of gains and losses. Here, we look at ridership over a segment of track instead of the number of entries and exits at a station. In other words, segment ridership measures how many riders traveled over a given stretch of track, regardless of whether they started or ended their trip along it. Though it does not equate to crowding per se, segments with higher ridership have more people, on average, on the trains that pass through them. For this analysis, we broke the system down into 15 large segments, each covering a branch or a trunk of the network, and 49 small segments, each covering the track between a pair of adjacent stations.

Table 3-4 provides maps of each of the larger segments and graphs of their ridership trends. In nearly every case, ridership rose between 2012 and 2015 and has fallen since. The most variation occurred in 2018, where about half of the segments stabilized or slightly grew their ridership, while the other half continued on the roughly same downward trajectory as the year or two prior. Across the spread of different segments, though, ridership appears again to be healthiest into and out of downtown San Francisco, while patronage is falling from the airports, among intra-East-Bay trips, and on the Richmond-Berkeley and southern San Francisco routes.

Table 3-4. BART Track Segments, Ordered by Change in the Number of Trips that Begin in, End in, and/or Pass through the Segment, 2012-2018

1



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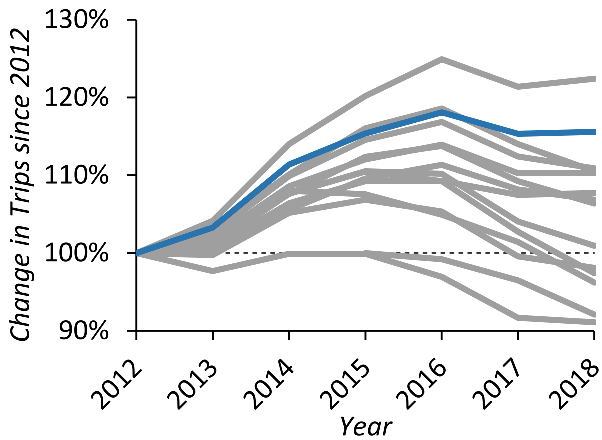

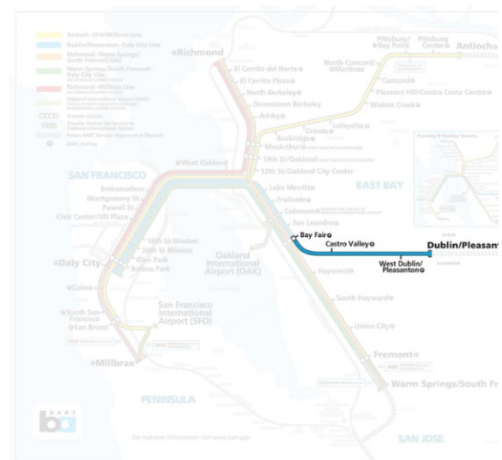

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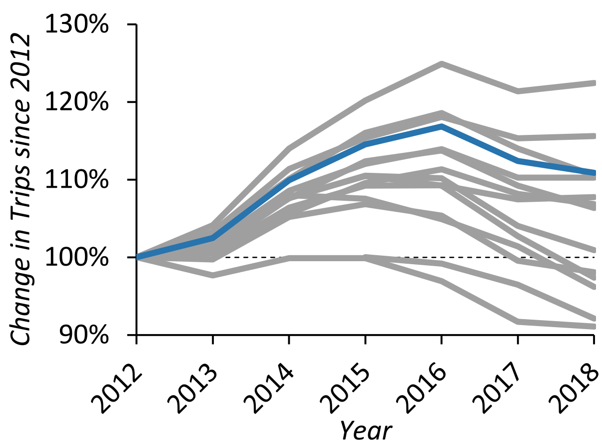

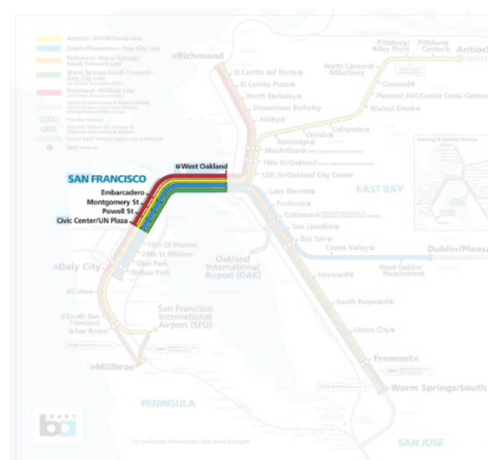

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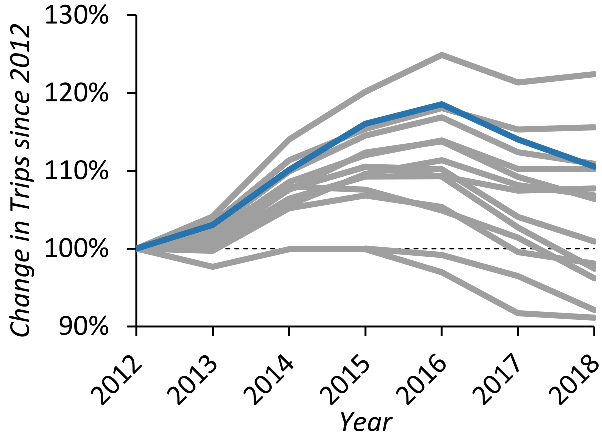
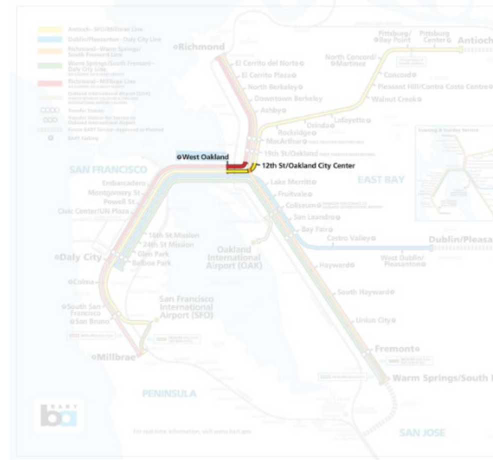
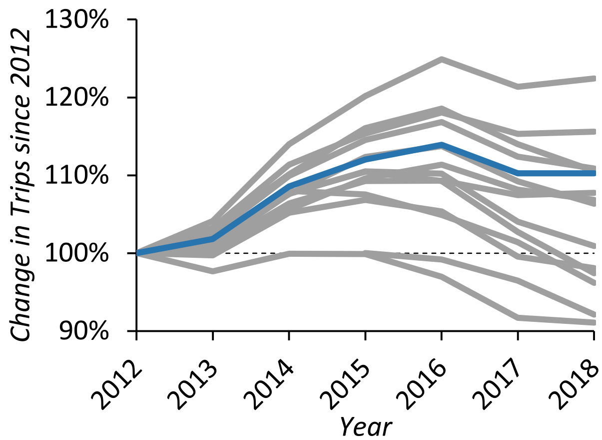


130%
120%
110%
100%
90%
Change in Trips since 2012
2012
2013
2014
2015
2016
2017
2018
Year



West Oakland
12th St/Oakland City Center

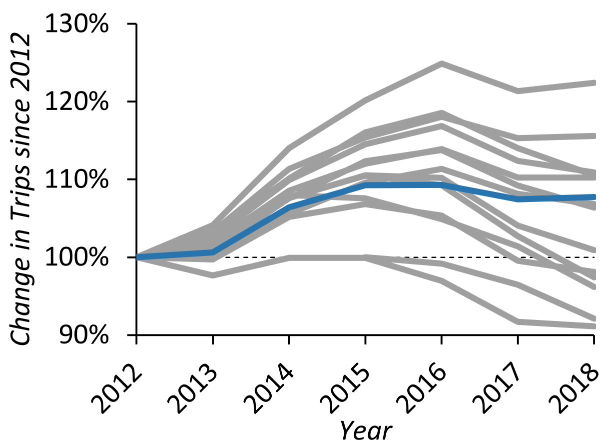
5



130%
120%
110%
100%
90%
Change in Trips since 2012
2012
2013
2014
2015
2016
2017
2018
Year

Lake Merritt
Fruitvale
Coliseum
San Leandro
Bay Fair

6



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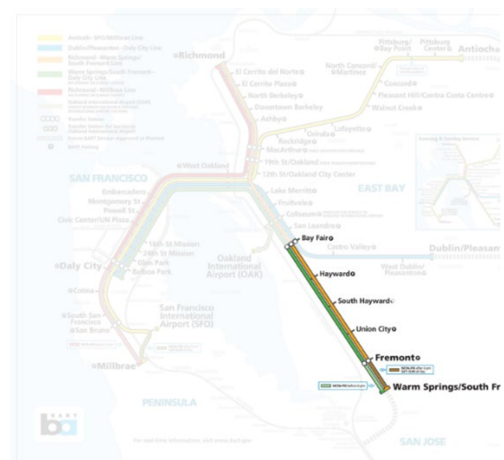
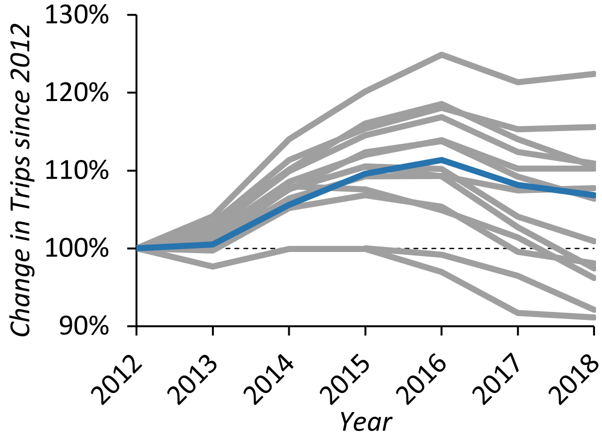


Bay Fair
Hayward
South Hayward
Union City
Fremont

7



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Change in Trips since 2012
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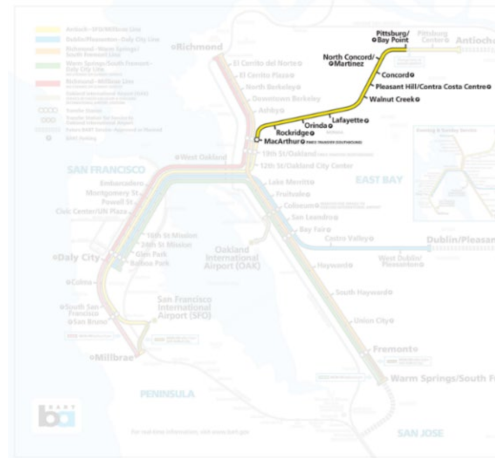
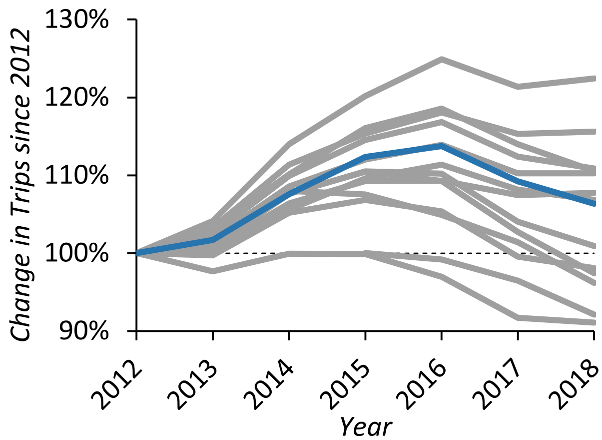


Pittsburg/Bay Point
North Concord/Martinez
Concord
Pleasant Hill/Contra Costa Centre
Walnut Creek
Lafayette
Orinda
Rockridge
MacArthur

8



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Change in Trips since 2012
2012
2013
2014
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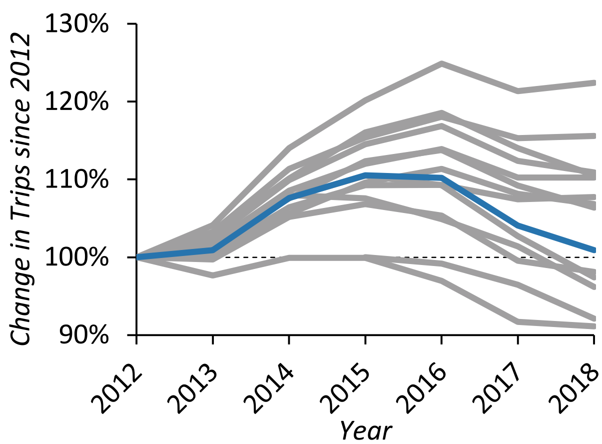
2016
2017
2018
Year

MacArthur
19th St/Oakland
12th St/Oakland City Center

9



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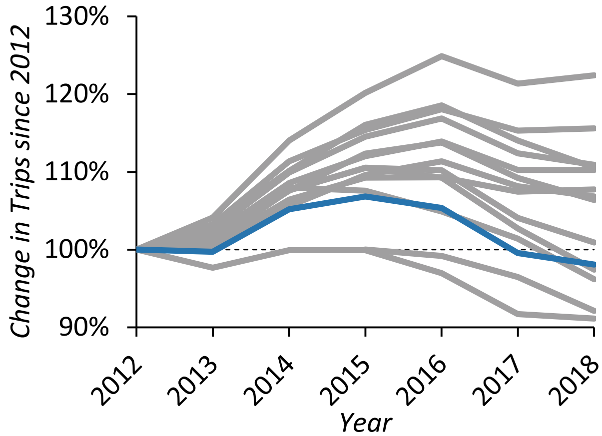
Change in Trips since 2012
2012
2013
2014
2015
2016
2017
2018
Year

Daly City
Colma
South San Francisco
San Bruno
Millbrae

10



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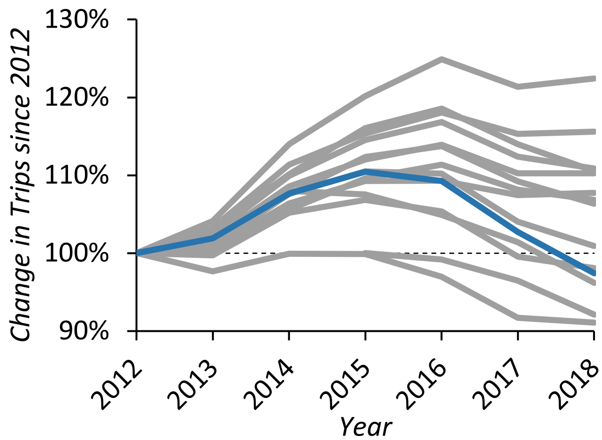
Change in Trips since 2012
2012
2013
2014
2015
2016
2017
2018
Year

Civic Center/UN Plaza
16th St Mission
24th St Mission
Glen Park
Balboa Park
Daly City

11



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Change in Trips since 2012
2012
2013
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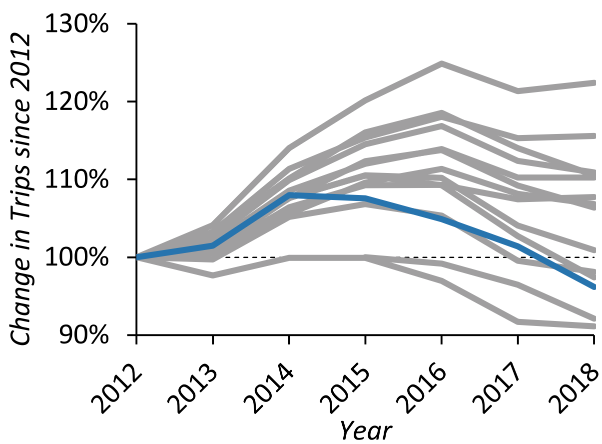
2016
2017
2018
Year

Richmond
El Cerrito del Norte
El Cerrito Plaza
North Berkeley
Downtown Berkeley
Ashby

12



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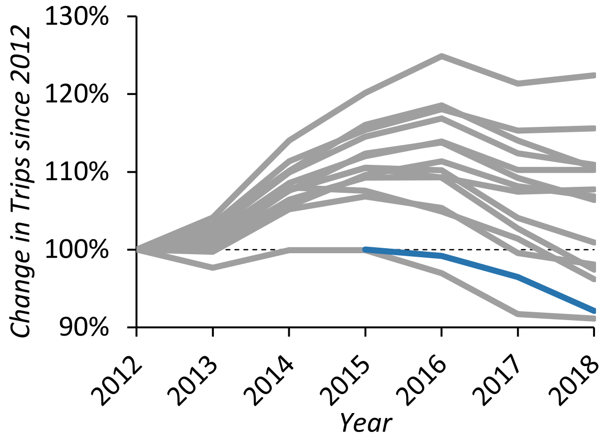
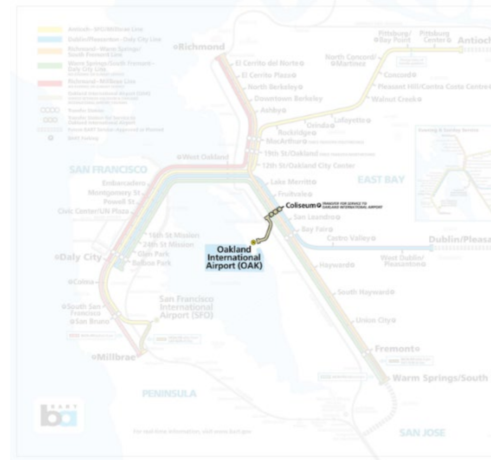
Change in Trips since 2012
2012
2013
2014
2015
2016
2017
2018
Year

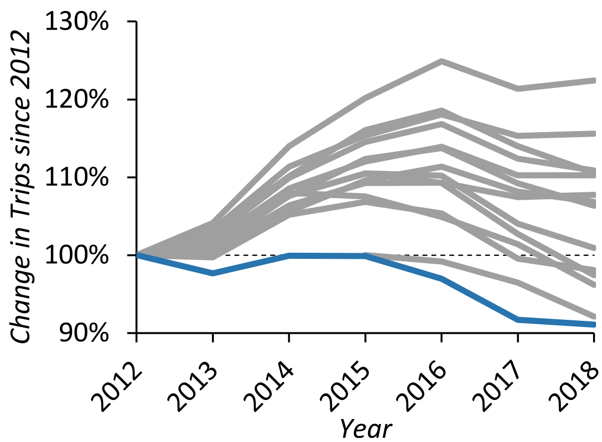
San Francisco International Airport (SFO)
San Bruno
Millbrae

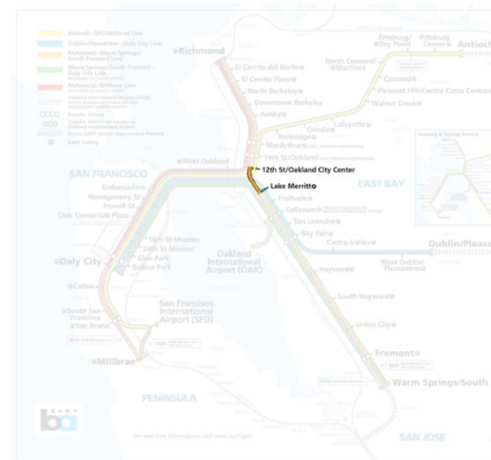
13





14





Data source: BART, 2018a, 2019e

Among the best performing segments between 2012 and 2018 by percent change (See Table 3-4) are the two branches immediately east of West Oakland in the Oakland Wye[11] (#1 and #4). While these segments appear small, recall that the measure of ridership in use here includes all trips that pass through a stretch of track, and these two segments carry all riders between San Francisco and the southern East Bay and between San Francisco and the northern East Bay, respectively. The second-highest-ranked segment is the Dublin/Pleasanton branch, a surprisingly strong performer, and the third-highest is the Transbay Tube and Market Street in downtown San Francisco. Three of these four are further evidence of BART's peaking problem and show why crowding and train capacity constraints in the Transbay Tube have become such problems for the agency.

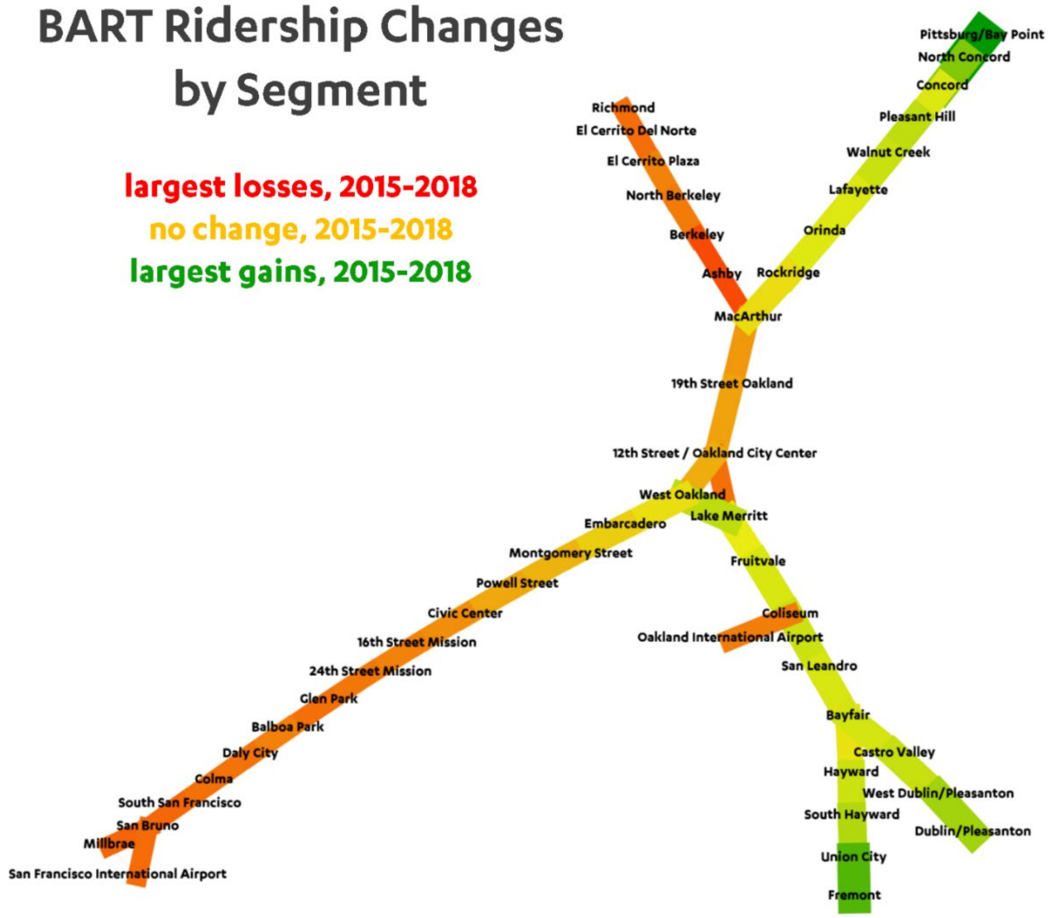
At the other end of the rankings (See Table 3-4) lie a branch south of the City of San Francisco (#10), the Berkeley-Richmond branch (#11), and the two airport connections (#12 and #13). The poor performance of the first may indicate some mode shift of people with jobs in San Mateo County and Silicon Valley switching from BART (or a BART-Caltrain combination) to company shuttles or other means of

11. The three-way intersection of BART lines between West Oakland, 12th Street/Oakland City Center, and Lake Merritt

transportation (See Volume I, Chapter 15). The plummeting ridership on the two airport connections, meanwhile, indicate further problems for these routes that compete with ridehail, taxis, and airport shuttles. Most tellingly, the segment between 12th Street/Oakland City Center and Lake Merritt, the north-south track in the Oakland Wye (#14), had the greatest drop in riders between 2012 and 2018. Carrying all riders between the north and south East Bay, this segment not only experienced a precipitous decline since 2015 but also did not grow, like the other segments, during the boom years between 2012 and 2015. The epicenter of BART's ridership problems, then, is intra-East-Bay trips.

A look at segment ridership between each station reveals more nuance. Figure 3-11 maps changes between 2015 and 2018 for each station segment. Again, the segments south of downtown San Francisco, north from Oakland to Richmond, and to the airports have lost a large share of riders over the past three years. The ends of the Pittsburg/Bay Point, Dublin/Pleasanton, and Fremont branches have experienced significant growth in relative terms, though their absolute growth is small compared to the downtown parts of the system. While the Pittsburg/Bay Point and Dublin/Pleasanton stations themselves may have lost riders due to extensions opening beyond them (not pictured in Figure 3-11), the number of riders passing through them has increased for the same reason. Moreover, while many segments in the East Bay have experienced growth, the short segment between 12th Street/Oakland City Center and Lake Merritt again shows up in the negatives. Therefore, while some of the East Bay branches have grown their ridership, these travelers are going to San Francisco instead of other East Bay destinations. This somewhat contradictory finding—large parts of the East Bay have experienced ridership growth but overall travel within the East Bay is falling—shows yet again the difficulties of BART's peaking problem.

Figure 3-11. Percentage Changes in Annual BART Segment Ridership



Data source: BART, 2019e

3.4. Causal Analysis of BART Ridership

On BART, on other large operators, and over the whole Bay Area, troubling peaking problems and precipitous off-peak drops have proven harmful to top-line ridership. The causes of these trends are thus of great importance if the region hopes to recover from its recent transit-use decline. In this section, we look at the determinants of BART ridership using a multivariate statistical model, aiming to determine the most influential factors driving the trends above. We estimate a model for BART, but not for other agencies, because the unique richness of its origin-destination data allows for such an analysis; the other Bay Area operators may have high-quality boarding data (in terms of time, location, mode, and direction), but lack alighting data.

3.4.1. Research Design

To examine the changing demand for and use of BART by Bay Area travelers, we model BART trips as a function of both temporal and spatial characteristics, particularly at the origin and destination of trips. Our model estimates the relative influence of a set of inputs, both internal and external to the BART system, on ridership between every pair of entry and exit stations in both 2011 and 2015. Unlike most research of this sort that examines spatial influences on travel at just one end of trips, we examine factors at both the origin and destination in order to separately measure their influence. Using the origin-destination pair as the unit of analysis also increases our sample size.

For our model, we use the annual BART origin-destination matrices (described in Chapter 3, Section 1) from 2011 and 2015 (BART, 2019e), the earliest and latest years for which full data for all inputs were available at the time of writing. Unfortunately, this time range does not allow us to examine 2017 and 2018, in which BART ridership and Bay Area transit use more broadly were falling. Nonetheless, a look at the relative weight and change over time of the determinants of BART ridership is revelatory.

To better delineate origin and destination effects, we ran separate models for A.M. (all trips before noon) and P.M. (all trips after noon) weekday ridership. Because many—and likely most—of BART riders on weekday mornings are commuting from home to work, residential patterns are generally reflected at the origin and employment patterns at the destination of each trip. To a lesser extent, the reverse is true of P.M. ridership. To be sure, some A.M. weekday trips may be from work to home (night-shift commutes), some P.M. weekday trips from home to work (evening shifts), and many trips at both times are not commutes at all (such as to socialize, run errands, seek medical care, and so on). To address this, the model includes employment and residential factors for both origins and destinations. Still, by separating the model into periods when riders predominantly travel from home to work and the reverse, we can most clearly isolate effects related to each.

Our ordinary least-squares model is log-linear, in order to fit the data better and ensure that the residuals are normally distributed. The dependent variable is the natural logarithm of the number of trips between each origin-destination pair. A log-linear model makes sense, given that ridership on the most traveled origin-destination pairs is exponentially higher than the least-traveled pairs.

The model includes a set of explanatory factors related to the origin, destination, or trip itself (See Tables 3-5 and 3-6). We summed residents and their demographics within a half-mile and jobs within a quarter-mile, per best-practices from Guerra, Cervero, and Tischler (2012); the model proved robust to varying these station-area radii. Residents and resident demographics were calculated from American Community Survey (ACS) five-year estimates centered on the year of the model (U.S. Census Bureau, 2019a), proportionally allocating parts of census block groups (U.S. Census Bureau, 2018). Job numbers come from Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES) (U.S. Census Bureau, n.d.). A terminus, for the purpose of this model, means the end of a branch of track, not necessarily the end of a BART line (Some lines share track, but one extends farther than the other.) (BART, 2019c). Using outputs from the MTC's regional travel model (Thomas, 2015), we estimated the travel times for each trip by taking the driving and walk-to-transit-to-walk times at the morning and afternoon weekday peaks in 2010 (the latest year of available data) between the transportation analysis zones in which the origin and destination stations lie. Finally, historical BART parking data are not available, so the number of spaces in 2019 was used in all models (BART, 2019d).

Table 3-5. Summary Statistics for BART Ridership Statistical Model, 2011

	FACTOR	MEDIAN	HIGH	LOW	STANDARD DEVIATION
By stati	Residents within a half-mile	8,264	35,510	717	7,817

	Jobs within a quarter-mile		1,005	80,983	13	15,995
	BART-provided parking spaces, 2019		1,006	2,978	0	900
	Lines serving the station		2	4	1	1.13
	Whether the station is a terminus		dummy variable (6 termini = 1; 38 through-stations = 0)			
	Nominal median household income within a half-mile		$69,967	$184,578	$26,921	$31,462
By trip (station pair)	BART travel time	weekday A.M.	1:01	2:52	0:06	0:30
		weekday P.M.	1:01	2:42	0:06	0:30
	Ratio of driving time to BART travel time	weekday A.M.	0.50	1.94	0.12	0.23
		weekday P.M.	0.53	1.72	0.11	0.20
	Whether the trip involves a transfer		dummy variable (518 trips with a transfer = 1; 1,418 without = 0)			

Data source: U.S. Census Bureau, n.d., 2018, 2019a; BART, 2019d, 2019c; and Thomas, 2015

Table 3-6. Summary Statistics for BART Ridership Statistical Model, 2015

	FACTOR		MEDIAN	HIGH	LOW	STANDARD DEVIATION
By station	Residents within a half-mile		8,317	39,491	33	8,564
	Jobs within a quarter-mile		987	95,591	19	20,058
	BART-provided parking spaces, 2019		954	2,978	0	903
	Lines serving the station		2	4	1	1.15
	Whether the station is a terminus		dummy variable (7 termini = 1; 38 through-stations = 0)			
	Nominal median household income within a half-mile		$78,707	$207,385	$29,905	$34,422
By trip (station pair)	BART travel time	weekday A.M.	1:01	2:52	0:06	0:30
		weekday P.M.	1:06	2:42	0:06	0:32
	Ratio of driving time to BART travel time	weekday A.M.	0.50	1.94	0.12	0.23
		weekday P.M.	0.52	1.72	0.11	0.19
	Whether the trip involves a transfer		dummy variable (604 trips with a transfer = 1; 1,421 without = 0)			

Data source: U.S. Census Bureau, n.d., 2018, 2019a; BART, 2019d, 2019c; and Thomas, 2015

Of special note for our analysis is the amount of service supplied, operationalized as the number of lines serving each origin and destination station. Since BART lines generally operate at the same headways (i.e., the time between arrivals), the number of lines fairly captures overall service level at a given station.

The amount of service supplied is a complex factor in explaining ridership. Teasing out this relationship with full rigor requires statistically accounting for the endogeneity between transit service supply and demand: while increased service tends to boost ridership, agencies often respond to higher ridership demand by increasing service; the same applies to service cuts. To address this, Taylor et al. (2009) estimate two-stage statistical models where predicted (rather than actual) service supply is estimated using variables thought to be otherwise unrelated to transit use. This predicted service supply is then included in a second model, in place of actual service supply, along with a host of other variables, to explain ridership.

While acknowledging the methodological superiority of such an approach, we do not attempt to account for endogeneity in this analysis for two reasons. First, headways did not change over the timeframe of our analysis. While new extensions have opened, BART has purchased and run new trains to keep headways the same at every station, according to staff. In BART's specific case, at least, staff appear not to be responding to change in ridership with changes in headways, thus reducing potential endogeneity between service supply and patronage within our analysis. Secondly, a one-stage regression model is, in effect, a best-case scenario: if the influence of service supply were to show up anywhere, it would be here. In other words, ignoring endogeneity should heighten the observed effect of service supply. The fact that service has so little influence in our model, as shown below, is therefore all the more telling.

Returning to the full set of inputs, the factors in Table 3-5 and 3-6 are the outcome of dozens of model specifications. In these draft models, we included a number of other inputs that were ultimately excluded from the final model: some too collinear with other factors; others lacking as strong a theoretical basis for inclusion. The tested but omitted independent variables include: surveyed station cleanliness, surveyed presence of a BART police officer, racial and ethnic percentages of the population within a half-mile of the station, fares between each pair of stations (which scale roughly with distance), whether the station lies in downtown San Francisco, whether the station lies in downtown Oakland, and more. The exclusion of these inputs from the final model did not change the primary findings described below; the model proved quite robust.

The model does not include a specific measure of the built environment and urban form. The job density, population density, and transit service supply variables each partially account for urban form, but only indirectly. Earlier versions of the model included a direct measure—Voulgaris et al.'s (2017) neighborhood types from their typology developed for the U.S. Federal Highway Administration, which are a composite of built environment, job access, road network, and transit supply characteristics. However, since this variable was constructed using much of the same data as the other inputs in the model, it explains the same portion of the variation in ridership as they do but in a less transparent way.

In developing the model, we hypothesized that the inputs would have the effects on ridership described in Table 3-7. These presumed directions stem from research literature and were largely borne out by the results.

Table 3-7. Hypothesized Relationship of Model Inputs to Weekday Ridership

	FACTOR	DATA SOURCE	HYPOTHESIZED EFFECT ON A.M. RIDERSHIP	HYPOTHESIZED EFFECT ON P.M. RIDERSHIP
Origin	Residents within a half-mile	ACS (U.S. Census Bureau, 2019)	+	+
Origin	Jobs within a quarter-mile	LODES (U.S. Census Bureau, n.d.)	∅	+
Origin	BART-provided parking spaces, 2019	BART internal data (BART, 2019d)	+	not in model
Origin	Lines serving the station	manual coding	+	+
Origin	Whether the station is a terminus	manual coding	+	∅
Origin	Nominal median household income within a half-mile	ACS (U.S. Census Bureau, 2019)	–	∅
Destination	Residents within a half-mile	ACS (U.S. Census Bureau, 2019)	∅	+
Destination	Jobs within a quarter-mile	LODES (U.S. Census Bureau, n.d.)	+	+
Destination	BART-provided parking spaces, 2019	BART internal data (BART, 2019d)	not in model	+
Destination	Lines serving the station	manual coding	+	+
Destination	Whether the station is a terminus	manual coding	∅	+
Destination	Nominal median household income within a half-mile	ACS (U.S. Census Bureau, 2019)	∅	–

	FACTOR	DATA SOURCE	HYPOTHESIZED EFFECT ON A.M. RIDERSHIP	HYPOTHESIZED EFFECT ON P.M. RIDERSHIP
Trip	BART travel time in the A.M./P.M.	the MTC's travel model (Thomas, 2015)	–	-

	Ratio of driving time to BART travel time in the A.M./P.M.	the MTC's travel model (Thomas, 2015)	+	+

3.4.2. Results: What Influences BART Ridership?

In our models, the inputs above collectively explain over 70 percent of the variation in ridership by origin-destination pair (See Table 3-8). Even though each model includes fourteen variables, the adjusted R^2 for each model is barely lower, and between 12 and 13 variables in each are significant at a 95 percent confidence level or better. To weigh the relative influence of each of these inputs, Table 3-8 gives the standardized coefficient for each factor. Shaded in Table 3-8, standardized coefficients with larger magnitudes in either the positive or negative direction indicate a greater effect on ridership, all else equal. These coefficients should be compared within each model, not across them.

Table 3-8. Model Outputs (with the Most Influential Factors in Each Model Shaded Darker)

MODEL	TIME OF DAY	A.M.		P.M.	
	YEAR	2011	2015	2011	2015
Model Statistics	Number of origin-destination pairs	n = 1,877	n = 1,965	n = 1,862	n = 1,965
	Coefficient of determination	R^2 = 0.709	R^2 = 0.719	R^2 = 0.734	R^2 = 0.746
	Adjusted coefficient of determination	adjusted R^2 = 0.707	adjusted R^2 = 0.717	adjusted R^2 = 0.732	adjusted R^2 = 0.744

MODEL	TIME OF DAY	A.M.		P.M.	
	YEAR	2011	2015	2011	2015
Standardized Coefficients for Inputs	Jobs at origin	0.085***	0.112***	0.407***	0.399***
	Jobs at destination	0.445***	0.445***	0.224***	0.244***
	BART travel time	-0.299***	-0.232***	-0.315***	-0.260***
	Transfer	-0.223***	-0.277***	-0.226***	-0.270***
	Population at origin	0.124***	0.114***	0.252***	0.236***
	Population at destination	0.225***	0.232***	0.215***	0.201***
	Origin at a terminus	0.099***	0.071***	0.151***	0.160***
	Destination at a terminus	0.161***	0.177***	0.120***	0.105***
	BART parking at origin	0.155***	0.155***	not in model	not in model
	BART parking at destination	not in model	not in model	0.136***	0.120***
	Drive-time-to-BART-time ratio	-0.026	-0.003	-0.137***	-0.158***
	Household income at origin	-0.095***	-0.106***	-0.065***	-0.069***
	Household income at destination	-0.035*	-0.035**	-0.080***	-0.077***
	Lines at origin	0.022	0.003	0.033	0.040*
	Lines at destination	0.053*	0.051**	0.013	0.030
	(Constant)	N/A***	N/A***	N/A***	N/A***

** significant at a 95 percent confidence level*

*** significant at a 99 percent confidence level*

**** significant at a 99.9 percent confidence level*

The model output indicates that station-area jobs are, by far, the most important factor explaining weekday BART ridership. Across both years and both times of day analyzed, station-area employment tops the list of influential factors: With only job numbers by station, an analyst could predict weekday BART ridership at a relatively high accuracy (R^2 values between 0.342 and 0.387). This confirms findings about BART ridership trends earlier in the decade by Erhardt (2016).

In the morning, when most trips are likely to be commutes to work, job concentrations at the destination draw transit riders. After noon, the same is true in reverse, though since the P.M. includes afternoon pre-peak and evening post-peak periods, in which many non-work trips occur, the relative effect of jobs is slightly less than in the A.M. On the other hand, jobs at the destination also have influence in the P.M. This factor may represent evening-shift commutes but also the effects of running errands, social trips, etc. There, the traveler may not be taking BART to their own job, but they are traveling to job centers nonetheless. Overall, employment at the end of the trip predicts the greatest share of morning weekday BART ridership, and employment at both ends most predict evening weekday ridership.

A few other factors stand out, though none so tall. In each model, BART travel time and whether the trip required a transfer rank between second- and fourth-most influential on weekday ridership. In either case, a long trip or a trip that involves changing trains depresses ridership.

Placing third in the morning both years was population density at the destination, with a larger predictive effect on weekday ridership than population at the origin. On a commuter system like BART, population within a half-mile of the origin does not capture the wide catchment area for morning park-and-ride commuters. Population at the destination, meanwhile, likely less reflects the influence of people returning home in the A.M. and more serves as a proxy for a built environment that facilitates last-mile connections to destinations. For instance, if the area around a destination station has a dense population, it is also likely to be walkable, to have connecting local bus services (difficult to capture otherwise due to the need to obtain data from every connecting agency), etc.

Notably, the number of lines at either end of the trip—effectively a measure of headways/service frequency—is low on the list of influential factors, with at least one of the two variables lacking statistical significance in each model. While Walker is generally right that "frequency is freedom" (2012, p. 85), on a commuter system like BART, many workers may be willing to make trips regardless of how long they have to wait for a train. After all, peak-period ridership is generally less elastic than off-peak (Litman, 2004), and increasingly more of BART's ridership is at peak times. And unlike some other trip types, the fixity of many work start times and BART's relatively strict schedule allows riders to plan their arrival time at the origin station to minimize wait times.

As we noted earlier, our model does not correct for the endogeneity between service supply and ridership. The relatively low measured influence of service supply on weekday BART ridership in the models is likely an overestimation of the factor's effect. In fairness, the number of lines serving each station varies only from one to four each; this small variance does dampen its effect in the model. Nevertheless, this reflects the realities of BART's system, on which headways are consistent by line and relatively similar on the corridors with the large majority of riders.

All other inputs have roughly the expected effects on ridership, in the expected directions.

3.4.3. Results: Change over Time

Not only does station-area employment best predict BART's weekday ridership, but its influence has grown over time. For 2011 mornings, jobs at the destination were 1.49 times more influential than the next-most predictive factor (travel time), while for 2015 mornings, jobs at the destination were 1.61 times more influential than the next factor (whether the trip requires a transfer). The same growth occurred after noon: in 2011, jobs at the origin had a 1.29 times greater effect on ridership than the next-most predictive factor, compared to 1.48 times greater in 2015. As the Bay Area's jobs numbers have ballooned faster than population growth, so too have their effects on BART. Otherwise, from 2011 to 2015, the relative influence of travel time has dropped slightly, as the relative effect of needing to transfer has risen.

3.4.4. Model Robustness and Variants

To test the robustness of these findings, we ran a number of model variants, which confirmed our conclusions. A log-log model, in which we took a logarithm of both the inputs and the dependent variable, produced similar results but explained less variation in total and lacks a stronger theoretical basis in this situation. The estimated influence of the number of lines at a station did rank higher, placing third or fourth but still solidly behind jobs. A model of all trips outside of the three morning and three afternoon peak hours—including A.M. off-peak, P.M. off-peak, and weekend ridership combined—also did not produce a substantively different output. Because off-peak ridership patterns do not divide cleanly by commute direction, jobs at the destination and at the origin both have large effects, the former ranking as most influential in both years. Last, we ran a model excluding all trips that end at the four downtown San Francisco stations in the A.M. and all trips that begin there in the P.M. In this model, which leaves out the majority of BART trips and the biggest job center in BART's service area, jobs at the destination still had the second-largest effect in 2011, behind travel time, and grew to the most influential in 2015. In short, no new smoking gun emerged among the other factors or their change over time in these alternative model specifications to convincingly explain ridership trends outside of the central business district.

Unaddressed in the models above, issues of safety and cleanliness on BART have dominated media coverage of the ridership decline. The lack of good time-series data on these factors, however, impeded us from including them. Likewise, perceptions of cleanliness and safety can vary widely depending on how surveys are structured; people's stated preferences and feelings on these issues may well differ from their actual preferences and feelings.

Acknowledging the caveats above, what modeling we were able to do shows no substantiable effects on ridership from these surveyed "quality of ride" factors. First, though, we first had to estimate data for other factors up to 2018, since the homeless counts (BART, 2019f) and geographically disaggregated rider survey data (BART, n.d.-b) do not date back earlier. At the time of running the models in this section, LODES jobs numbers—the most influential determinant of BART ridership—were only released up to 2015 (U.S. Census Bureau, n.d.), and ACS population estimates have only been published up to the five-year span centered on 2015 (U.S. Census Bureau, 2019a). To account for growth since then, for each factor with unavailable 2018 data, we constructed a linear best-fit line for each station based on data points from 2011 through 2015. This is a rough method of estimation; treat these findings with appropriate caution.

The effect on ridership from the number of homeless people in a station, the presence of police in a station, and the perception of cleanliness at a station are either not significant or inseparable from other factors' effects. First, the 2018 homeless counts in the four downtown San Francisco stations (BART, 2019f) were too colinear with population density to establish an independent effect. Perceived station cleanliness—as measured on a four-point scale by a BART rider survey (BART, n.d.-b)—was also too correlated with population and with number of BART lines to ascertain an independent effect. Put differently, people experiencing homeless tend to be in dense areas, and stations with more people nearby and more lines going through tend to be less clean. These conclusions are intuitive, but they prevent the independent effects of each factor from being analyzed in a model like the ones above. It appears far more likely that population density and number of lines are responsible for this portion of the variation in ridership than presence of people experiencing homelessness or the perception of dirty stations.

BART also surveyed riders in 2017 and 2018 asking if they had seen a police officer in the station (BART, n.d.-b). Unlike the factors above, the results of this survey were not substantially colinear with other inputs. But when included, police presence did not have a statistically significant effect on ridership. We cannot, though, firmly draw conclusions here. In all likelihood, the presence of police both affects and is affected by the crime rate in the station, the crime rate in the area, and, unfortunately, the demographics of each station's ridership. Without controlling for these other factors—and accounting their endogeneity—the ridership effects of police cannot be rigorously established. Still, as a basis for potential future research, our analysis at least suggests that police presence does not significantly influence ridership.

3.4.5. Analysis

Not only do we find that trip-making on BART is driven overwhelmingly by station-area employment, the effect of employment measurably increased between 2011 and 2015—a time when BART was adding riders. In some respects, the strong effect of jobs on BART ridership follows from the structure and purpose of the BART system. But while this result is perhaps not surprising for our A.M. and P.M. weekday models, our models of off-peak and non-downtown-San-Francisco trips produced similar results. To take a step back, choosing to model BART, a commuter-oriented system, instead of other Bay Area operators also slants the results toward jobs being important. Even so, the scale of jobs' effect is impressive. Not only are BART passengers increasingly concentrated in peak commute periods, they appear to be attracted to ride BART overwhelmingly by station-area employment access, particularly into and out of downtown San Francisco.

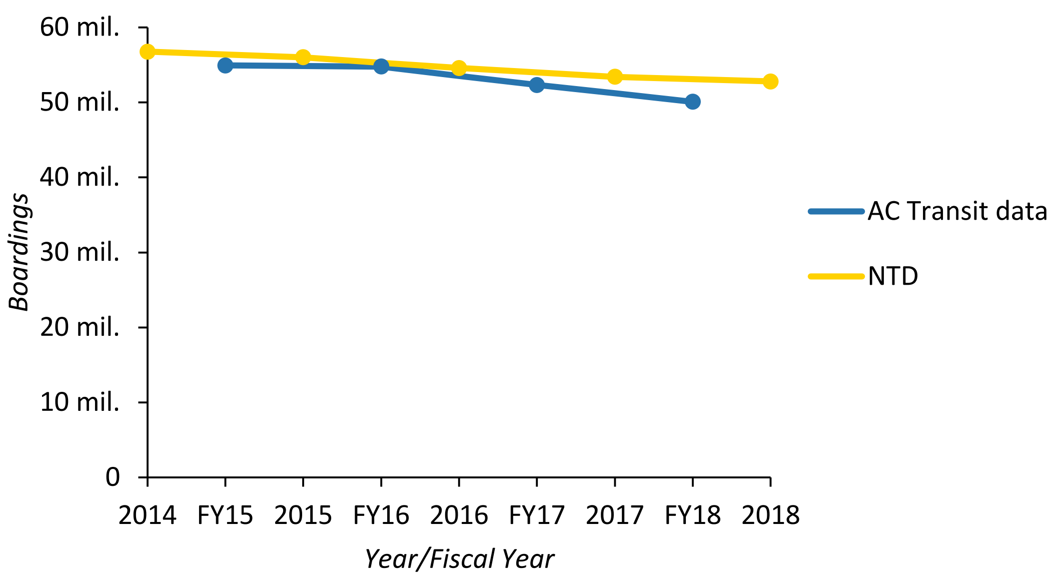
4. AC Transit Ridership Trends

4.1. Overview and Data Validation

The Alameda-Contra Costa Transit District has simultaneously lost a substantial share of its ridership but avoided the peaking problems of other agencies like BART. AC Transit has lost ridership across its route types, days of the week, and lines (AC Transit, 2018). Like SFMTA, AC Transit operates in a relatively dense service area, centered on Oakland, the third-most populous city in the region. This may explain both operators' relatively even declines. However, unlike SFMTA, AC Transit's service area lacks the explosive job growth of downtown San Francisco (U.S. Census Bureau, n.d.), likely contributing to AC Transit's deeper ridership drops. Indeed, AC Transit lost the third-most boardings of all Bay Area operators between 2015 and 2018 (FTA, 2019).

To explore these trends, we examine internal data from AC Transit. AC Transit staff have provided data on boardings and headways, broken down by route, route type, and day of the week (AC Transit, 2018). We have compiled these spreadsheets together from Fiscal Year 2015 to Fiscal Year 2018 (July 1st-June 30th); when peak or off-peak headways are given as a range, we took the average of the high and low of each range. AC Transit's internal data tracks its submissions to the NTD relatively closely (See Figure 4-1), allowing its ridership trends to be compared to others in the NTD (FTA, 2019).

Figure 4-1. AC Transit Annual Ridership: NTD versus Internal AC Transit Data



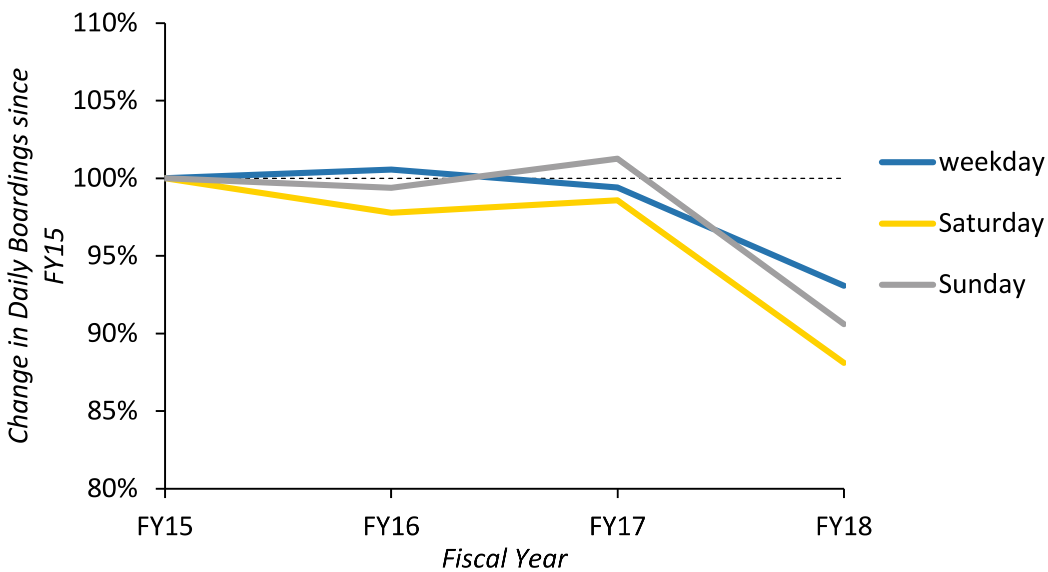
Data source: AC Transit, 2018 and FTA, 2019

Overall, the operator lost 3.2 million annual riders between 2015 and 2018, according to the NTD (FTA, 2019). AC Transit's boardings peaked in 2014, earlier than the Bay Area overall, and have declined every year thereafter.

4.2. Breakdown by Time and Frequency

AC Transit ridership had fallen relatively evenly across the week and across routes with different headways. Unlike the stark differences by day of the week on BART, AC Transit's daily ridership on Saturdays (around 89,000 trips daily in FY18) and on Sundays (around 72,000 trips daily in FY18) has declined only slightly more than on weekdays (around 168,000 trips daily in FY18) (See Figure 4-2). For each day of the week, most of the decline has come in the most recent fiscal year of data.

Figure 4-2. Change in Daily AC Transit Ridership by Weekday



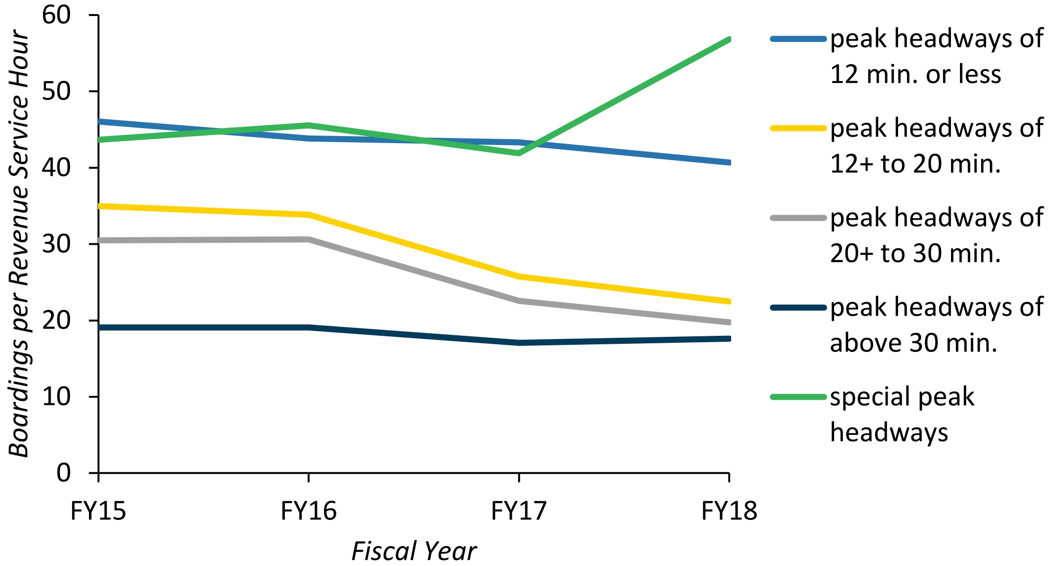
Data source: AC Transit, 2018

AC Transit may be experiencing more peaking by headways than by day of the week. Figure 4-3 shows the productivity (boardings per revenue service hour) of categories of lines, broken down by the lines' peak headways.[12] We use productivity here, rather than raw ridership, to account for service changes. The most frequent routes, with peak headways of 12 minutes or less, have only slightly declined in productivity. But lines with less frequent peak headways, between 12 and 30 minutes, have seen their productivity decline far more steeply (Lines with longer peak headways or special peak headways carry a very small share of the operator's ridership.). AC Transit's most frequent peak service, in other words, has proven more resilient than its less frequent lines. Divided by off-peak headways, though, the declines in ridership appear more even (See Figure 4-4[13]). The only type of peaking on AC Transit is thus on its most frequent peak routes.

Figure 4-3. AC Transit Productivity by Peak Frequency

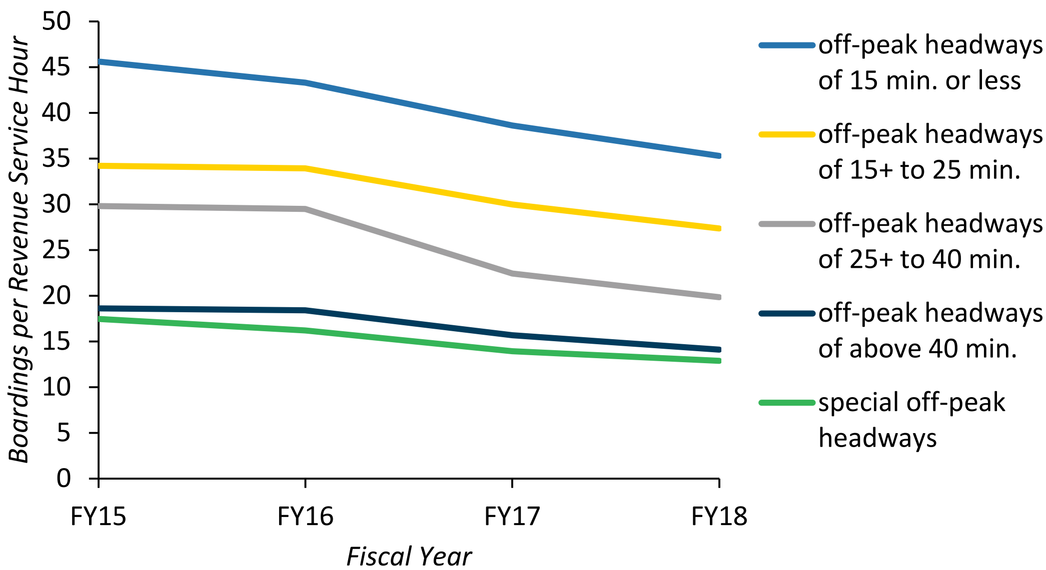
12. Unfortunately, the dataset does not separate trips by time of day. Figure 4-3 therefore includes trips *all day*, even though the lines are separated by their *peak* frequencies.

13. Unfortunately, the dataset does not separate trips by time of day. Figure 4-4 therefore includes trips *all day*, even though the lines are separated by their *off-peak* frequencies.



Data source: AC Transit, 2018

Figure 4-4. AC Transit Productivity by Off-peak Frequency

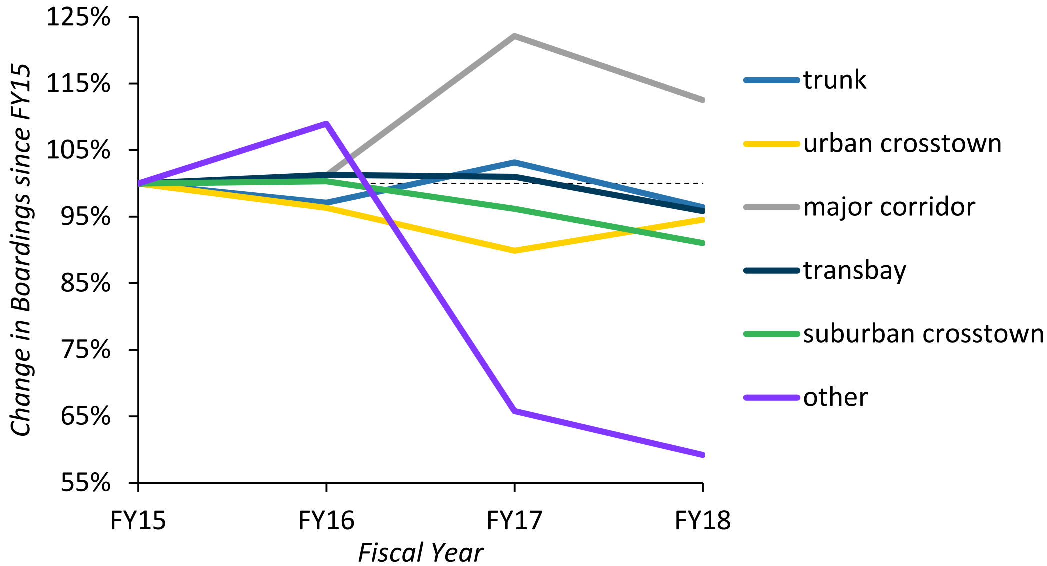


Data source: AC Transit, 2018

4.3. Breakdown by Line

Geographically, AC Transit has also lost ridership across many areas and lines. However, some trends emerge when breaking down lines by their route type, an internal categorization of AC Transit's lines (See Figure 4-5). On major corridor routes, ridership has jumped up since FY15, while trip counts on transbay lines and the most well-ridden category, trunk routes, have stayed mostly flat. Meanwhile, crosstown routes and especially other lines (rapid, supplemental, very low density, etc.) have lost patronage since FY15.

Figure 4-5. Change in Annual AC Transit Ridership by Route Type



Data source: AC Transit, 2018

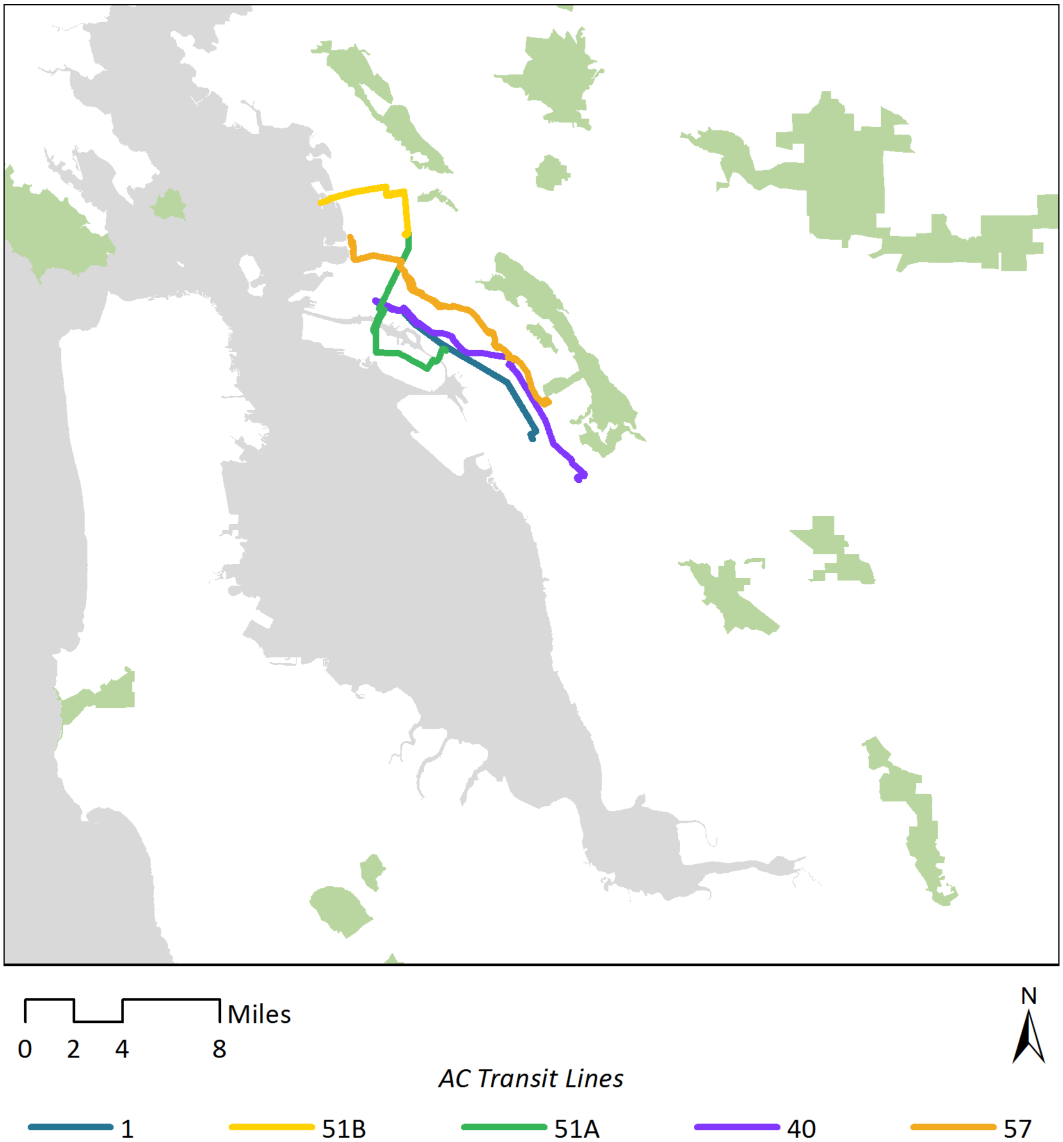
Unlike Muni or BART, most of AC Transit's largest lines have suffered the operator's largest ridership losses, with one prominent exception. Table 4-1 lists the top five AC Transit lines by Fiscal Year 2018 patronage. Line 1, down International Boulevard in Oakland and San Leandro, is both the most-ridden route and the route with the largest gains between Fiscal Years 2015 and 2018. AC Transit is investing heavily in this corridor, currently constructing a bus rapid transit line there (AC Transit, 2019a), though some or most of the route's gain may come from absorbing riders from the now-discontinued 1R rapid line (AC Transit, 2016). But the rest of AC Transit's top five lines are among the worst performers, with significant losses over the same time period. Unlike the peaking on BART, where the most crowded trains are becoming even more crowded, the opposite appears true on AC Transit.

Table 4-1. AC Transit Lines with the Most Boardings, Fiscal Year 2018

LINE	ANNUAL BOARDINGS, FISCAL YEAR 2018	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018	
1 (trunk)	3,921,220	+440,732	1st out of 138
51B (trunk)	2,805,649	-118,542	123rd out of 138
51A (trunk)	2,705,941	-271,599	129th out of 138
40 (trunk)	2,605,392	-447,868	136th out of 138
57 (trunk)	2,001,412	-340,218	133rd out of 138

Data source: AC Transit, 2018

Figure 4-6. AC Transit Lines with the Most Boardings, Fiscal Year 2018



Data source: AC Transit, 2018, 2019b; CaliDetail, n.d.; and Esri, 2010

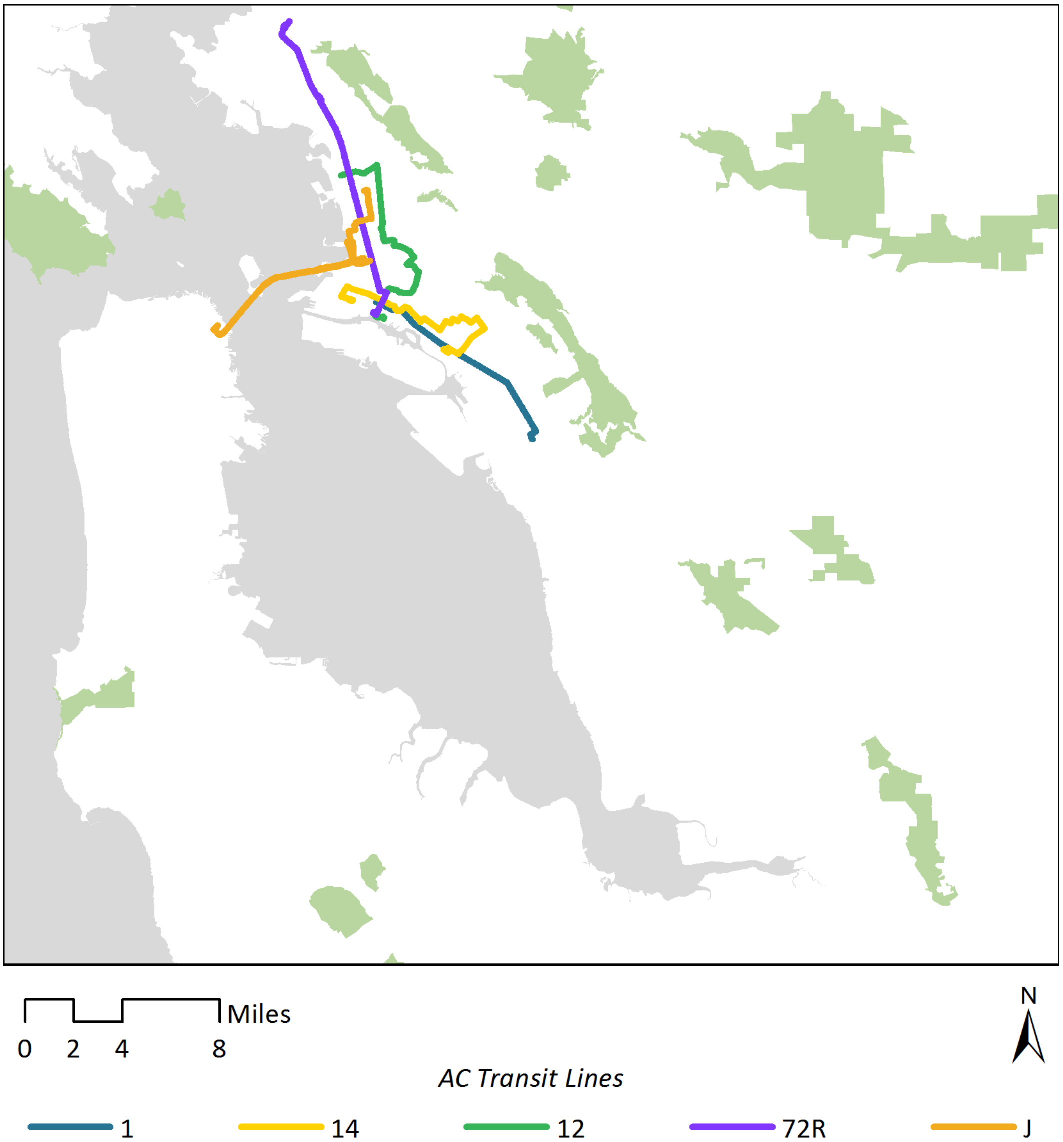
The lines with the greatest absolute ridership growth between Fiscal Years 2015 and 2018 are concentrated in the densest parts of AC Transit's service area, like downtown Oakland (See Table 4-2 and Figure 4-7). Interestingly, Line 7R down San Pablo Avenue through Richmond, Berkeley, and Oakland has gained significant ridership, even though the BART line along the same corridor has lost much patronage. The largest percentage gains over the same period have occurred on a number of central Oakland school routes (See Table 4-3 and Figure 4-8).

Table 4-2. AC Transit Lines with the Largest Absolute Gains, Fiscal Year 2015-Fiscal Year 2018

LINE	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018
1 (trunk)	+440,732
14 (urban crosstown)	+280,705
12 (urban crosstown)	+199,749
72R (rapid)	+68,748
J (transbay)	+65,993

Data source: AC Transit, 2018

Figure 4-7. AC Transit Lines with the Largest Absolute Gains, Fiscal Year 2015-Fiscal Year 2018



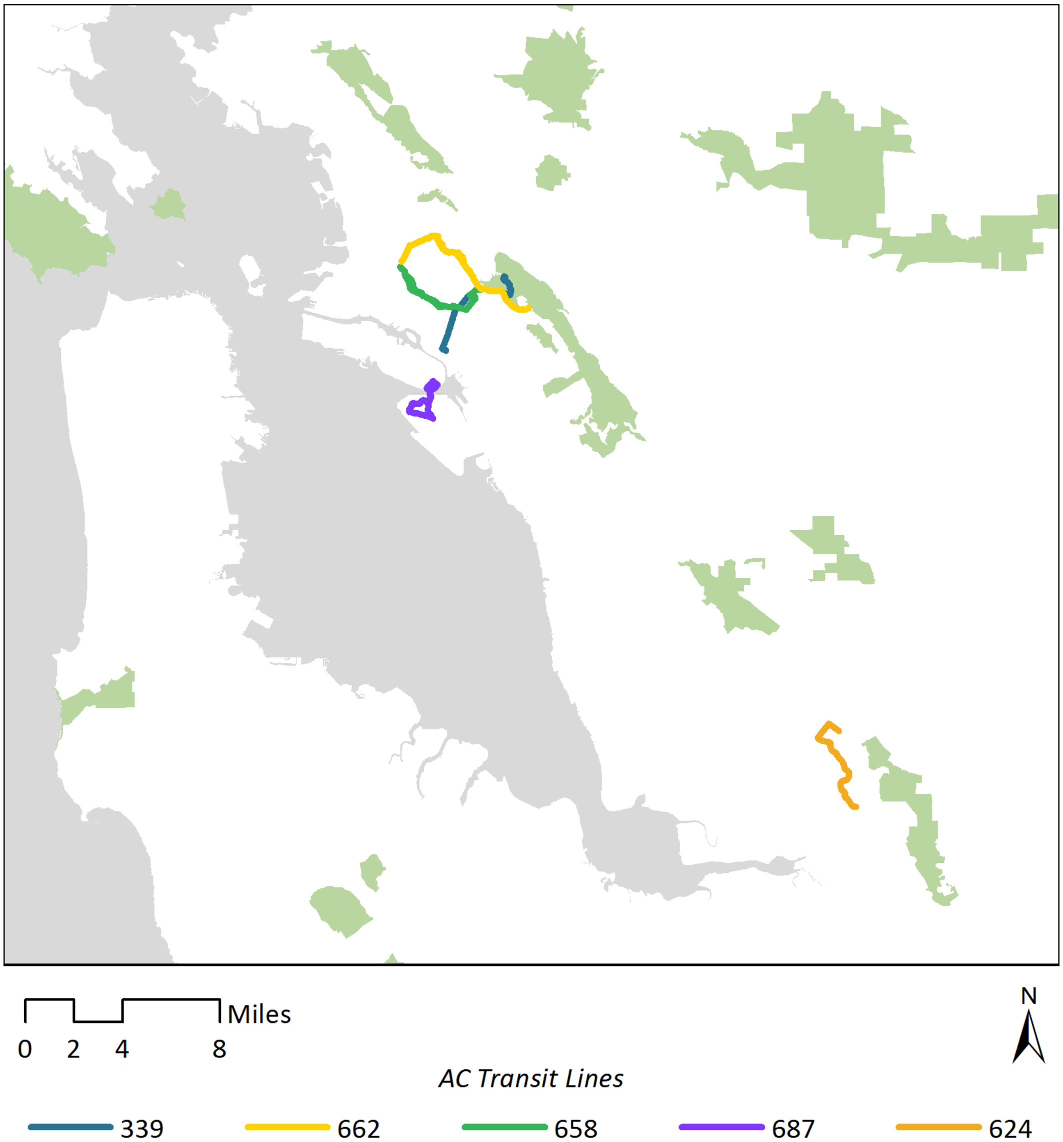
Data source: AC Transit, 2018, 2019b; CaliDetail, n.d.; and Esri, 2010

Table 4-3. AC Transit Lines with the Largest Percentage Gains, Fiscal Year 2015-Fiscal Year 2018

LINE	PERCENT CHANGE IN ANNUAL BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018
339 (feeder)	+293%
662 (supplemental)	+186%
658 (supplemental)	+158%
687 (supplemental)	+111%
624 (supplemental)	+95%

Data source: AC Transit, 2018

Figure 4-8. AC Transit Lines with the Largest Percentage Gains, Fiscal Year 2015-Fiscal Year 2018



Data source: AC Transit, 2018, 2019b; CaliDetail, n.d.; and Esri, 2010

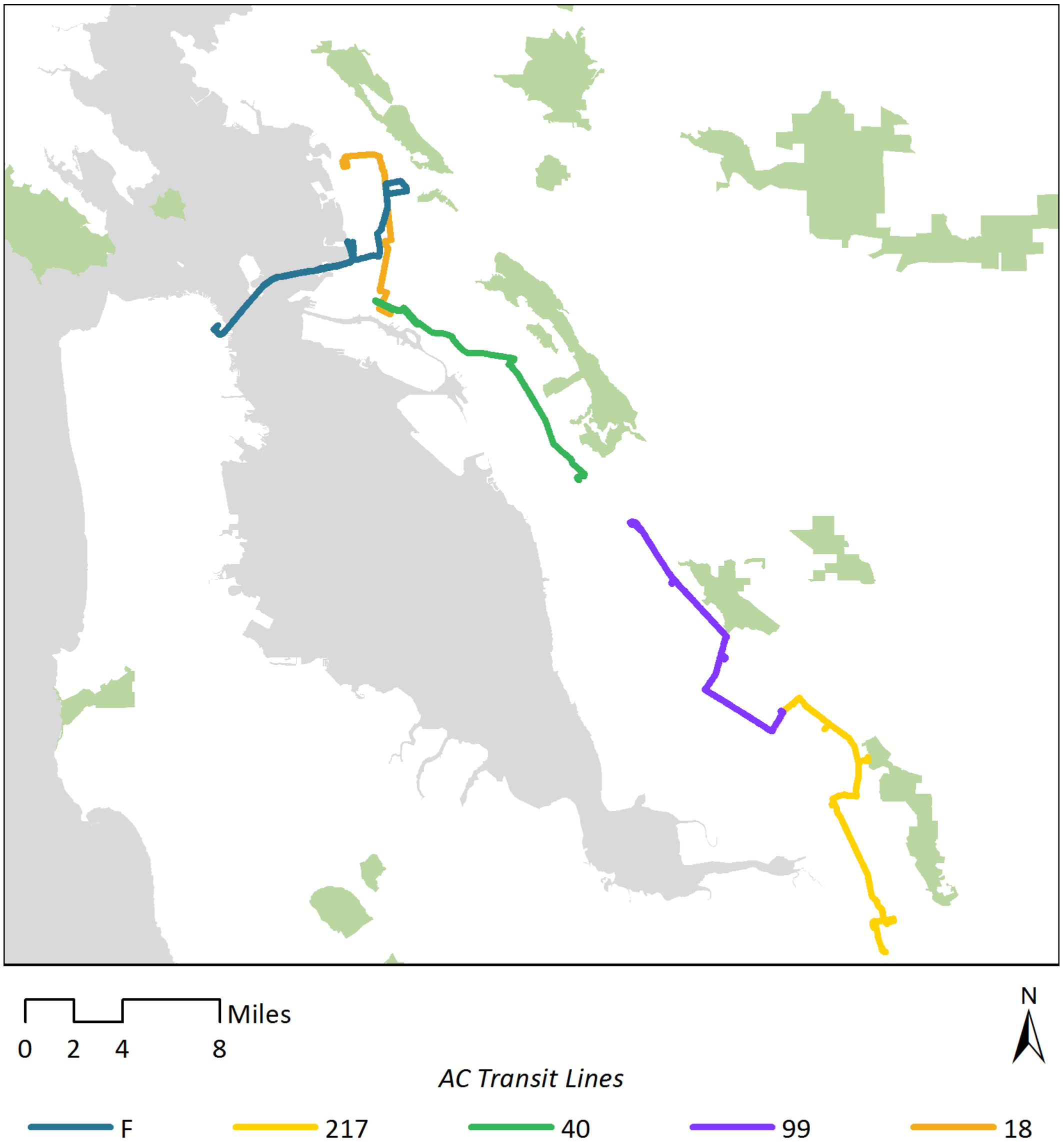
Meanwhile, the lines with the most significant losses are mostly trunk or corridor lines lined up from Oakland south towards Fremont (See Table 4-4 and Figure 4-9). Again, this contrasts with the BART line along the same corridor, which has gained patronage. The routes with the greatest percentage losses are very low density and school routes in Oakland, Alameda, and Fremont (See Table 4-5 and Figure 4-10).

Table 4-4. AC Transit Lines with the Largest Absolute Losses, Fiscal Year 2015-Fiscal Year 2018

LINE	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018
F (transbay)	-350,522
217 (very low density)	-372,272
40 (truck)	-447,868
99 (major corridor)	-484,691
18 (trunk)	-1,096,908

Data source: AC Transit, 2018

Figure 4-9. AC Transit Lines with the Largest Absolute Losses, Fiscal Year 2015-Fiscal Year 2018



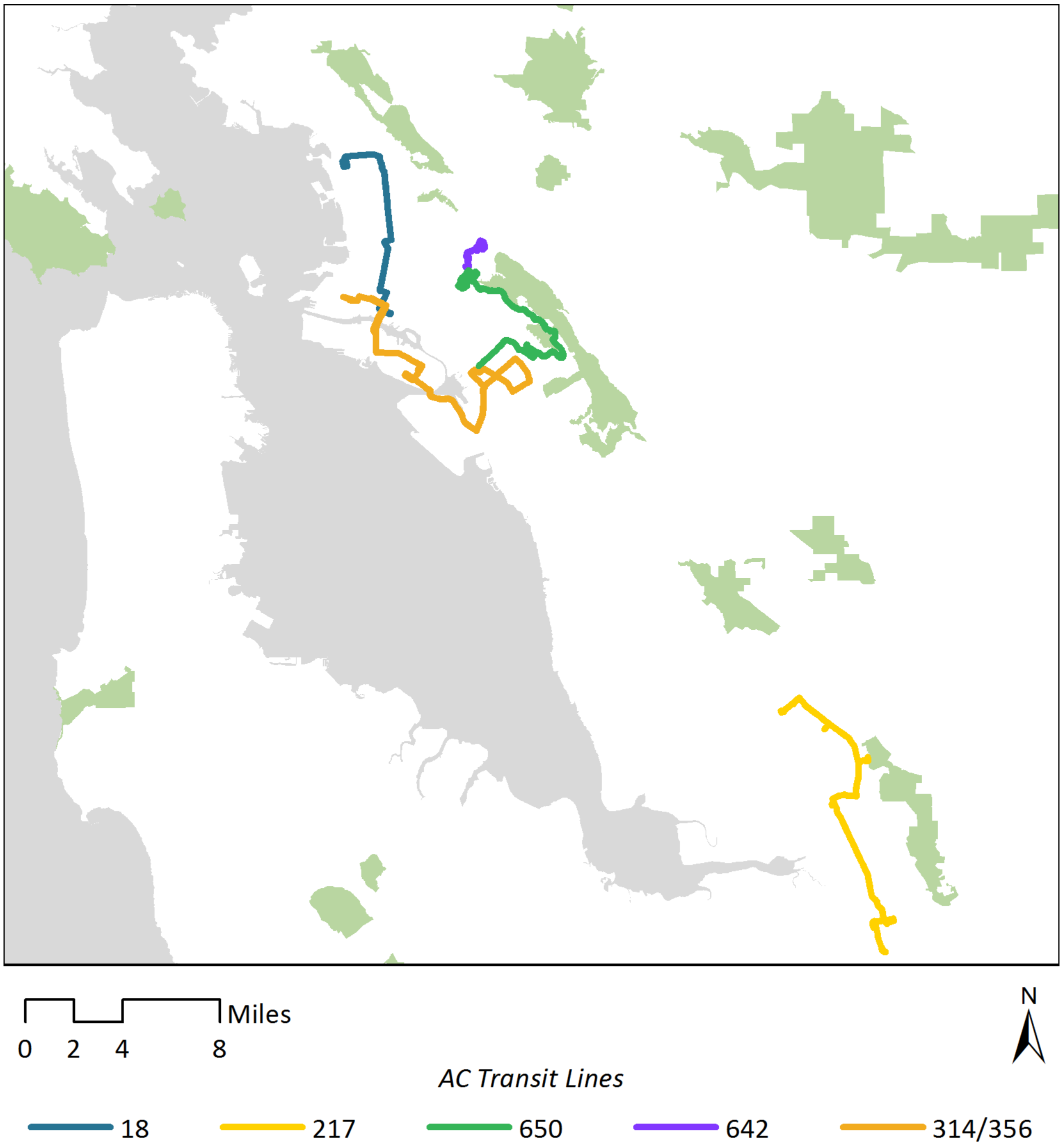
Data source: AC Transit, 2018, 2019b; CaliDetail, n.d.; and Esri, 2010

Table 4-5. AC Transit Lines with the Largest Percentage Losses, Fiscal Year 2015-Fiscal Year 2018

LINE	PERCENT CHANGE IN ANNUAL BOARDINGS, FISCAL YEAR 2015-FISCAL YEAR 2018
18 (trunk)	-45%
217 (very low density)	-50%
650 (supplemental)	-54%
642 (supplemental)	-56%
314/356 (very low density)	-88%

Data source: AC Transit, 2018

Figure 4-10. AC Transit Lines with the Largest Percentage Losses, Fiscal Year 2015-Fiscal Year 2018



Data source: AC Transit, 2018, 2019b; CaliDetail, n.d.; and Esri, 2010

5. VTA Ridership Trends

5.1. Overview and Data Validation

Compared to BART, Muni, and AC Transit, the Santa Clara Valley Transportation Authority operates in a more typical American metropolitan environment. Home to the office parks, corporate campuses, and single-family suburbs of Silicon Valley, Santa Clara County contains just over 1,500 people per square mile, as compared to 2,250 people per square mile in Alameda County and around 18,900 people per square mile in San Francisco (U.S. Census Bureau, 2019a and California Open Data, 2019). To be sure, Santa Clara is still quite urban—San José is America's tenth-most-populous city, after all (U.S. Census Bureau, 2019a)—but the more spread-out urban form in which VTA operates is still markedly different from Muni's San Francisco or AC Transit's inner East Bay cities. Indeed, using the neighborhood typology created by Voulgaris et al. (2017), one percent of Santa Clara County residents live in the most transit-supportive neighborhood type, "old urban," compared to seven percent in Alameda County and 36 percent in San Francisco (Voulgaris et al., 2017; California Open Data, 2019; and U.S. Census Bureau, 2018).

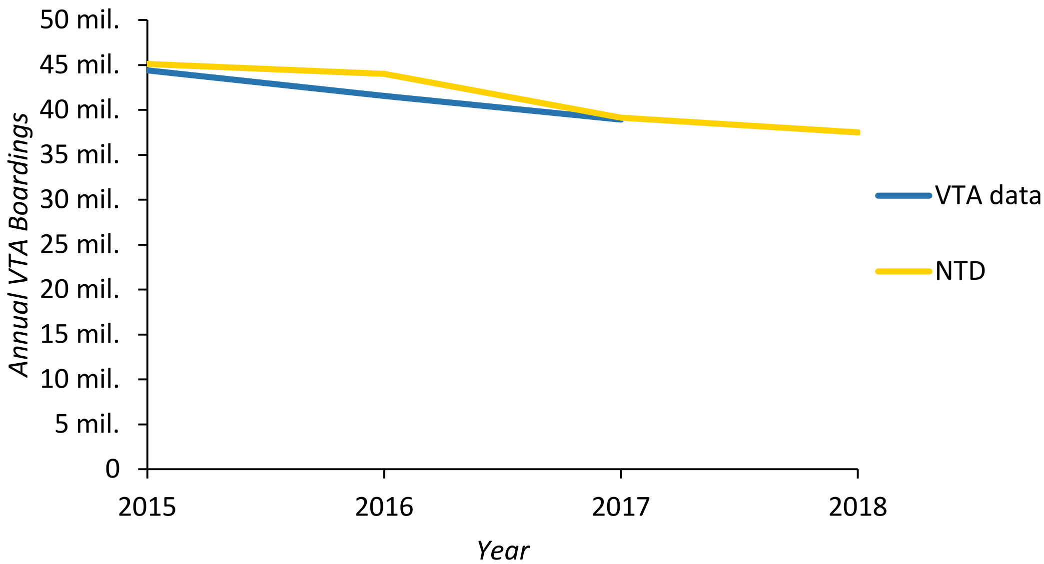
Likewise, VTA itself is more typical of transit agencies nationwide. In 1991, VTA opened the first segment of its light rail system, near the start of America's current light-rail building boom (VTA, 2005), while BART began rail service in 1972 (BART, n.d.-a and Healy, 2016) and Muni in 1912 (SFMTA, 2019a). Buses carried over three quarters of VTA's unlinked trips in 2018 (FTA, 2019), while studies and reports have found cost-ineffectiveness in its rail capital construction program (Guerra and Cervero, 2011, pp. 268, 283), along with its overall operations (Rosenberg, 2012; Jaffe, 2013; and Civil Grand Jury of Santa Clara County, 2019) (See Volume I, Chapter 11). A detailed look at VTA can reveal whether unique influences have affected ridership across the whole Bay Area or whether the rest of the region's otherwise nationally typical ridership trends are largely hidden by Muni and BART.

Overall, VTA has lost the most boardings of any Bay Area agency, with a drop of 7.6 million annual boardings between 2015 and 2018 (FTA, 2019). Moreover, like BART above and Caltrain below, VTA has suffered from some clear peaking problems, at least by time of day. This combination of trends bodes ill for the agency's potential for ridership recovery.

To shed light on these trends, VTA staff have provided data on the agency's monthly ridership every three months, from January 2015 to July 2018, broken down by line, time of day, and day of the week (VTA, 2018). We matched this dataset to route types and modes from VTA's website (VTA, 2019a). We also eliminated January 2018 from the dataset and replaced that month with averages of the prior and following months (The reported ridership totals for January 2018 were over 50 percent higher than the months before or after it, an increase evenly spread across most lines, creating an unexplained spike likely due to a data error.).

We summed up the four months of ridership each year, multiplied by three to estimate annual ridership, and compared the results to numbers from the National Transit Database to validate them (See Figure 5-1). The two datasets appear to track fairly closely, in both absolute values and direction of trends over time (VTA, 2018 and FTA, 2019). Therefore, VTA's own data appear valid for comparison internally and with other agencies.

Figure 5-1. VTA Annual Ridership: NTD versus Internal VTA Data



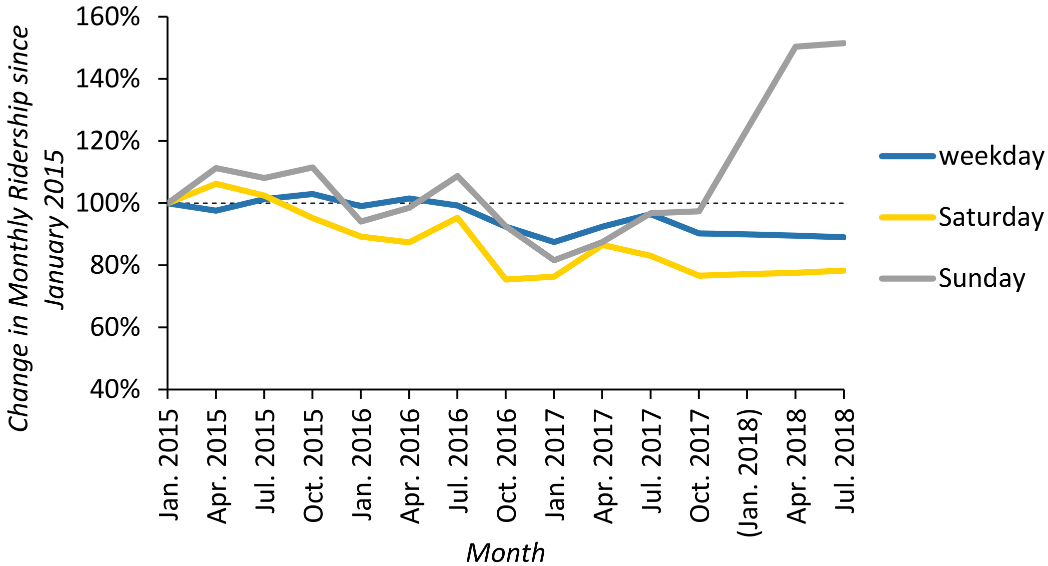
Data source: VTA, 2018 and FTA, 2019

5.2. Temporal Breakdown of VTA Ridership

VTA's ridership trajectory looks more like that of the U.S. than the Bay Area overall. VTA ridership, for instance, flattened in 2015 and fell thereafter. This pattern looks similar to American transit's overall 2014 plateau and subsequent drop but different from the Bay Area's later, sharper 2016 peak and ensuing decline (See Figure 1-1). While VTA trips have increasingly concentrated in the peak, VTA has also seen declines across the board.

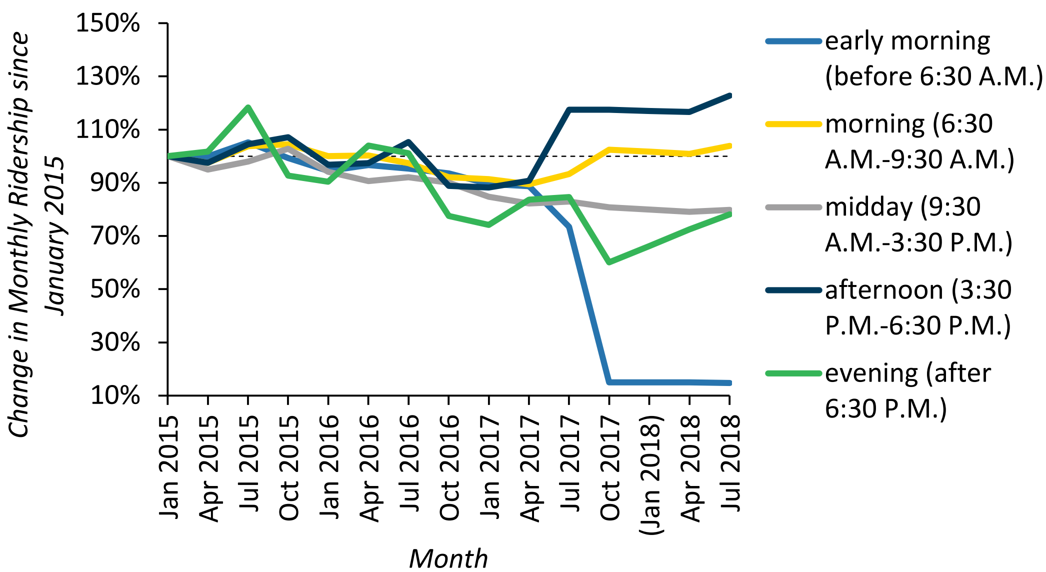
Take changes in ridership by day of the week and time of day. Between the first month (January 2015) and last month (July 2018), weekday ridership has slowly and steadily declined (See Figure 5-2). Meanwhile, Saturday ridership has fallen by a larger percentage, and Sunday ridership has—excluding a spike in the last two months of data—dropped similarly but with more variability. Looking past the monthly bumps and troughs, ridership is generally falling throughout the week. Ridership also fell somewhat uniformly by time of day, until mid-2017 (See Figure 5-3). A significant service reallocation that year ended up increasing morning and afternoon ridership and decreasing ridership at other times of day (Hoang, 2017 and Richards, 2017). Ridership has concentrated at peak times, but only after the service change.

Figure 5-2. Change in Monthly VTA Ridership by Weekday



Data source: VTA, 2018

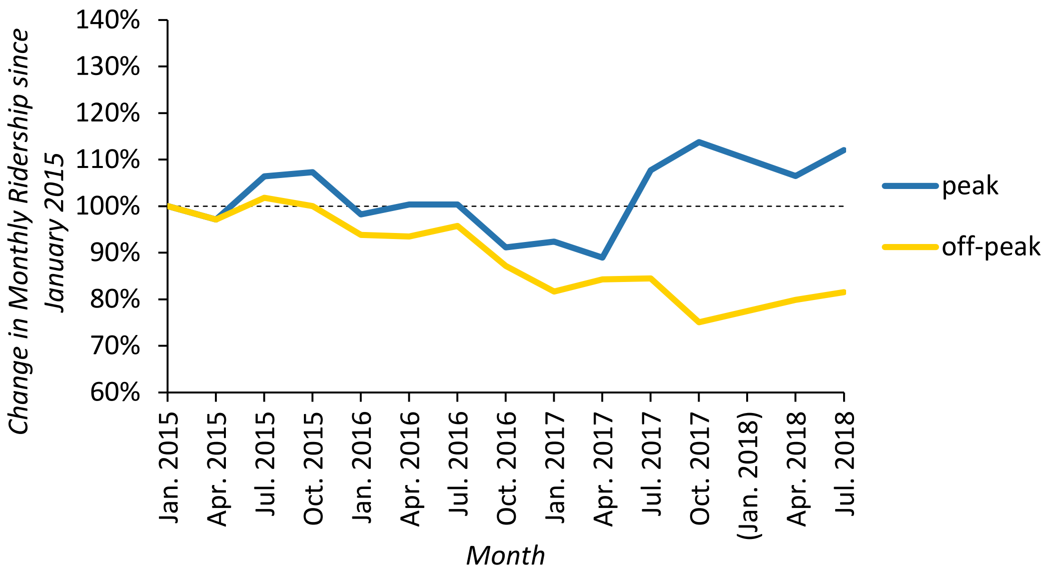
Figure 5-3. Change in Monthly VTA Ridership by Time of Day



Data source: VTA, 2018

VTA's peaking problem shows up most clearly when dividing ridership into weekday peak versus all other times (See Figure 5-4). Since the service changes, peak patronage has recovered to around ten percent above January 2015 ridership—an increase that any transit agency would be thrilled to have. But at the same time, off-peak patronage has continued to drop, down around 20 percent since January 2015. This decline has dragged VTA's top-line ridership down with it.

Figure 5-4. VTA's Peaking Problem

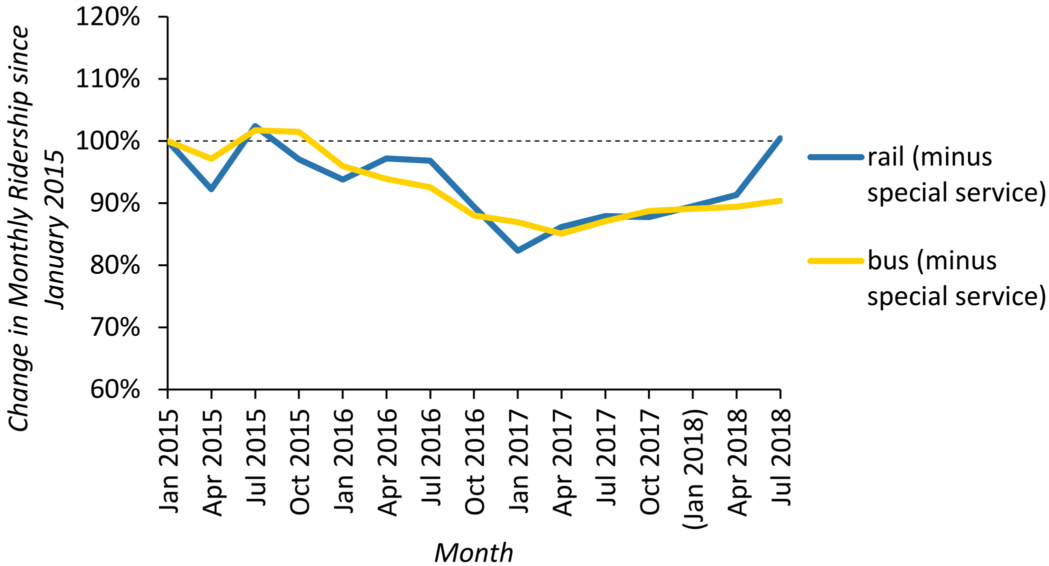


Data source: VTA, 2018

5.3. Modal and Geographic Breakdown of VTA Ridership

As earlier in this report, ridership trends in the Bay Area as a whole vary considerably by mode, with bus ridership consistently falling and rail ridership growing until recently. However, VTA has not seen the same split. As with differences by day of the week, VTA's patronage is down on both of its primary modes. Since January 2015, rail and bus ridership have each fallen around ten percent, with significant month-to-month variability in the former. Removing special service, like extra game-day shuttles, somewhat smooths out these trends and produces the values in Figure 5-5. Ridership on the two modes track nearly perfectly throughout the timeframe of the data. Without BART to prop up the region's rail numbers, rail and bus use have declined similarly on an agency like VTA.

Figure 5-5. Modal Similarities in VTA Ridership Change



Data source: VTA, 2018

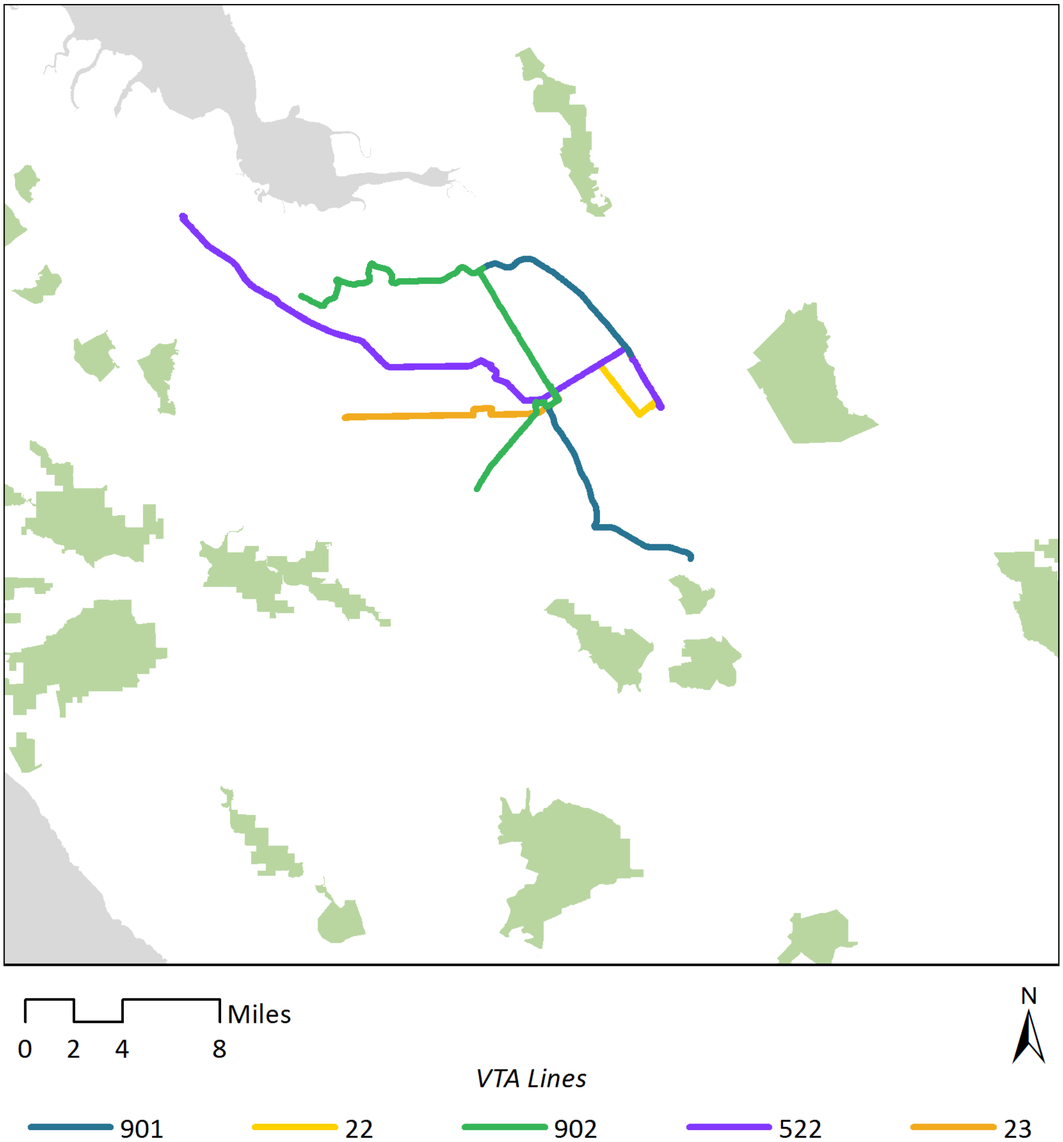
Across bus and rail, VTA ridership is concentrated in a few lines. The top five of VTA's 79 lines in April 2018, listed in Table 5-1, carried 42 percent of the agency's total ridership. Among them are the two main light-rail lines and three buses along major east-west corridors (See Figure 5-6). These lines, however, suffered some of the largest absolute declines between April 2015 and April 2018. Indeed, four of the five lines in Table 5-1 rank in the bottom five by absolute change over that three-year period. Unlike on BART and SFMTA but like AC Transit, VTA's losses come from its most-patronized lines.

Table 5-1. VTA Lines with the Most Boardings, April 2018

LINE	MONTHLY BOARDINGS, APRIL 2018	ABSOLUTE CHANGE IN MONTHLY BOARDINGS, APRIL 2015-APRIL 2018	
901: Alum Rock-Santa Teresa (light rail)	408,178	-42,568	71st out of 72
22 (regular bus)	300,053	-88,336	72nd out of 72
902: Mountain View-Winchester (light rail)	285,021	-17,628	68th out of 72
522 (limited-stop bus)	200,446	+17,766	3rd out of 72
23 (regular bus)	188,990	-31,810	70th out of 72

Data source: VTA, 2018

Figure 5-6. VTA Lines with the Most Boardings, April 2018



Data source: VTA, 2018, 2019b; CaliDetail, n.d.; and Esri, 2010

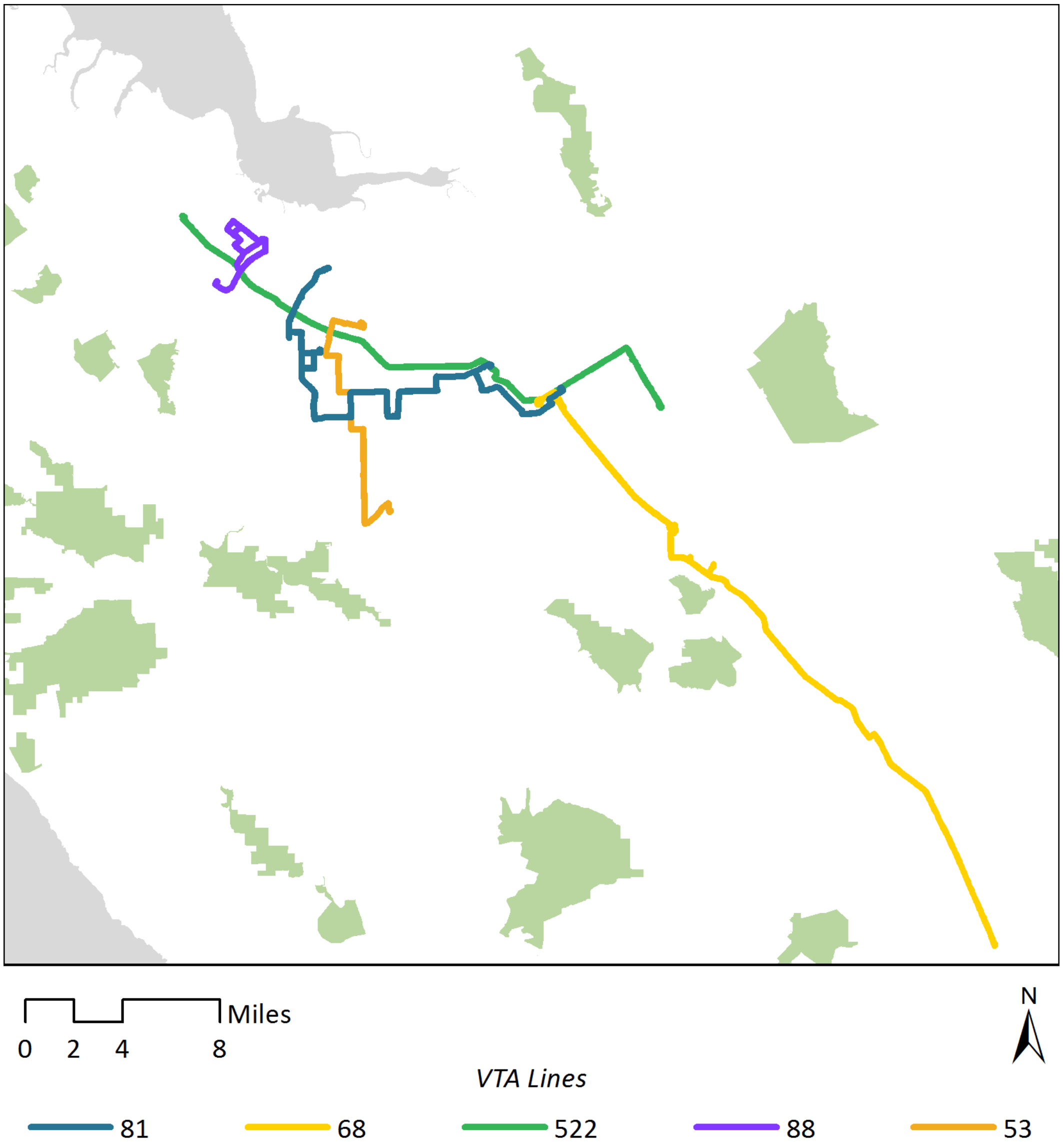
Meanwhile, 38 percent of VTA lines are gaining riders. The top five of these lines, both by absolute numbers and by percentage, lie west of San José, for the most part either long corridors ending in Silicon Valley or shorter local routes within Silicon Valley (See Tables 5-2 and 5-3 and Figures 5-7 and 5-8). Despite the reputation of area tech workers as taking private shuttles over public transportation, the growing number of jobs of all types in Silicon Valley (U.S. Census Bureau, n.d.) may be fueling a rise in transit trips there.

Table 5-2. VTA Lines with the Largest Absolute Gains, April 2015-April 2018

LINE	ABSOLUTE CHANGE IN MONTHLY BOARDINGS, APRIL 2015-APRIL 2018
81 (regular bus)	+27,135
68 (regular bus)	+17,781
522 (limited-stop bus)	+17,766
88 (regular bus)	+8,927
53 (regular bus)	+7,218

Data source: VTA, 2018

Figure 5-7. VTA Lines with the Largest Absolute Gains, April 2015-April 2018



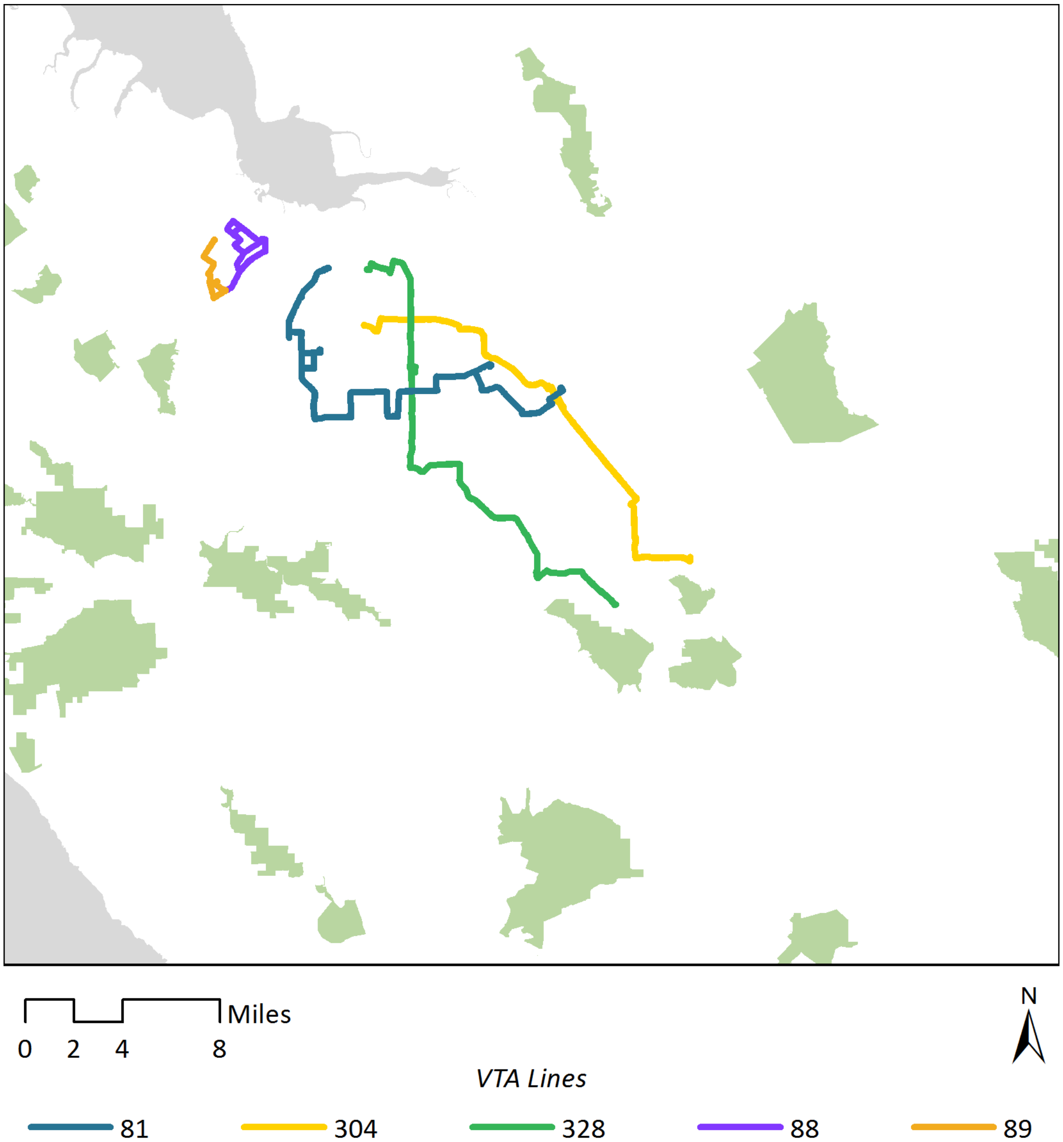
Data source: VTA, 2018, 2019b; CaliDetail, n.d.; and Esri, 2010

Table 5-3. VTA Lines with the Largest Percentage Gains, April 2015-April 2018

LINE	PERCENT CHANGE IN MONTHLY BOARDINGS, APRIL 2015-APRIL 2018
304 (limited-stop bus)	+234%
88 (regular bus)	+231%
328 (limited-stop bus)	+136%
81 (regular bus)	+124%
89 (regular bus)	+92%

Data source: VTA, 2018

Figure 5-8. VTA Lines with the Largest Percentage Gains, April 2015-April 2018



Data source: VTA, 2018, 2019b; CaliDetail, n.d.; and Esri, 2010

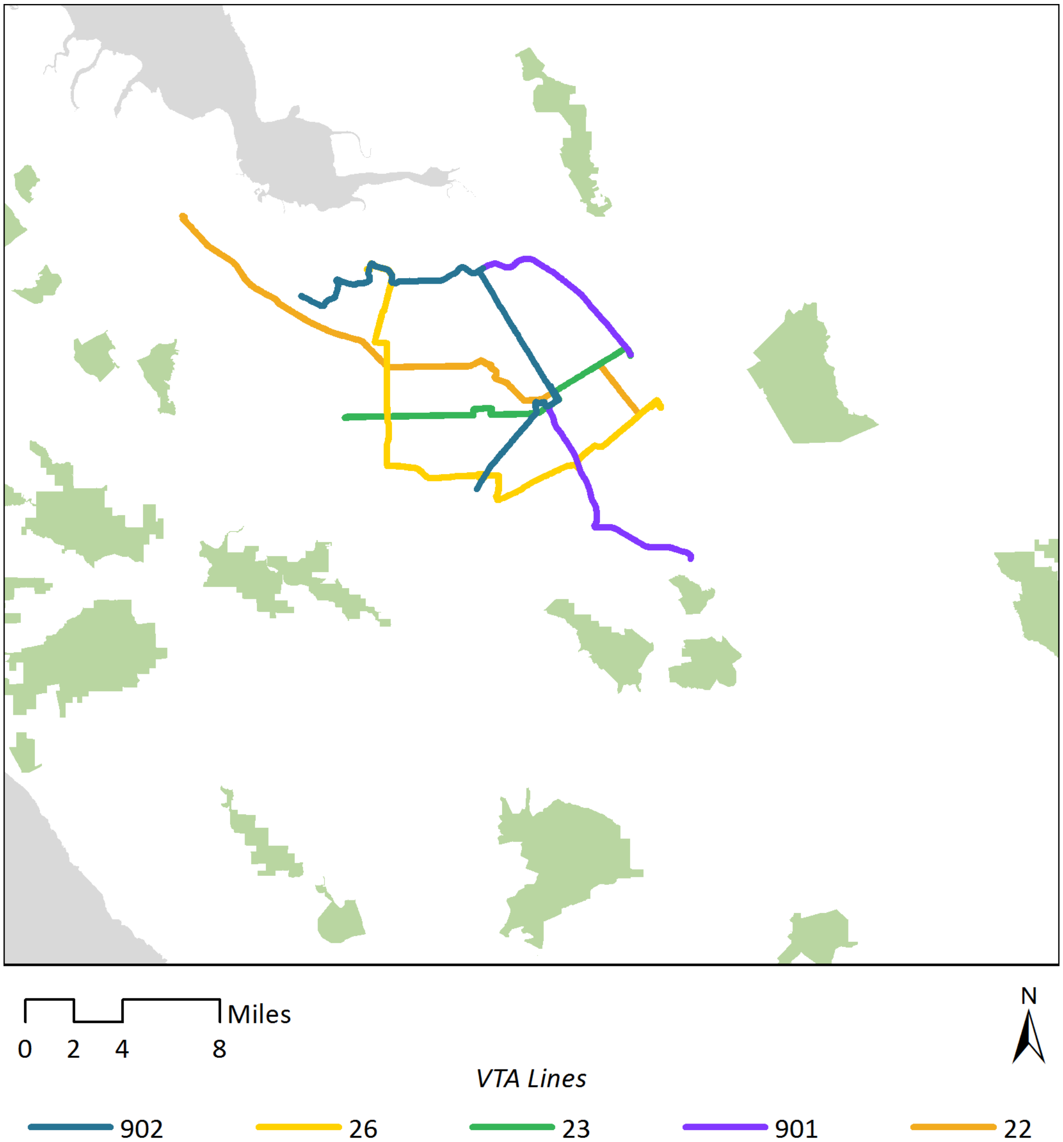
The lines with the greatest absolute losses, on the other hand, are radial light-rail and bus routes extending out from downtown San José (See Table 5-4 and Figure 5-9). As economic and job growth shift, perhaps central San José is no longer as much of an attractor of transit riders it once was. But these routes still carry the bulk of VTA ridership; as mentioned above, these lines mostly overlap with the list of highest-patronage lines (See Table 5-1). The lines with the largest percent change, on the other hand, are a collection of outlying local lines in smaller cities like Campbell and Gilroy (See Table 5-5 and Figure 5-10). These decreases indicate that, despite the losses in high-ridership lines, trips are also down on relatively low-ridership, low-service lines in built environments that are not especially transit-supportive.

Table 5-4. VTA Lines with the Largest Absolute Losses, April 2015-April 2018

LINE	ABSOLUTE CHANGE IN MONTHLY BOARDINGS, APRIL 2015-APRIL 2018
902 (light rail)	-17,628
26 (regular bus)	-23,093
23 (regular bus)	-31,810
901 (light rail)	-42,568
22 (regular bus)	-88,336

Data source: VTA, 2018

Figure 5-9. VTA Lines with the Largest Absolute Losses, April 2015-April 2018



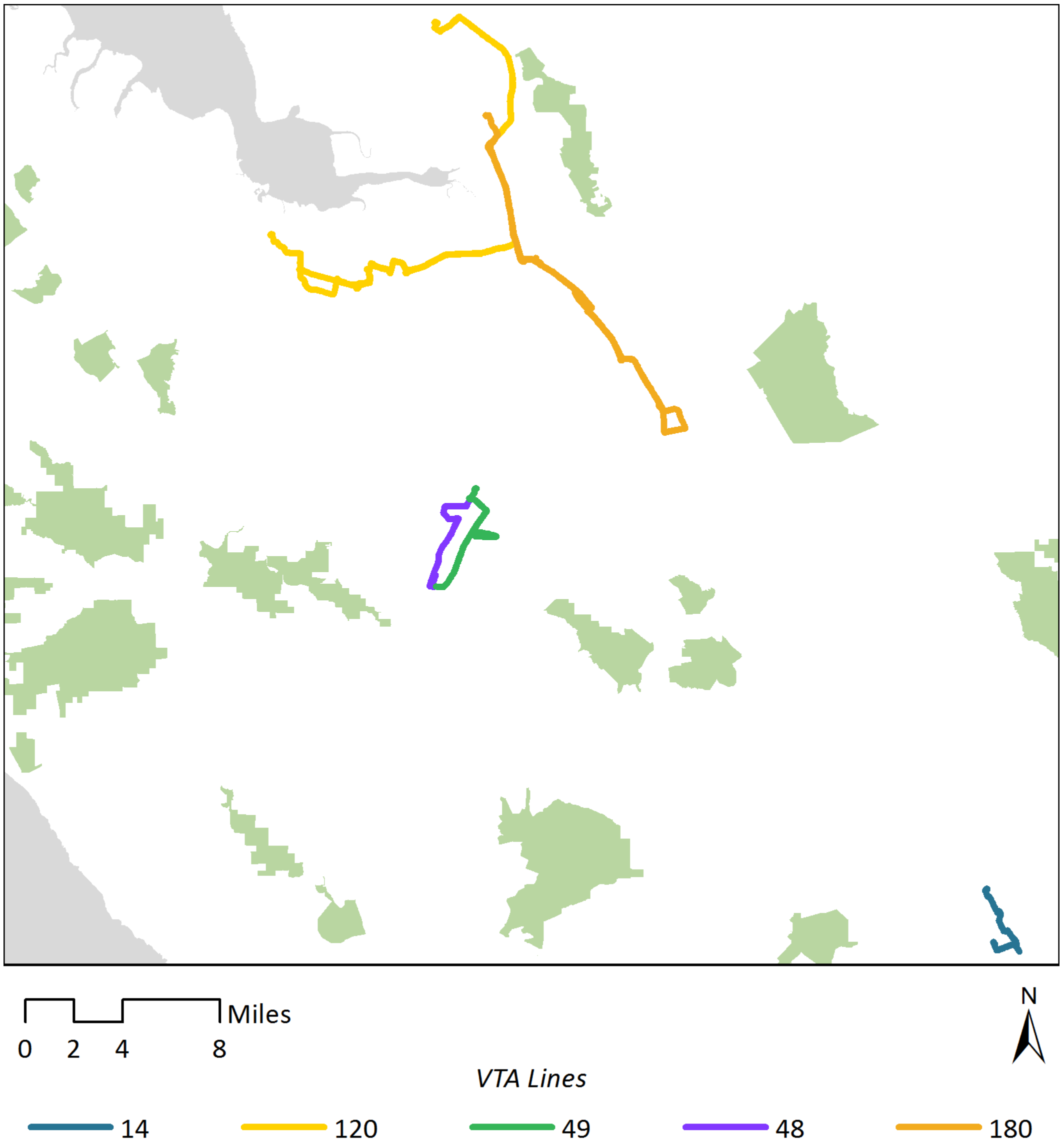
Data source: VTA, 2018, 2019b; CaliDetail, n.d.; and Esri, 2010

Table 5-5. VTA Lines with the Largest Percentage Losses, April 2015-April 2018

LINE	PERCENT CHANGE IN MONTHLY BOARDINGS, APRIL 2015-APRIL 2018
14 (community bus)	-31%
120 (express bus)	-33%
49 (regular bus)	-36%
48 (regular bus)	-39%
180 (express bus)	-62%

Data source: VTA, 2018

Figure 5-10. VTA Lines with the Largest Percentage Losses, April 2015-April 2018



Data source: VTA, 2018, 2019b; CaliDetail, n.d.; and Esri, 2010

6. Caltrain Ridership Trends

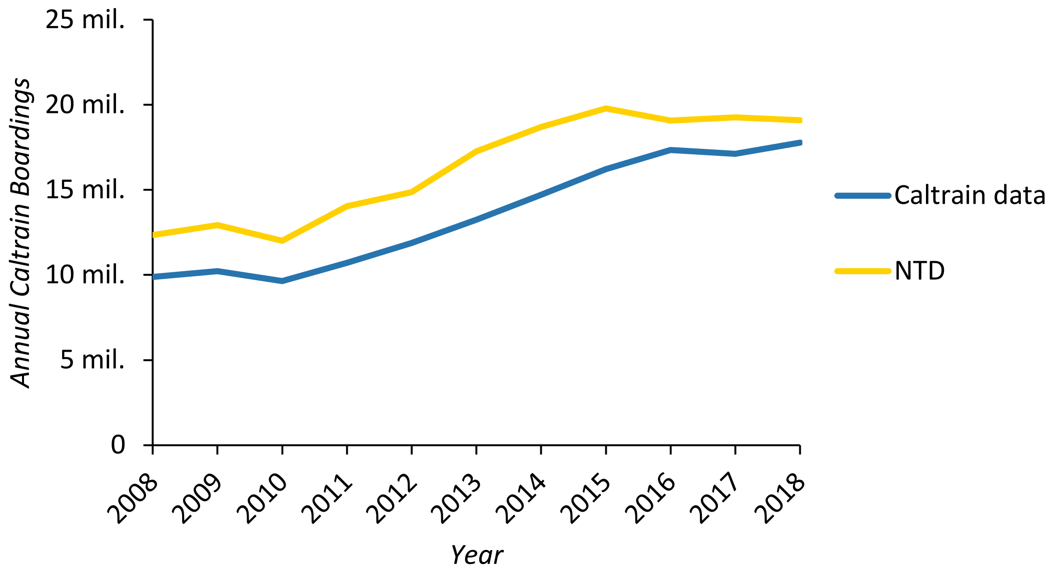
6.1. Overview and Data Validation

If any agency in the Bay Area represents a ridership success story, it is Caltrain. Coming off over a dozen years of nearly uninterrupted ridership growth, Caltrain connects the Bay Area's two largest cities, San Francisco and San José, and its two largest job centers, downtown San Francisco and Silicon Valley. A single north-south train line from San Francisco to Gilroy, Caltrain is a commuter-oriented service that has added service and ridership over the years outside the peak as well.

Unlike other operators, which compile their internal ridership data from year-round, automated sources like bus passenger counters and faregates, Caltrain calculates its ridership data from an annual manual passenger count in January and February (Caltrain, 2018b). Caltrain staff provided us these boarding and alighting counts, with ridership broken down by train, station, and day of the week (Caltrain, 2018a). We matched this dataset with information on the Caltrain website to break down ridership by direction, train type, and time of day as well (Caltrain, 2018c).

While Caltrain's ridership surveys are comparable year-to-year and representative of ridership during the months they are taken, winter ridership may not reflect average ridership across the year. Further, the annual surveys avoid days with special events, allowing the survey to avoid outliers but also making total ridership seem lower that it actually may be (Caltrain, 2018b). Thus, when the daily ridership from the Caltrain surveys is multiplied out to a full year, it sums to less than the annual numbers Caltrain reports to the NTD (derived from different surveys) (See Figure 6-1) (Caltrain, 2018a and FTA, 2019). Nonetheless, the upwards trends are similar across both data sources, meaning that the direction, if not the magnitude, of ridership changes are externally valid. Throughout this section, "annual ridership" refers to the daily ridership from Caltrain's annual surveys multiplied out to a full year, considering the different number of weekdays, weekend days, and holidays each year.

Figure 6-1. Caltrain Annual Ridership: NTD versus Internal Caltrain Data



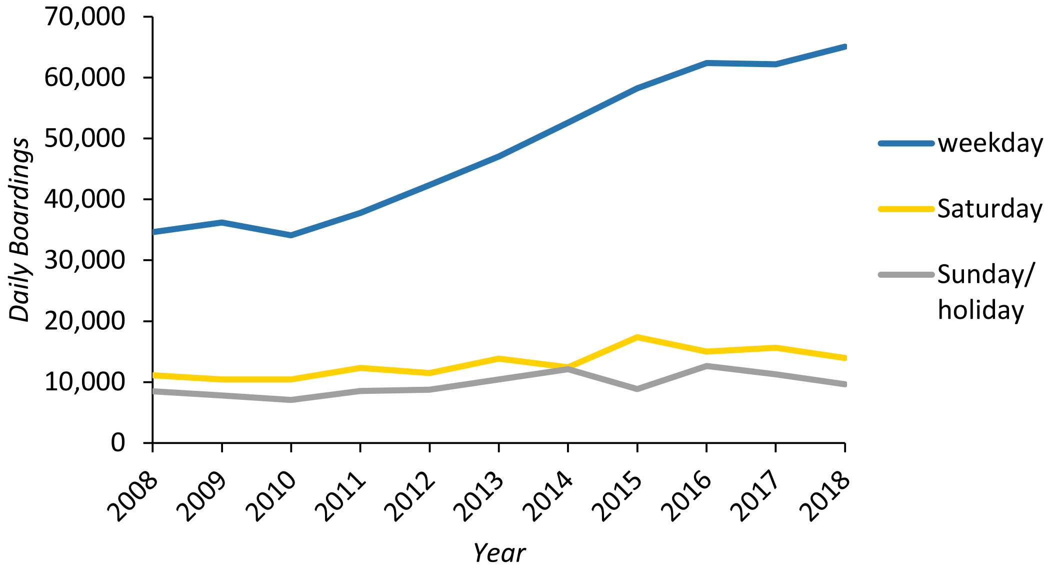
Data source: Caltrain, 2018a and FTA, 2019

Likely buoyed by job growth along its corridor, Caltrain has steadily gained ridership for the past decade (See Figure 6-1). Ridership very slightly dipped in 2010—a far smaller and shorter decline than most operators during the Great Recession—and also hardly fell during the recent regional ridership slump, albeit it has stagnated recently (Caltrain, 2018a and FTA, 2019). Yet while Caltrain's ridership has proven more resilient than any other major Bay Area operators, its peaking problem is arguably more acute than most other major Bay Area operators. Recent ridership growth has come exclusively from trips at peak hours, on weekdays, and on express services, pushing up total patronage as off-peak trip counts fall.

6.2. Temporal Breakdown of Caltrain Ridership

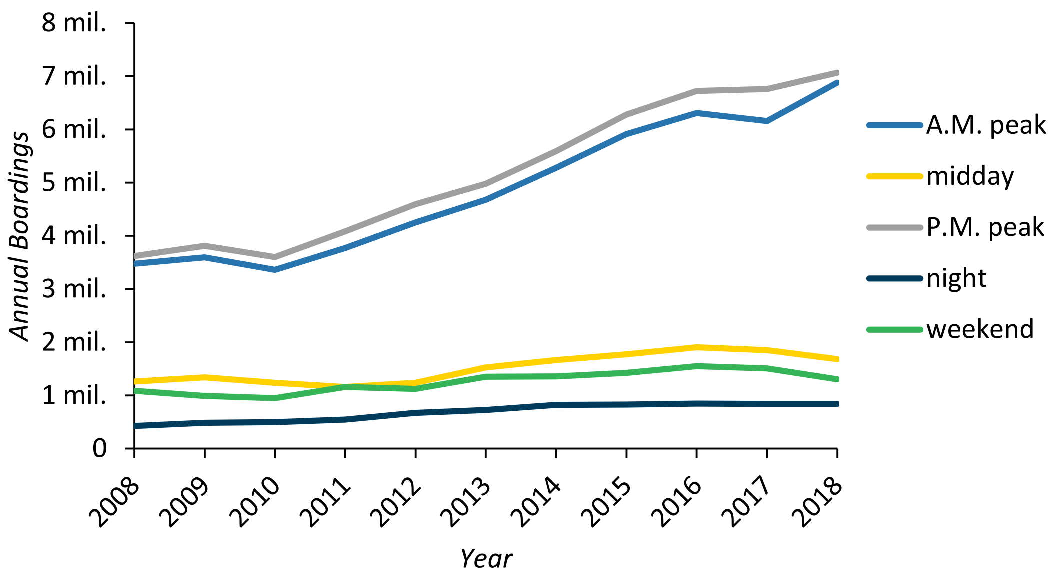
More and more, Caltrain ridership is focused at weekday commute times. For instance, weekday ridership accounts for almost all ridership growth both recently and over the past decade, with Saturday and Sunday/holiday ridership mostly flat or bumpy (See Figure 6-2). The same is true for time of day: patronage growth at the A.M. and P.M. peak, as defined by Caltrain, has risen dramatically since 2010 and made up almost the whole of the agency's overall ridership gains (See Figure 6-3). Since 2016, midday, night, and weekend ridership has fallen, while morning peak patronage dipped and recovered and afternoon peak patronage rose. Caltrain use is increasingly concentrated in the peak.

Figure 6-2. Daily Caltrain Ridership by Weekday



Data source: Caltrain, 2018a

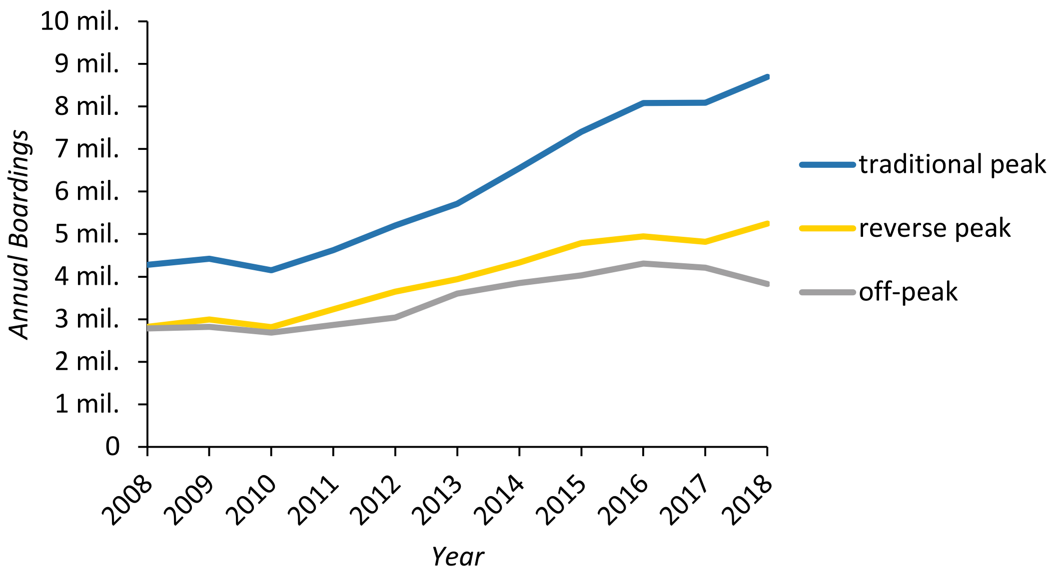
Figure 6-3. Annual Caltrain Ridership by Time of Day



Data source: Caltrain, 2018a

The peak direction of Bay Area travel, though, is changing. Caltrain classifies northbound A.M. commutes and southbound P.M. commutes as the "traditional peak"—travel from homes along the San Francisco Peninsula to jobs in downtown San Francisco and back. But Caltrain also operates many trains in the "reverse peak," southbound A.M. commutes and northbound P.M. commutes—travel from homes in San Francisco to jobs in Silicon Valley and back. The former has grown immensely in the past decade, with just short of half of all annual boardings occurring in the traditional peak. Reverse commutes have also grown, though not to the same extent (See Figure 6-4). In either direction, though, peak ridership trends are up recently, recovering from a recent stumble, while off-peak ridership dropped 11 percent between 2016 and 2018.

Figure 6-4. Annual Caltrain Ridership in Different Peak Directions versus Off-Peak

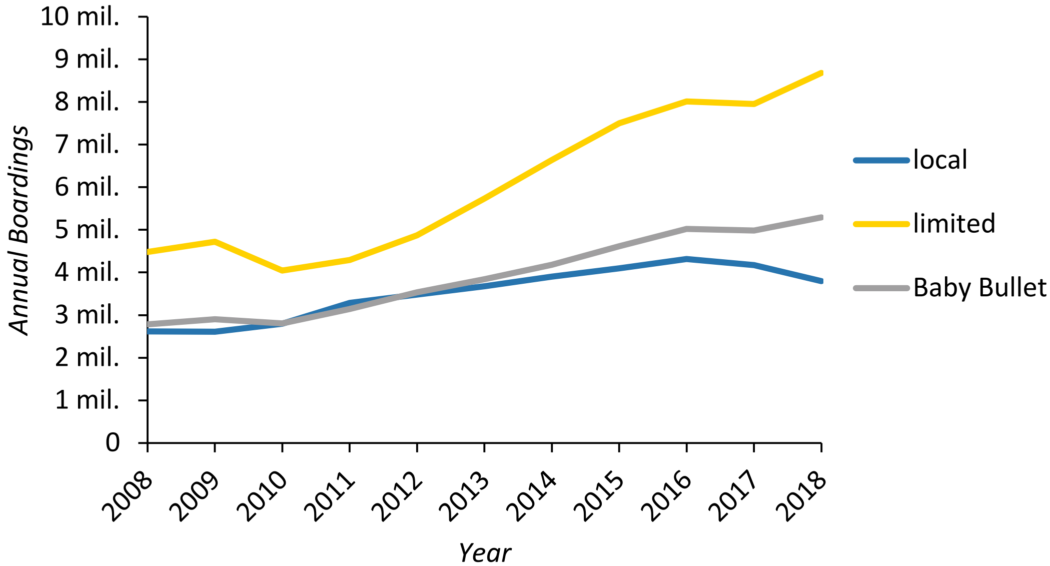


Data source: Caltrain, 2018a

6.3. Geographic and Service Breakdown of Caltrain Ridership

Beyond time of day, Caltrain's ridership is also concentrated at its busiest stations and on its busiest services. Caltrain operates three types of trains: locals that stop at nearly every station, "Baby Bullets" that stop at just a few major stations, and limiteds that either skip some stops throughout the route ("uniform limited" or "unified limited" trains) or operate express for half the route and local the other ("express-local" trains) (Caltrain, 2018b). Together, this last category of limiteds carries an increasing number of riders and an increasing share of Caltrain ridership (just under half in 2018) (See Figure 6-5). Baby Bullet patronage, too, is up, while locals have lost ridership. Though Caltrain has made service changes a few times over the past decade, these small additions and subtractions likely do not explain those larger trends. As Baby Bullets and limiteds are scheduled primarily during peak hours, the same forces driving temporal peaking—potentially job growth—have packed riders onto express services.

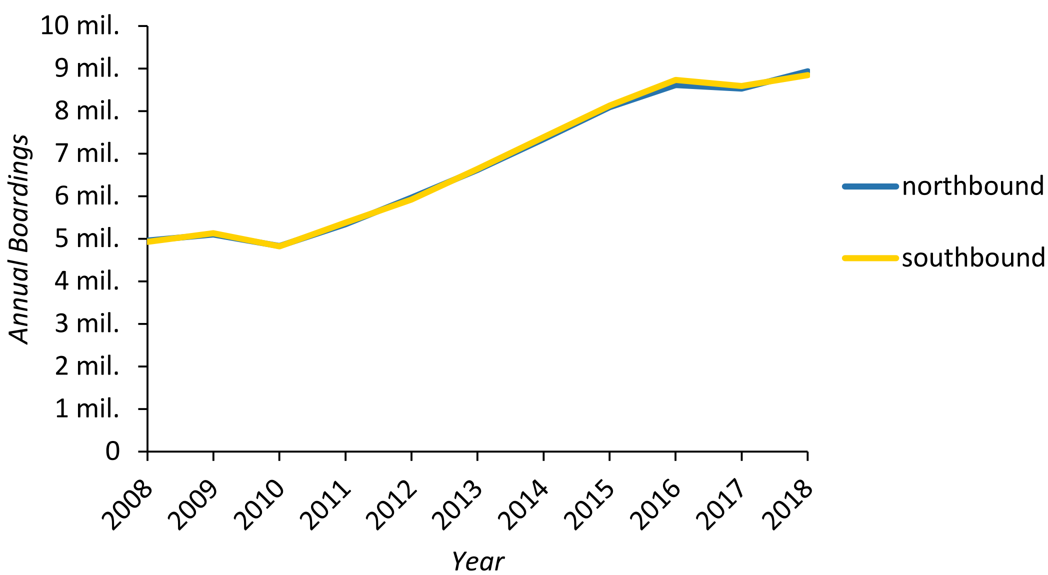
Figure 6-5. Annual Caltrain Ridership by Service Type



Data source: Caltrain, 2018a

While total northbound and southbound ridership have tracked closely (See Figure 6-6), patronage growth at some of its largest stations is outpacing the rest of the system. The top five stations by combined boardings and alightings, shown in Table 6-1 and Figure 6-7, all place in the top ten by ridership growth. The start and end for most trains—4th and King Station in downtown San Francisco and Diridon Station in downtown San José—and three frequent express stops in job-rich Silicon Valley are Caltrain's busiest, and each are some of its fast-growing.

Figure 6-6. Annual Caltrain Ridership by Direction



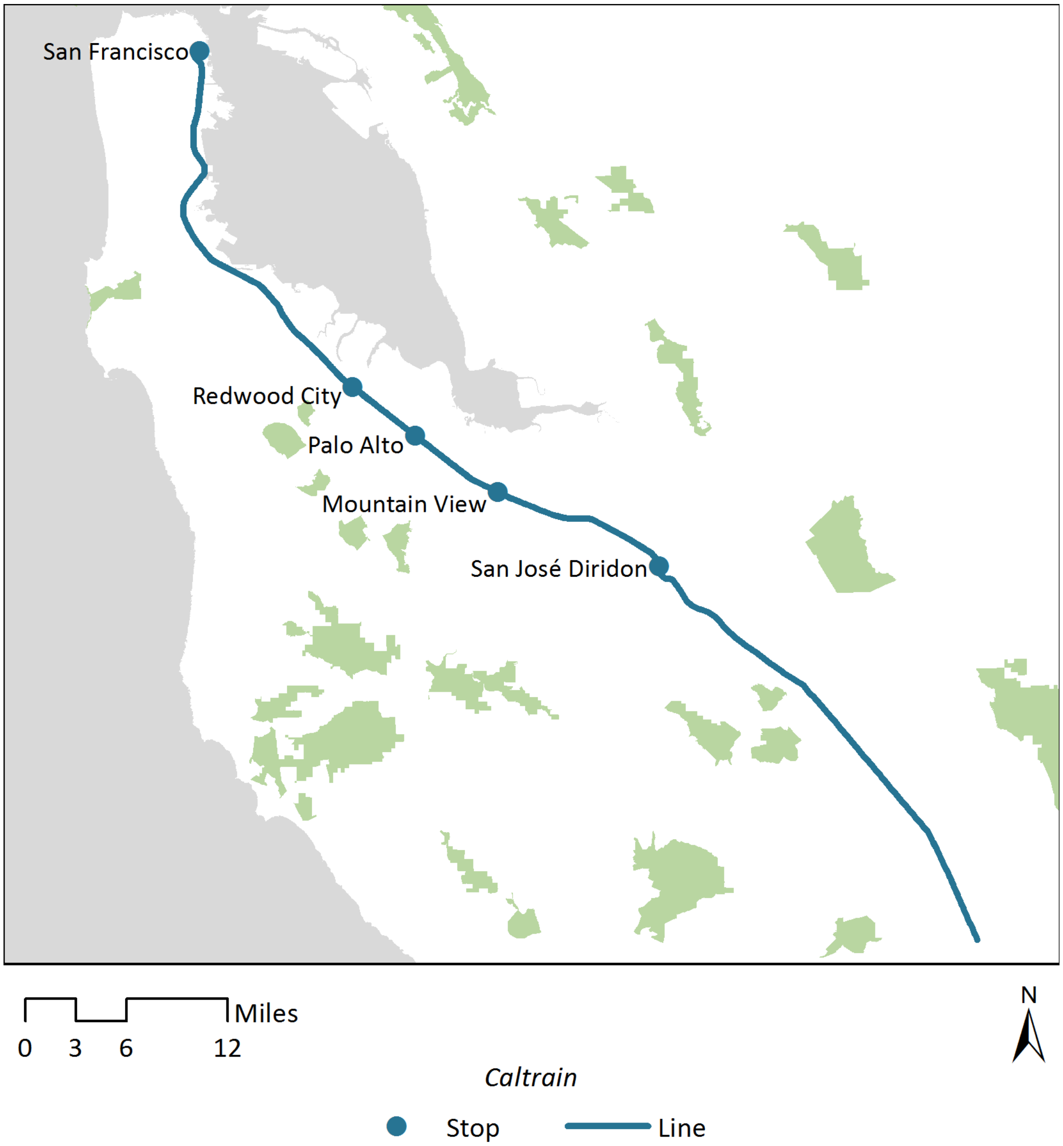
Data source: Caltrain, 2018a

Table 6-1. Caltrain Stations with the Most Combined Boardings and Alightings, 2018

STATION	ANNUAL COMBINED BOARDINGS AND ALIGHTINGS, 2018	ABSOLUTE CHANGE IN ANNUAL COMBINED BOARDINGS AND ALIGHTINGS, 2015-2018	
San Francisco	8,521,949	+886,104	1st out of 31
Palo Alto	4,182,027	+214,444	6th out of 31
San José	2,739,982	+322,835	3rd out of 31
Mountain View	2,582,844	+110,944	8th out of 31
Redwood City	2,231,236	+439,110	2nd out of 31

Data source: Caltrain, 2018a

Figure 6-7. Caltrain Stations with the Most Combined Boardings and Alightings, 2018



Data source: Caltrain, 2018a, 2019; CaliDetail, n.d.; and Esri, 2010

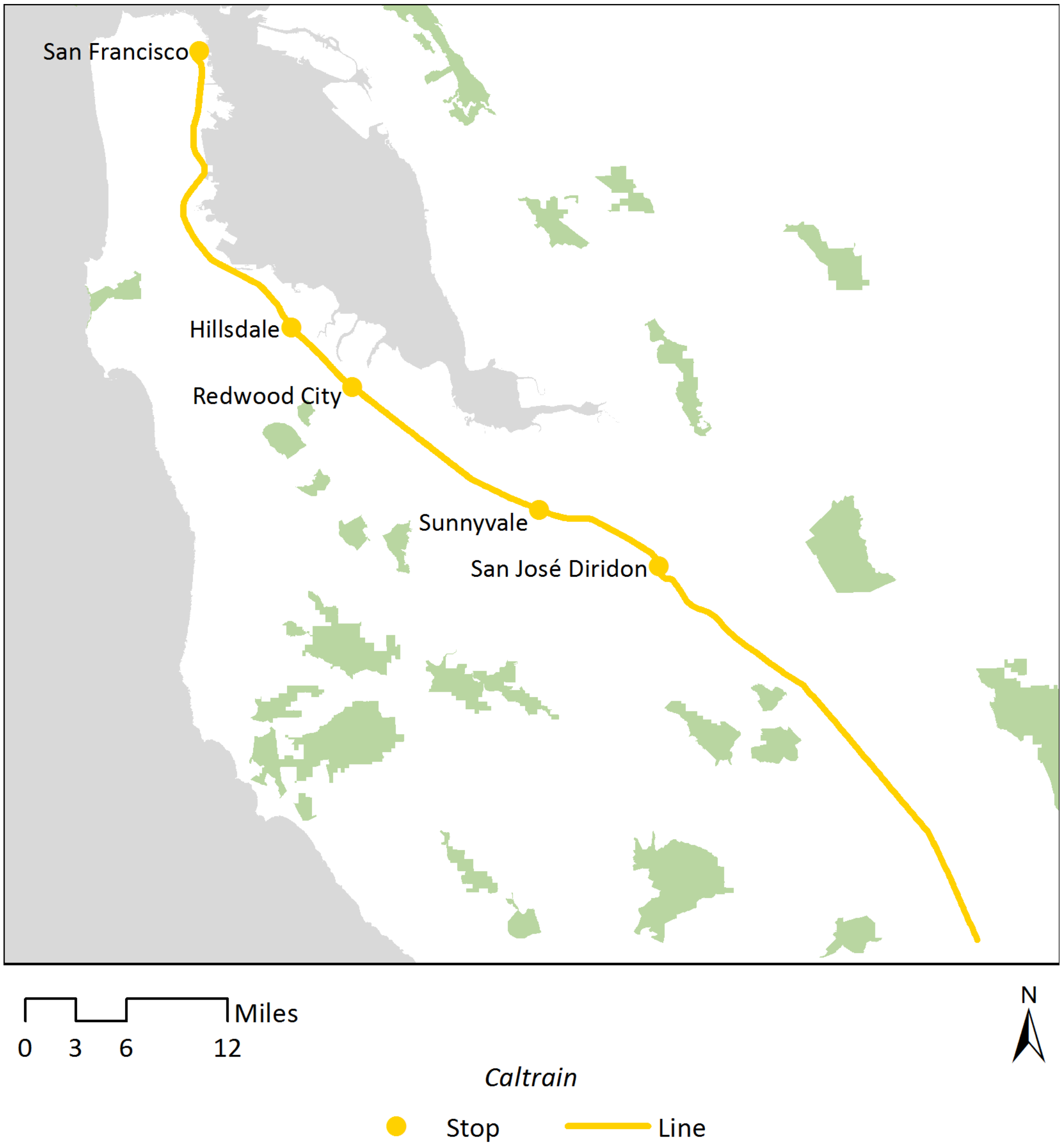
The station with the largest absolute gain in combined boardings and alightings is San Francisco, where all Caltrain trains originate or terminate and where employment has boomed (U.S. Census Bureau, n.d.). Four express stops stretching south to Silicon Valley and San José round out the list (See Table 6-2 and Figure 6-8). Three of the stations with the largest percentage gains, meanwhile, are weekday-only stops on the Caltrain branch south to Gilroy (See Table 6-3 and Figure 6-9).

Table 6-2. Caltrain Stations with the Largest Absolute Gains, 2015-2018

STATION	ABSOLUTE CHANGE IN ANNUAL COMBINED BOARDINGS AND ALIGHTINGS, 2015-2018
San Francisco	+886,104
Redwood City	+439,110
San José	+322,835
Hillsdale	+230,102
Sunnyvale	+220,438

Data source: Caltrain, 2018a

Figure 6-8. Caltrain Stations with the Largest Absolute Gains, 2015-2018



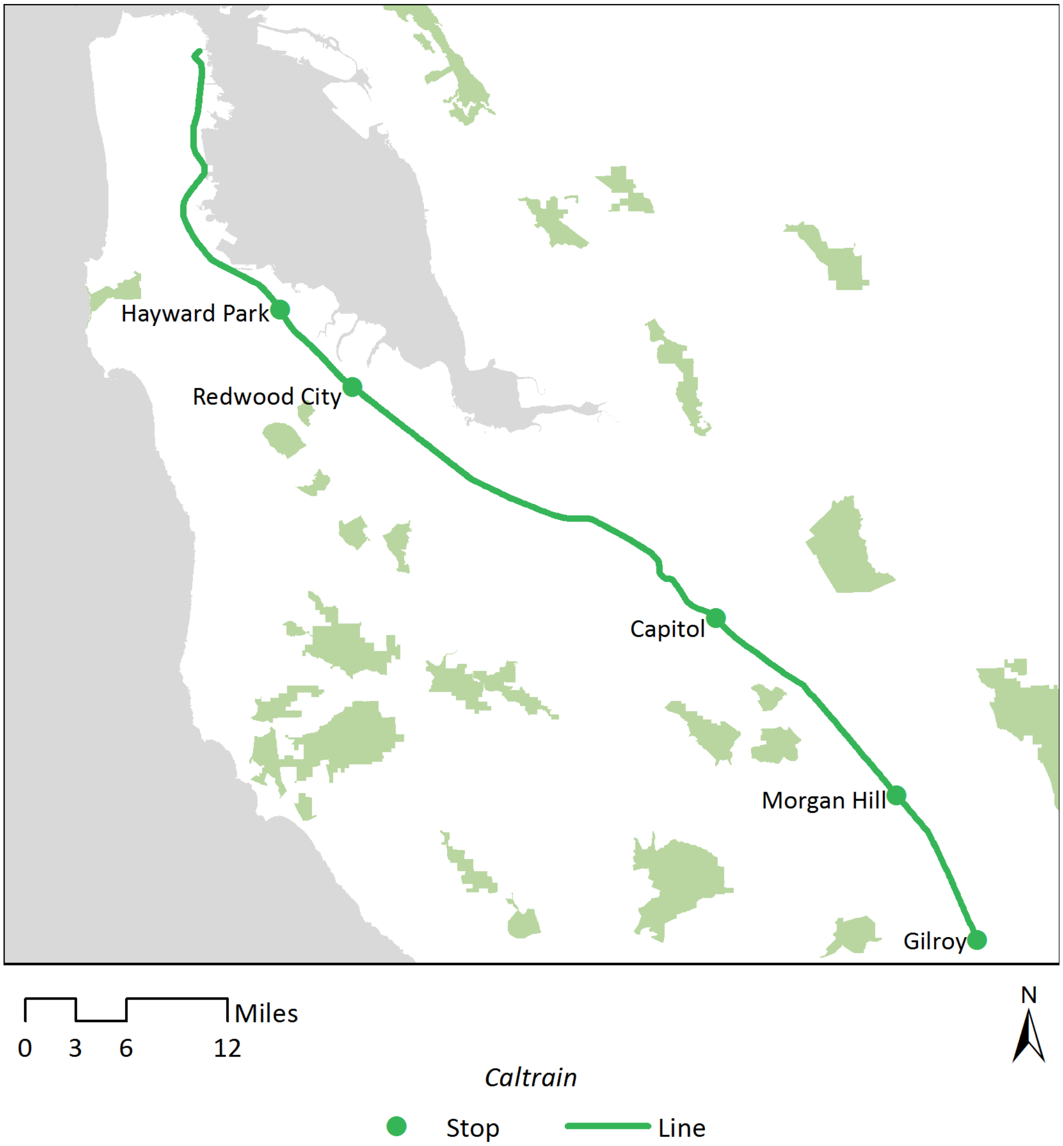
Data source: Caltrain, 2018a, 2019; CaliDetail, n.d.; and Esri, 2010

Table 6-3. Caltrain Stations with the Largest Percentage Gains, 2015-2018

STATION	PERCENT CHANGE IN ANNUAL COMBINED BOARDINGS AND ALIGHTINGS, 2015-2018
Capitol	+89%
Gilroy	+62%
Hayward Park	+39%
Morgan Hill	+35%
Redwood City	+25%

Data source: Caltrain, 2018a

Figure 6-9. Caltrain Stations with the Largest Percentage Gains, 2015-2018



Data source: Caltrain, 2018a, 2019; CaliDetail, n.d.; and Esri, 2010

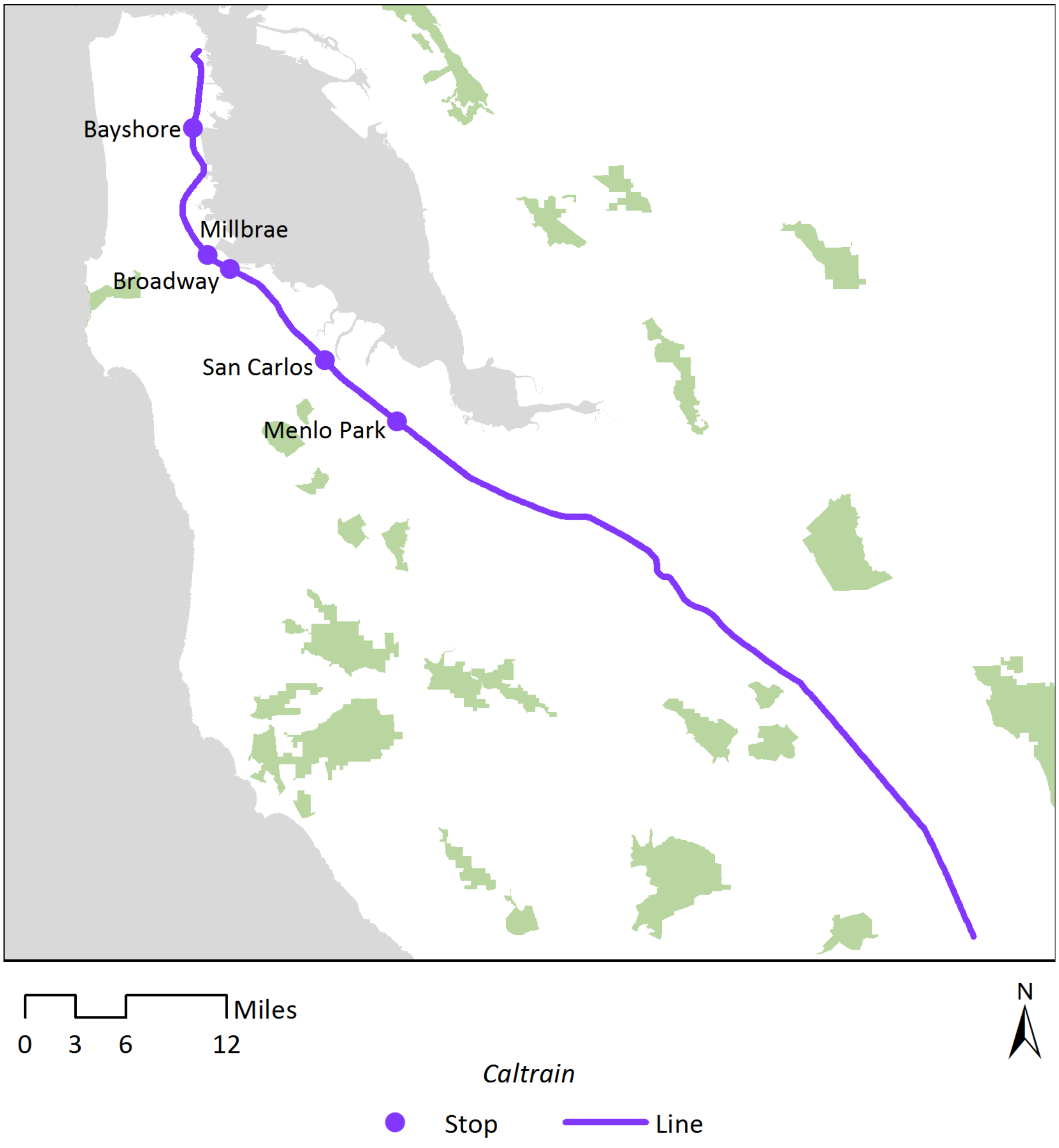
Tables 6-4 and 6-5 and Figures 6-10 and 6-11 detail the stations with the largest absolute and percentage ridership losses, respectively. These lists largely overlap and lie in north and central San Mateo County, between San Francisco and Silicon Valley. What stands out more is how few stations—six of 31—have lost boardings and alightings between 2015 and 2018. The losses at these few stations are also much smaller in magnitude than the gains documented above. Thus, while Caltrain does have a definite peaking problem, it also has shown strong ridership growth, even under relatively adverse conditions.

Table 6-4. Caltrain Stations with the Largest Absolute Losses, 2015-2018

STATION	ABSOLUTE CHANGE IN ANNUAL COMBINED BOARDINGS AND ALIGHTINGS, 2015-2018
Bayshore	-4,117
Broadway	-9,784
Menlo Park	-10,683
Millbrae	-60,285
San Carlos	-80,183

Data source: Caltrain, 2018a

Figure 6-10. Caltrain Stations with the Largest Absolute Losses, 2015-2018



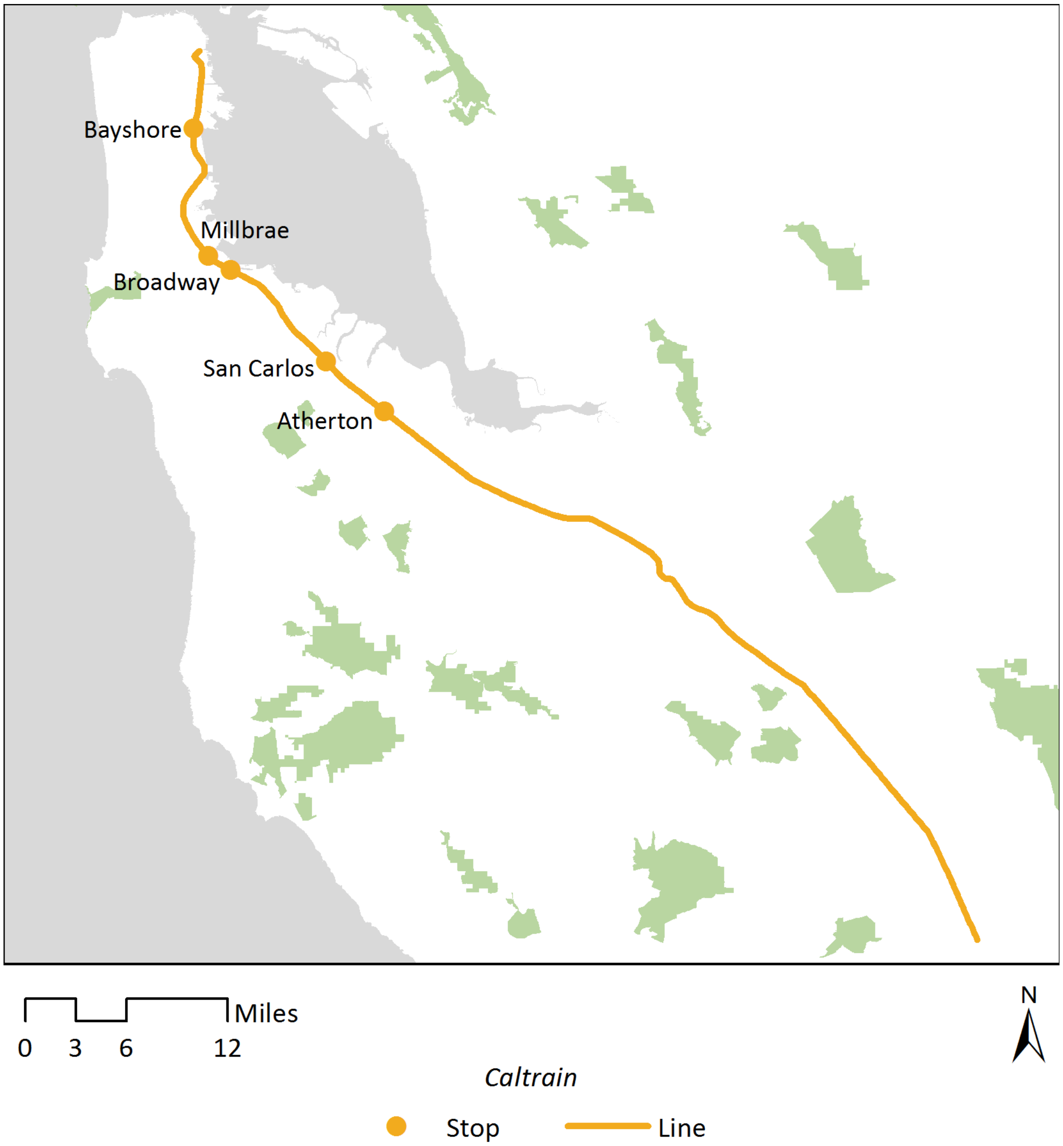
Data source: Caltrain, 2018a, 2019; CaliDetail, n.d.; and Esri, 2010

Table 6-5. Caltrain Stations with the Largest Percentage Losses, 2015-2018

STATION	PERCENT CHANGE IN ANNUAL COMBINED BOARDINGS AND ALIGHTINGS, 2015-2018
Bayshore	-3%
Millbrae	-3%
Atherton	-5%
San Carlos	-10%
Broadway	-41%

Data source: Caltrain, 2018a

Figure 6-11. Caltrain Stations with the Largest Percentage Losses, 2015-2018



Data source: Caltrain, 2018a, 2019; CaliDetail, n.d.; and Esri, 2010

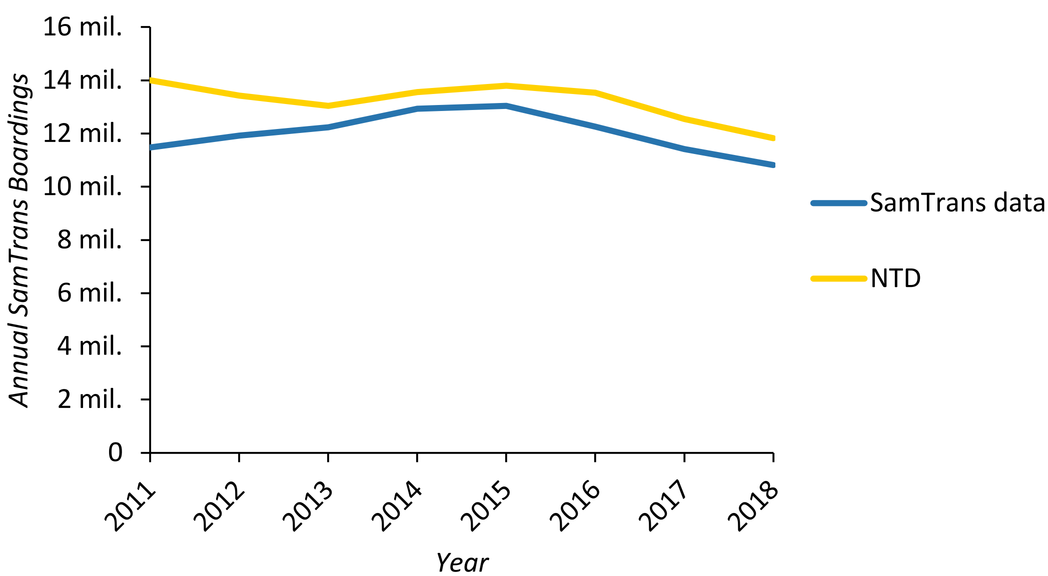
7. SamTrans Ridership Trends

7.1. Overview and Data Validation

Ridership trends on SamTrans in some ways complicate the story we tell of other operators' patronage trends. Operated by the San Mateo County Transit District, SamTrans serves the neck of the San Francisco Peninsula from Daly City to Menlo Park, with some lines to downtown San Francisco and the Pacific Coast. SamTrans' service area has experienced substantial job growth (U.S. Census Bureau, n.d.), which, elsewhere, has sustained peak but not off-peak ridership on BART, GGT, and VTA. But on SamTrans, boardings have fallen across the board. Despite—or perhaps because of—the (peak) gains on Caltrain in the same geographic area, SamTrans's topline ridership count fell by nearly 2 million annual boardings between 2015 and 2018, the fourth-most in the region (FTA, 2019), with SamTrans' densest service areas, most commute-oriented route types, and weekday patronage doing little to prop it up (SamTrans, 2019a). With housing growth failing to keep up with job growth in San Mateo County (U.S. Census Bureau, 2019a, n.d.), the internal ridership data suggest that job growth alone has failed to support ridership on relatively short trips within the service area (SamTrans, 2019a).

We used a dataset provided by SamTrans staff to analyze these trends. The spreadsheet breaks down ridership by day of the week and route, dating back to 2011 (SamTrans, 2019a). We matched these data to information on the SamTrans website on the geographic area and route type of each line (SamTrans, 2019c). Other than in 2011, this internal dataset tracks relatively closely with the ridership numbers in the NTD (See Figure 7-1) (FTA, 2019), allowing for comparison to other agencies' internal data.

Figure 7-1. SamTrans Annual Ridership: NTD versus Internal SamTrans Data

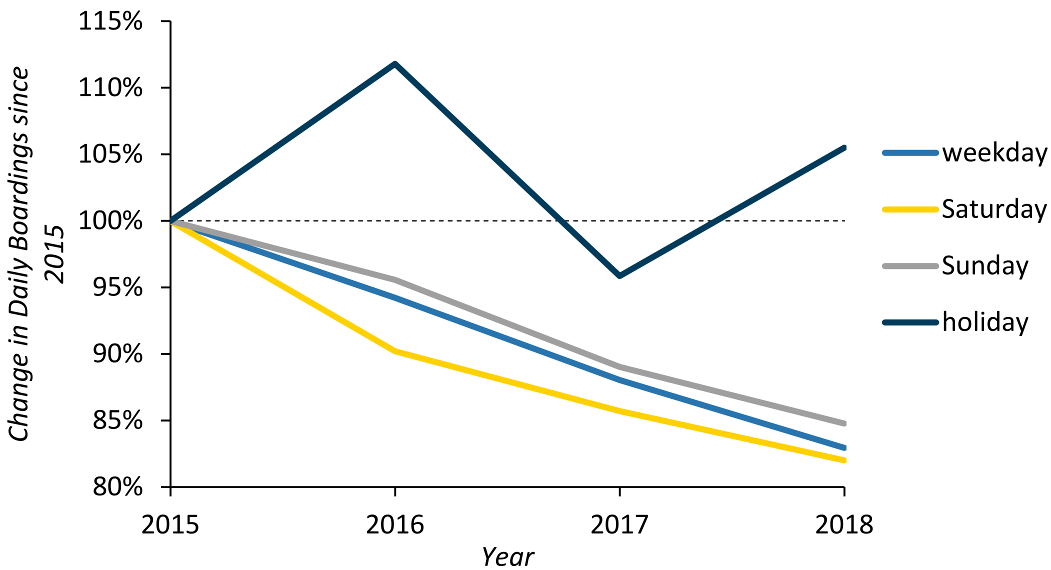


Data source: SamTrans, 2019a and FTA, 2019

7.2. Temporal and Geographic Breakdown of SamTrans Ridership

Across the week and across SamTrans' service area, ridership has fallen relatively evenly. Unlike VTA at one end of San Mateo County, BART at the other, and Caltrain through it, SamTrans' weekday and weekend ridership have dropped at the same rate (See Figure 7-2). Between 2015 and 2018, weekday, Saturday, and Sunday ridership fell 17 percent, 18 percent, and 15 percent, respectively. Despite the job growth at either edge of the county, the weekday transit use on SamTrans has fared no better than weekend ridership.

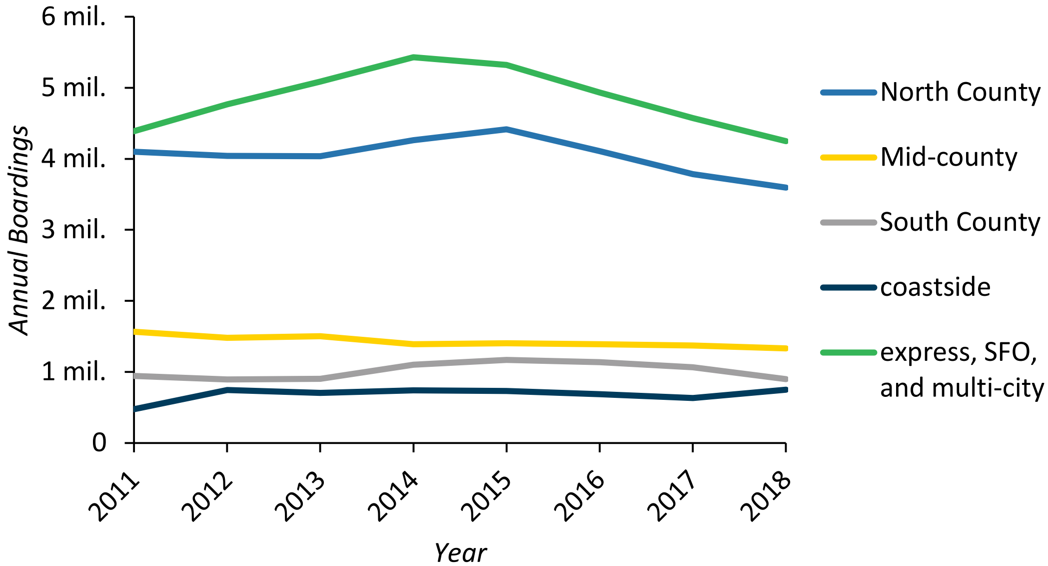
Figure 7-2. Change in Annual SamTrans Ridership by Weekday



Data source: SamTrans, 2019a

SamTrans classifies its lines into five geographic areas: the North County between San Francisco and Burlingame, the Mid-county between San Mateo and Redwood City, the South County between Atherton and Palo Alto, the coastside between Pacifica and Half Moon Bay, and a category of routes that span multiple areas. Since a peak in 2014 or 2015, each of these areas except the relatively low-ridership coastside has seen declining ridership (See Figure 7-3). The busiest of these regions, the North County and multi-city routes, have lost many boardings, but smaller areas like the South County have also fallen. The Mid-county has stayed flat, but overall, SamTrans declines are spread across the county.

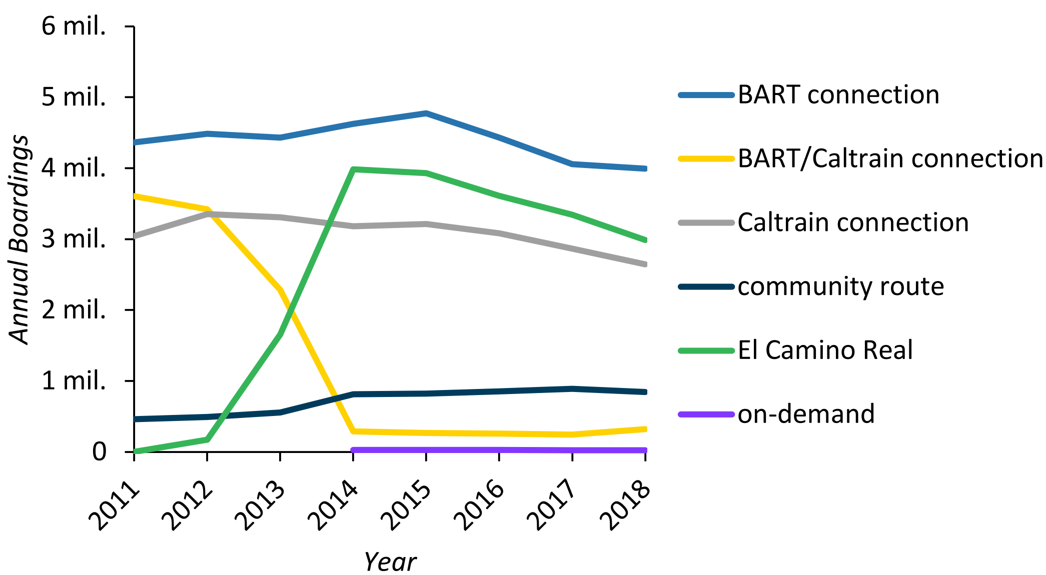
Figure 7-3. Change in Annual SamTrans Ridership by Geographic Area



Data source: SamTrans, 2019a

The same across-the-board declines apply by route type. SamTrans' three major route classifications—BART connections, Caltrain connections, and routes along El Camino Real—have each lost ridership since 2014 (See Figure 7-4). Other than a service reallocation from BART/Caltrain connection lines to El Camino Real lines between 2012 and 2014, the trendlines for each major route type trend down. Community routes—local lines often serving schools—have bucked this trend, with slight year-over-year growth since 2011. Unlike other major operators, the less-commute-oriented lines have retained or gained ridership.

Figure 7-4. Change in Annual SamTrans Ridership by Route Type



Data source: SamTrans, 2019a

7.3. Breakdown by Line

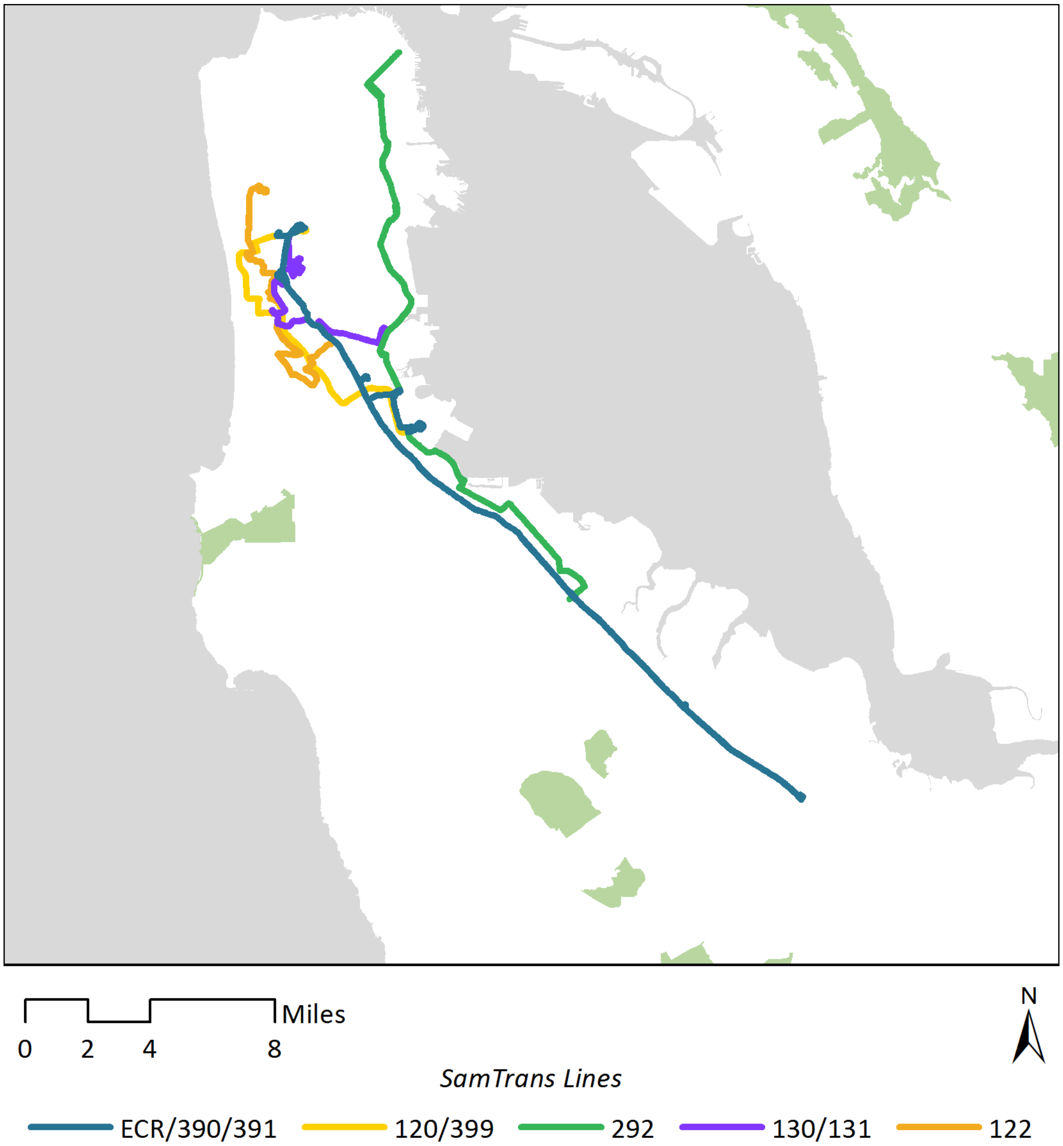
Not only is peak SamTrans ridership falling similarly to its off-peak ridership, but its largest lines are actually faring worse than its smaller ones. Of the five highest-ridership lines in the system (See Table 7-1 and Figure 7-5), most major north-south routes, all lost ridership between 2015 and 2018. Four of the five busiest lines make up four of the five lines with the greatest ridership losses. Like on VTA but unlike on other major agencies, the largest lines have lost the most ridership.

Table 7-1. SamTrans Lines with the Most Boardings, 2018

LINE	ANNUAL BOARDINGS, 2018	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, 2015-2018	
ECR/390/391 (El Camino Real)	2,897,031	-1,033,584	63rd out of 63
120/399 (BART connection)	1,367,556	-305,454	62nd out of 63
292 (Caltrain connection)	901,232	-176,804	59th out of 63
130/131 (BART connection)	737,676	-6,324	41st out of 63
122 (BART connection)	589,567	-265,899	61st out of 63

Data source: SamTrans, 2019a

Figure 7-5. SamTrans Lines with the Most Boardings, 2018



Data source: SamTrans, 2019a, 2019b; CaliDetail, n.d.; and Esri, 2010

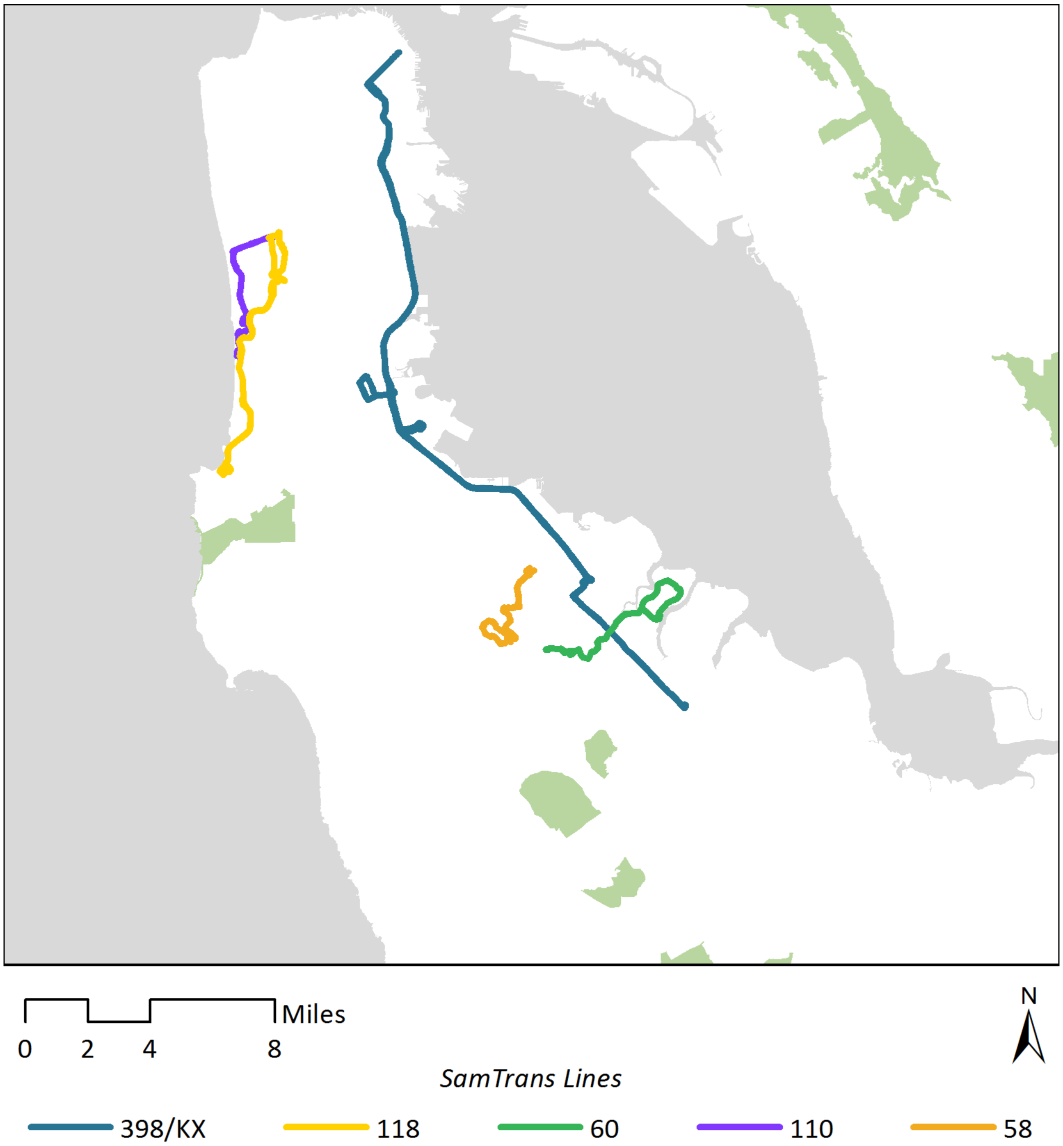
The line that has gained the most boardings recently is Line 398, the express route from central San Mateo County into downtown San Francisco. Like on BART, SamTrans' commute-oriented service into job-rich downtown San Francisco is booming. The other large gainers are two lines along the Pacific Coast and two community routes near San Mateo (See Table 7-2 and Figure 7-6). With some overlap, the lines with the greatest relative gains are mostly community routes as well (See Table 7-3 and Figure 7-7).

Table 7-2. SamTrans Lines with the Largest Absolute Gains, 2015-2018

LINE	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, 2015-2018
398/KX (BART/Caltrain connection)	+38,520
118 (BART connection)	+25,758
60 (community route)	+16,030
11 (community route)	+12,086
58 (community route)	+9,768

Data source: SamTrans, 2019a

Figure 7-6. SamTrans Lines with the Largest Absolute Gains, 2015-2018



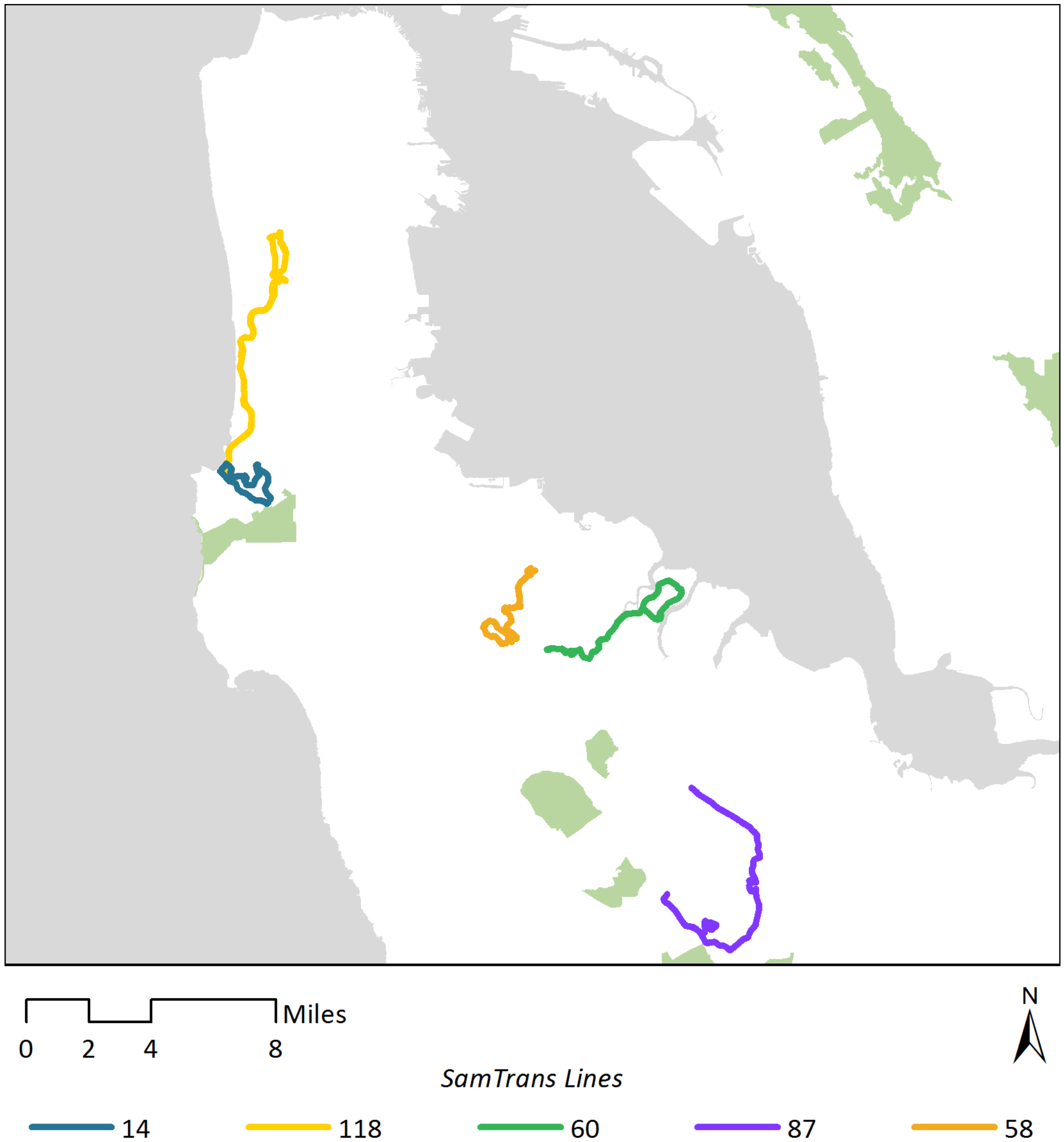
Data source: SamTrans, 2019a, 2019b; CaliDetail, n.d.; and Esri, 2010

Table 7-3. SamTrans Lines with the Largest Percentage Gains, 2015-2018

LINE	PERCENT CHANGE IN ANNUAL BOARDINGS, 2015-2018
118 (BART connection)	+95%
58 (community route)	+64%
14 (community route)	+31%
60 (community route)	+27%
87 (community route)	+26%

Data source: SamTrans, 2019a

Figure 7-7. SamTrans Lines with the Largest Percentage Gains, 2015-2018



Data source: SamTrans, 2019a, 2019b; CaliDetail, n.d.; and Esri, 2010

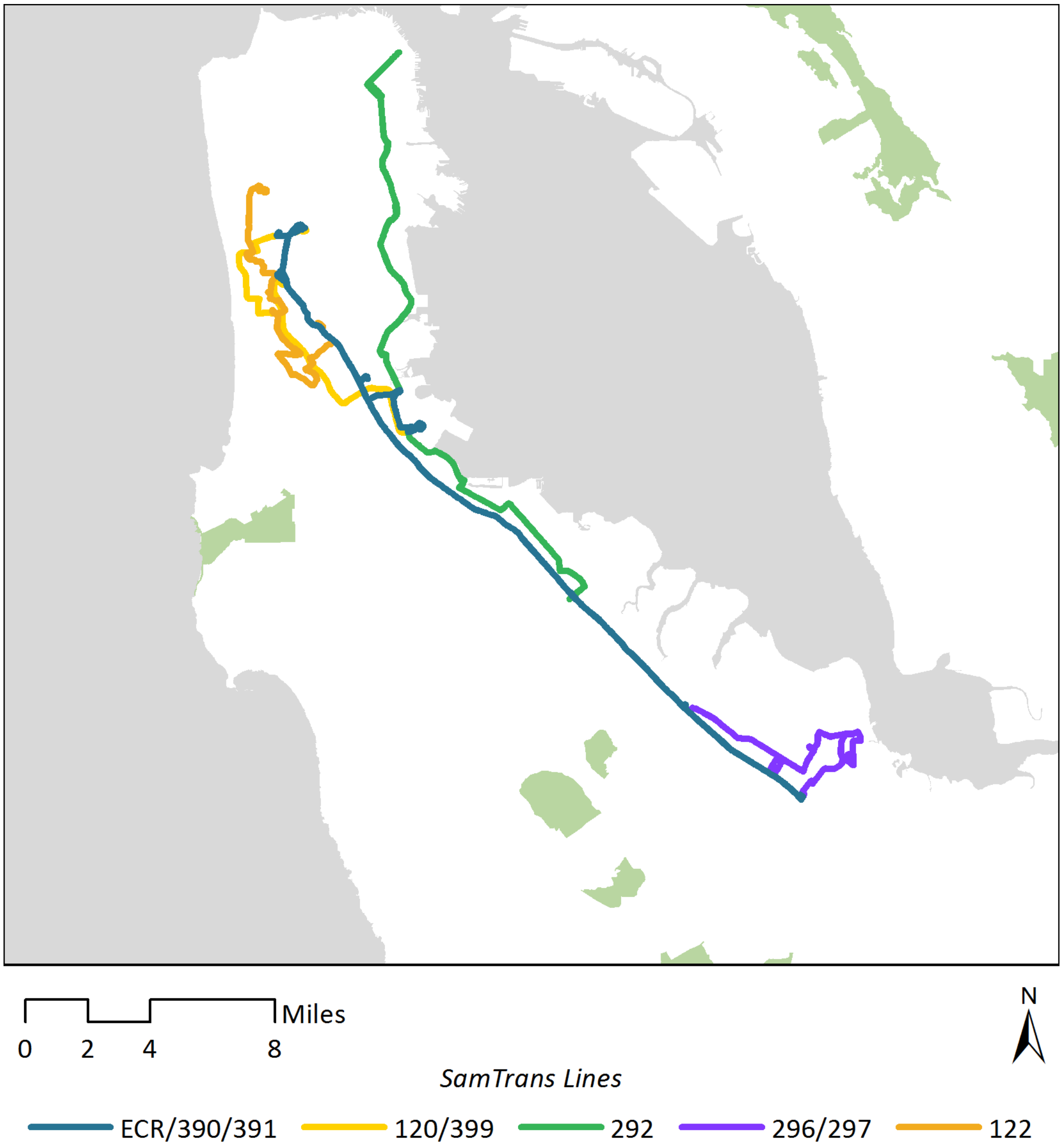
As mentioned above, the lines with the most significant losses are SamTrans' largest lines (See Table 7-4 and Figure 7-8). Among these lines is 292, which operates local service along much of the same corridor as the ridership-gaining 398. Peak-period riders into and out of downtown San Francisco may be shifting away from Line 292 onto Line 398, Caltrain, or other modes. Other major north-south lines have lost much of their patronage, including SamTrans' flagship ECR line along El Camino Real. The lines with the greatest relative losses, meanwhile, are a smattering of community routes, four of which are short lines in the south of the county (See Table 7-5 and Figure 7-9).

Table 7-4. SamTrans Lines with the Largest Absolute Losses, 2015-2018

LINE	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, 2015-2018
292 (Caltrain connection)	-176,804
296/297 (Caltrain connection)	-182,076
122 (BART connection)	-265,899
120/399 (BART connection)	-305,454
ECR/390/391 (El Camino Real)	-1,033,584

Data source: SamTrans, 2019a

Figure 7-8. SamTrans Lines with the Largest Absolute Losses, 2015-2018



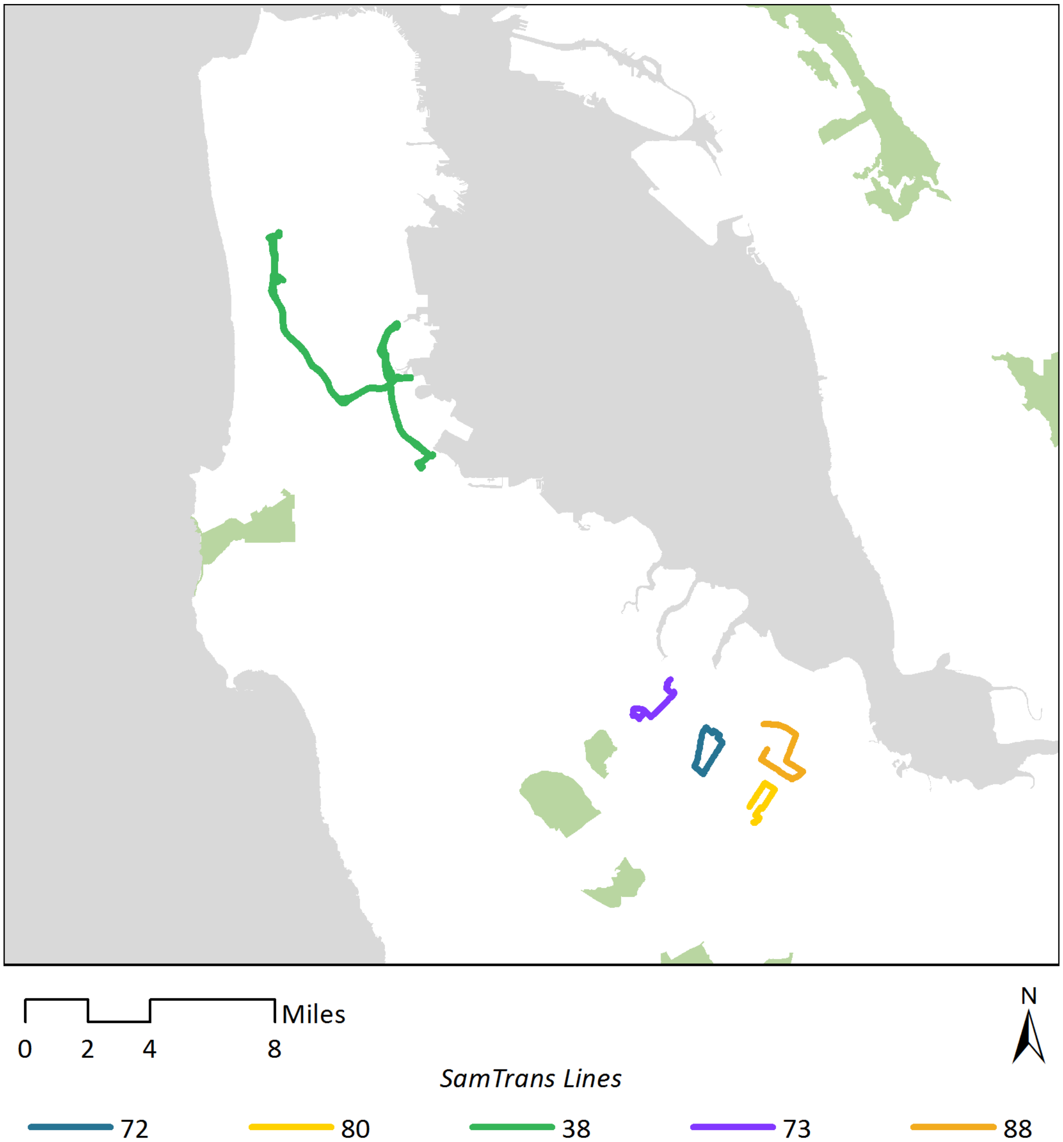
Data source: SamTrans, 2019a, 2019b; CaliDetail, n.d.; and Esri, 2010

Table 7-5. SamTrans Lines with the Largest Percentage Losses, 2015-2018

LINE	PERCENT CHANGE IN ANNUAL BOARDINGS, 2015-2018
72 (community route)	-35%
80 (community route)	-36%
38 (community route)	-42%
73 (community route)	-42%
88 (community route)	-65%

Data source: SamTrans, 2019a

Figure 7-9. SamTrans Lines with the Largest Percentage Losses, 2015-2018



Data source: SamTrans, 2019a, 2019b; CaliDetail, n.d.; and Esri, 2010

8. GGT Ridership Trends

8.1. Overview and Data Validation

Like BART and Caltrain, Golden Gate Transit's off-peak ridership trends have diverged starkly from its peak trends, especially by time of day, day of the week, and mode. But unlike those agencies, GGT's overall patronage has dropped as its peaking problems have sharpened. Between 2015 and 2018, the agency lost 6.3 percent of its annual boardings, the third-largest relative losses among the agencies profiled here (FTA, 2019). Most of these declines have come at off-peak hours and on buses. Yet, while GGT faces the same employment-driven peaking pressures as other large Bay Area operators, wildfires, service reclassifications, and competing transit options offer explanations for these trends unique to GGT.

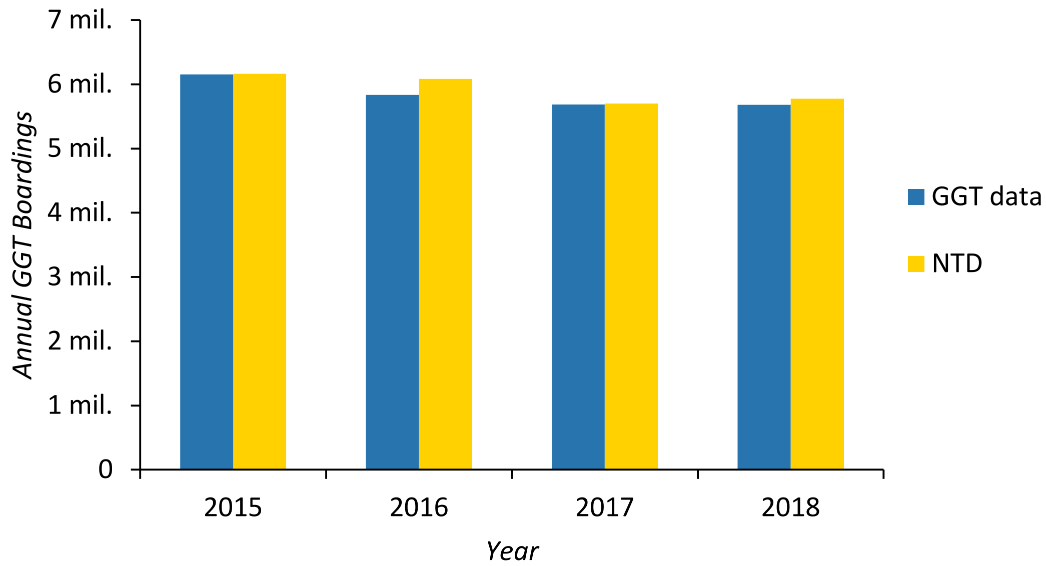
Operated by the Golden Gate Bridge, Highway, and Transportation District (GGBHTD), GGT runs both buses and ferries along the US-101 corridor north from San Francisco into the suburban and exurban North Bay counties of Marin and Sonoma. Primarily a commuter service into and out of San Francisco, GGT serves many intracity trips, with smaller agencies like Petaluma Transit and Marin Transit[14] carrying shorter trips (GGBHTD, 2018 and FTA, 2019).

Over the past five years, Golden Gate Transit has faced circumstances that both complicate apples-to-apples comparisons with other operators and offer explanations for its patronage losses not shared by them. In 2017, the Tubbs Fire swept through the northern part of GGT's service area. In the short term, the wildfire disrupted GGT's service (KTVU Fox 2, 2017); in the longer term, it displaced area residents, perhaps especially lower-income, high-propensity transit riders (Downing, 2020). While too recent to see its effects in the data, the 2019 Kincade Fire may have similar effects as well (San Francisco Chronicle, 2020). In August 2017, the Sonoma-Marin Area Rail Transit (SMART) train opened along GGT's major US-101 corridor (SMART, 2017). Riders along that corridor are already likely switching to SMART, given its speed and ability to avoid traffic that can snarl buses. However, total GGT ridership fell in the four quarters preceding SMART's opening, compared to the year prior, yet rose in the four quarters after (GGBHTD, 2019b). SMART's effects on GGT therefore appear limited to a few parallel lines. Finally, GGT has undergone two major service changes during the study period. In Fiscal Year 2014-2015, Marin Transit began reporting a number of lines to the NTD that were previously counted under GGT (Downing, 2020). And in 2017, GGT took over operations of the major Tiburon-San Francisco ferry route from a private operator (Clemens, 2017). Both changes mean that GGT's topline ridership number actually measures a substantively different set of routes now than it did half a decade ago.

Throughout all this, GGT has shed much of its off-peak ridership. To investigate this and other trends, we received a time-series spreadsheet of trip counts, broken down by route, time of day and date, from staff at the district (GGBHTD, 2019b). We matched these data to information on the district's website, adding mode and route type information (GGBHTD, 2018). These figures match reasonably well with GGT's numbers submitted to the NTD (See Figure 8-1) (FTA, 2019).

Figure 8-1. GGT Annual Ridership: NTD versus Internal GGT Data

14. Golden Gate Transit in fact operates some Marin Transit routes under a purchased transportation contract (GGBHTD, 2018), but these routes count towards Marin Transit in the NTD (FTA, 2019).

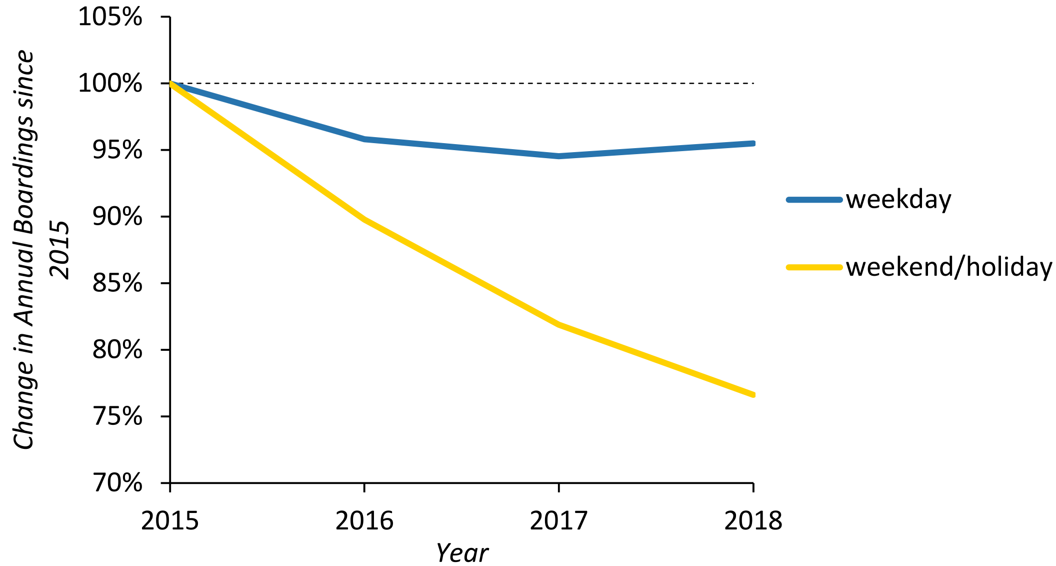


Data source: GGBHTD, 2019b and FTA, 2019

8.2. Temporal Breakdown of GGT Ridership

Peak-hour and weekday Golden Gate Transit patronage has held relatively steady since the region's overall ridership began falling, while off-peak and weekend transit use has dropped substantially. By day of the week, this disjuncture is stark and widening (See Figure 8-2). Weekday ridership only slipped five percent between 2015 and 2018, with a slight increase in the last of these years. But weekend ridership has cratered, falling 23 percent over the same period. While GGT has always been a commuter-oriented service, it is even more dependent on weekday ridership as of late.

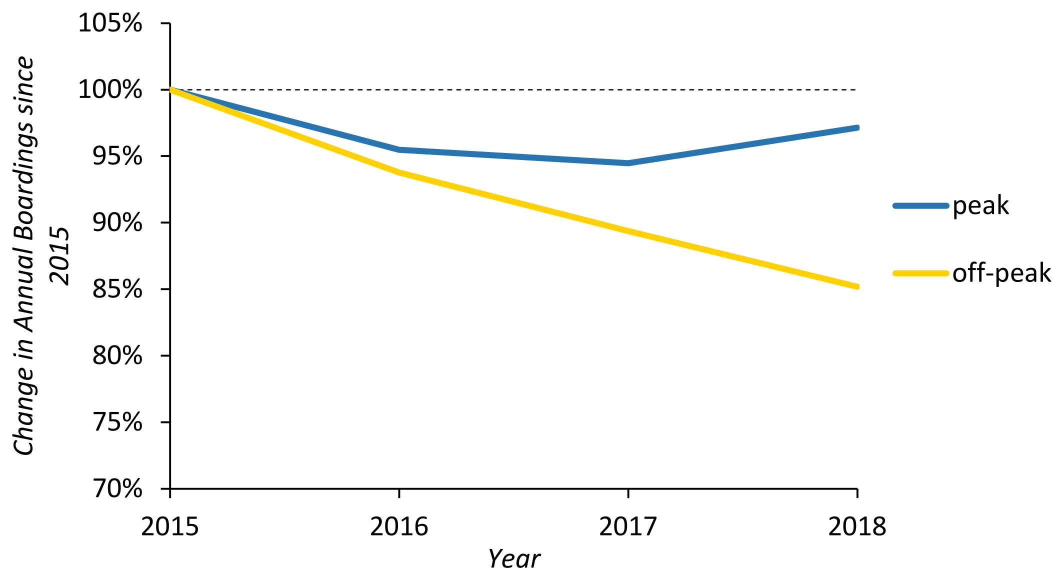
Figure 8-2. Change in Annual GGT Ridership by Weekday



Data source: GGBHTD, 2019b

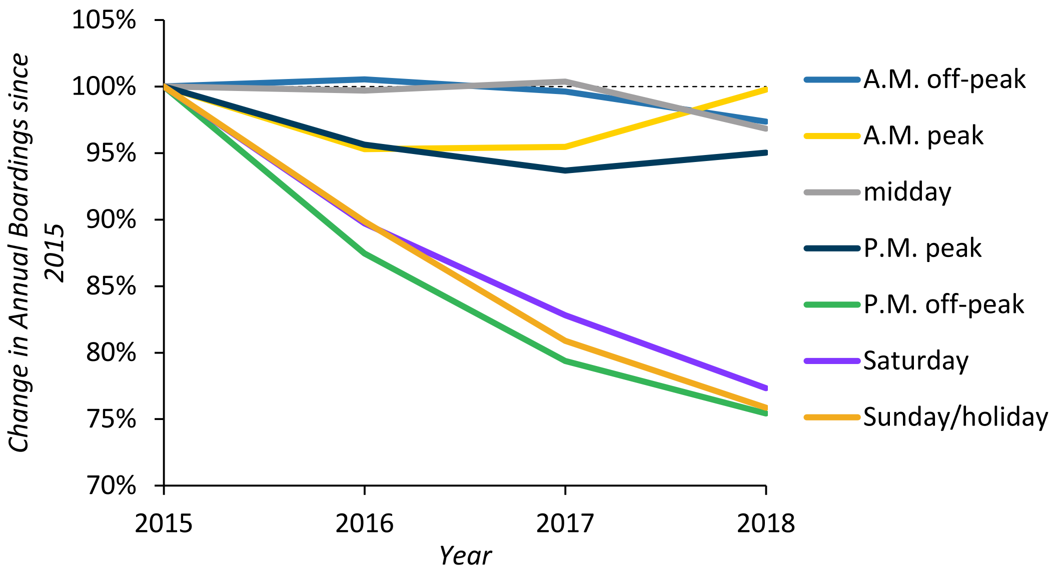
The same divergence has opened between peak and off-peak ridership (See Figure 8-3). During the peak commute hours, ridership was only down three percent between 2015 and 2018, with an increase in the last year. Off-peak patronage, though, has dropped 15 percent. These decreases have come especially in the evenings after commute hours and on Saturdays and Sundays, with early morning and midday transit use roughly as stable as peak ridership (See Figure 8-4).

Figure 8-3. Change in Annual GGT Ridership: Peak versus Off-peak



Data source: GGBHTD, 2019b

Figure 8-4. Change in Annual GGT Ridership by Time of Day



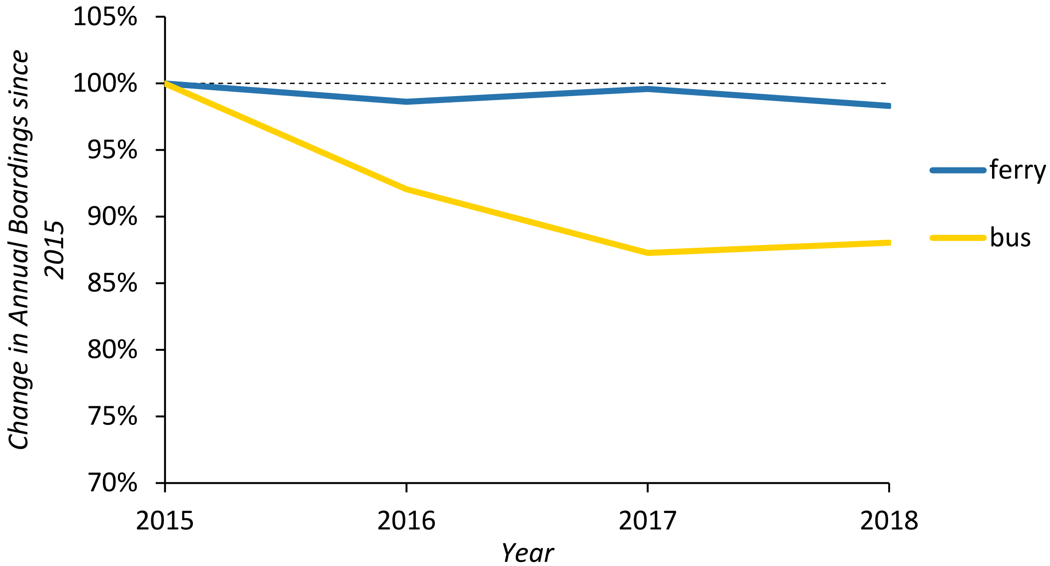
Data source: GGBHTD, 2019b

8.3. Geographic and Service Breakdown of GGT Ridership

Along with the temporal differences, another widening chasm in Golden Gate Transit ridership is by mode. GGT's ferries are comparable to rail lines on other operators: higher capacity per vehicle than buses; a few heavily used lines with higher ridership each than bus routes; and more expensive per boarding than buses most years, factoring in capital costs (FTA, 2019). At first glance, since the region's ridership decline began, GGT ferry ridership has held steady (See Figure 8-5). However, the main reason ferry ridership has not fallen is that GGT took over the previously privately-run Tiburon-San Francisco ferry service in 2017 (Clemens, 2017). The extra patronage GGT gained from the Tiburon route has been negated by losses on its other ferries: excluding the Tiburon route, GGT ferries have lost nine percent of their patronage.[15] Still, GGT's commute-oriented ferries have stayed afloat better than its busses. GGT bus ridership has capsized, sinking 12 percent. Buses today carry a smaller and smaller share of Golden Gate Transit ridership.

15. Compared with 2015 ridership estimates from when it was operated privately, the Tiburon ferry lost around 14 percent of its ridership by 2018—though data reporting requirements and estimation methods differ now that it is run by GGT (Downing, 2020).

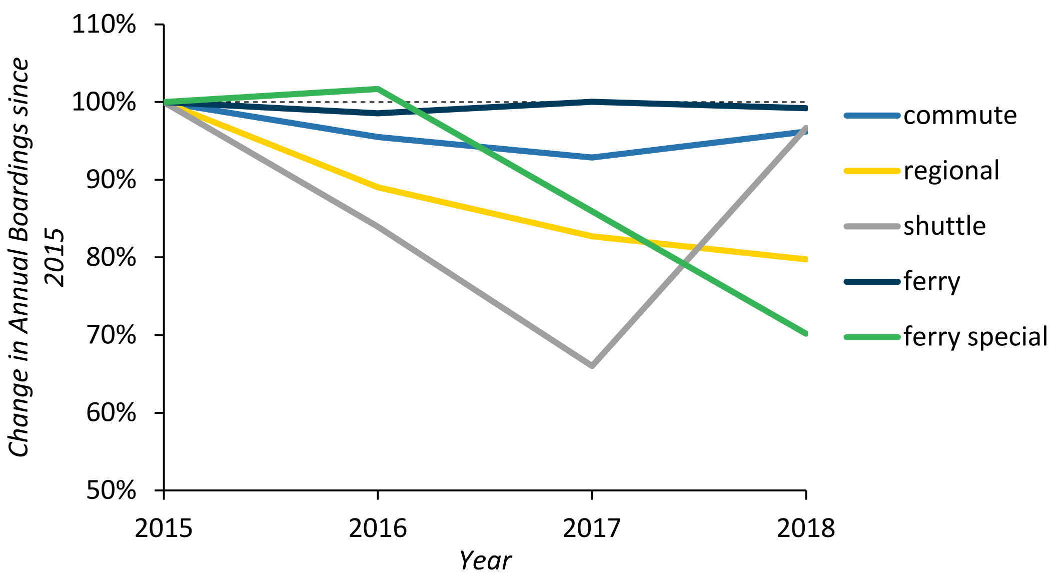
Figure 8-5. Change in Annual GGT Ridership by Mode



Data source: GGBHTD, 2019b

Within GGT's bus services, peaking is also an increasing problem. Commute services, which operate only during peak weekday hours, have better retained boardings, while regional services—some along similar corridors as commute routes, but all-day and often with more stops—account for most of GGT's bus ridership losses (See Figure 8-6).

Figure 8-6. Change in Annual GGT Ridership by Route Type



Data source: GGBHTD, 2019b

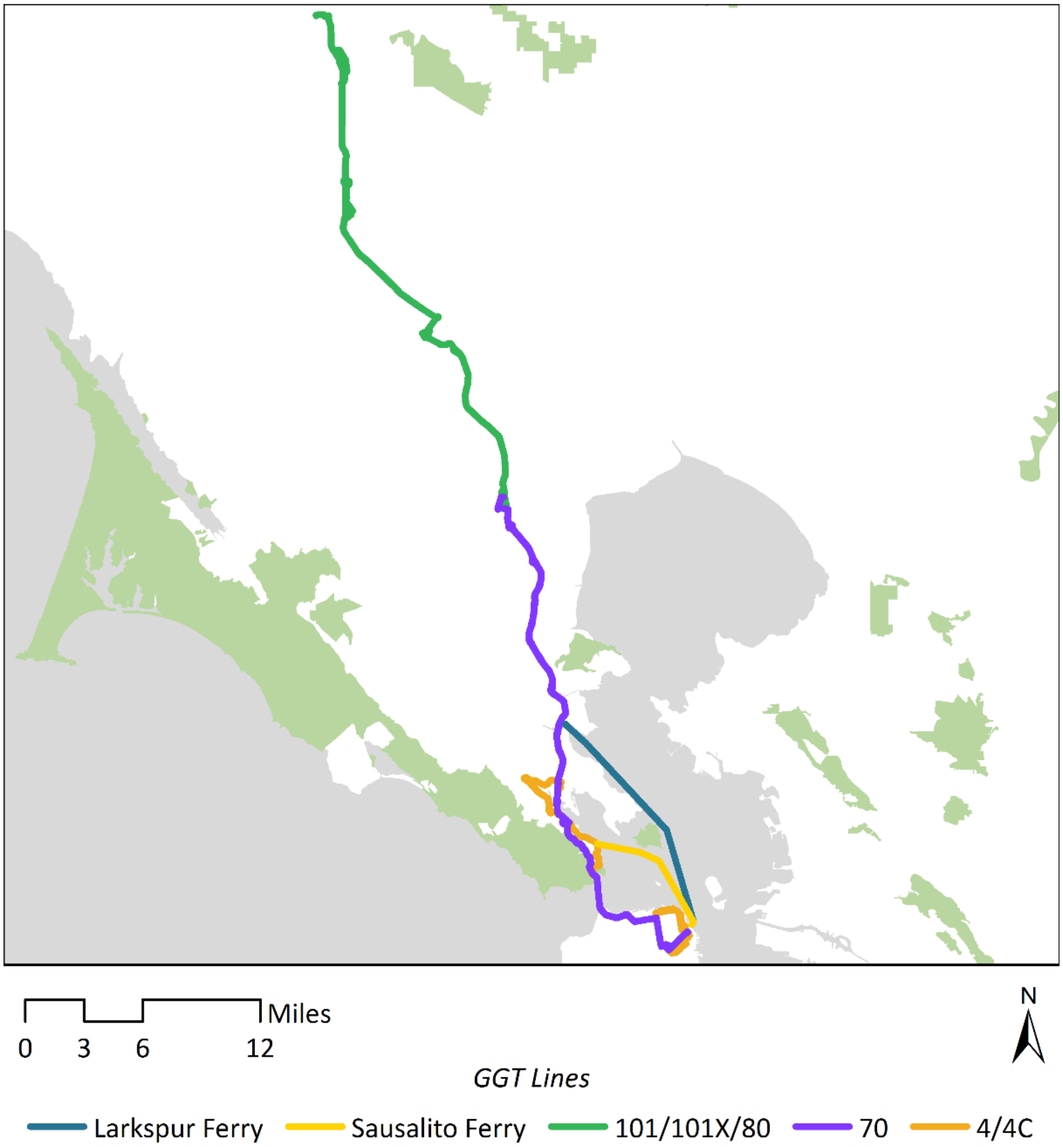
The five busiest GGT lines include the two largest ferry routes, two longer lines along the US-101 corridor, and a commute route between downtown San Francisco and the nearest Marin suburbs (See Table 8-1 and Figure 8-7). As with VTA and AC Transit, GGT's highest-ridership lines have suffered its largest losses. As discussed above, GGT's two longtime ferry lines have lost significant numbers of boardings. Next, the 101 and 70 trunk lines have lost a large share of their boardings—placing near and at the bottom, respectively, of absolute change in ridership between 2015 and 2018—for reasons discussed further below. The 4 commute line, though, has expanded its patronage.

Table 8-1. GGT Lines with the Most Boardings, 2018

LINE	ANNUAL BOARDINGS, 2018	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, 2015-2018	
Larkspur-San Francisco (ferry)	1,606,371	-72,648	22nd out of 24
Sausalito-San Francisco (ferry)	672,549	-140,498	23rd out of 24
101/101X/80 (regional/commute)	520,705	-45,565	21st out of 24
70 (regional)	406,004	-392,115	24th out of 24
4/4C (commute)	366,209	15,376	3rd out of 24

Data source: GGBHTD, 2019b

Figure 8-7. GGT Lines with the Most Boardings, 2018



Data source: GGBHTD, 2019b, 2019a; CaliDetail, n.d.; and Esri, 2010

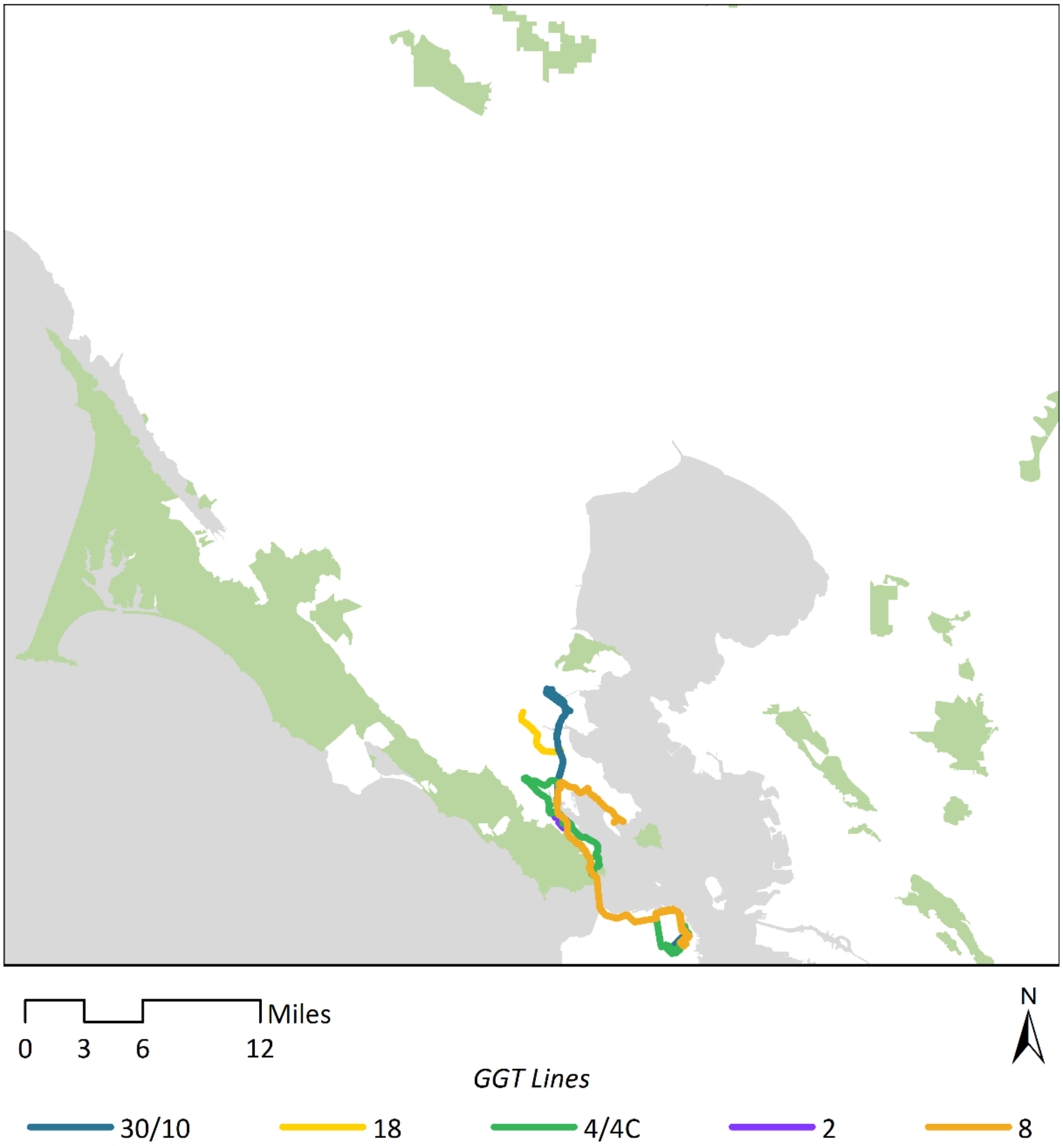
Like Line 4, almost all of the lines that have gained ridership are concentrated in the southern part of the district's service area, the inner-ring suburbs of Marin. The top five lines by absolute change in annual boardings (See Table 8-2 and Figure 8-8)—which also make up the top five lines by percentage change (See Table 8-3 and Figure 8-9) —all connect these areas to downtown San Francisco. Indeed, shorter South Marin routes are almost the only lines in the system to have gained patronage between 2015 and 2018. Only seven of GGT's 24 lines grew their ridership over those three years.

Table 8-2. GGT Lines with the Largest Absolute Gains, 2015-2018

LINE	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, 2015-2018
30/10 (regional)	+117,973
18 (commute)	+22,393
4/4C (commute)	+15,376
2 (commute)	+3,690
8 (commute)	+1,867

Data source: GGBHTD, 2019b

Figure 8-8. GGT Lines with the Largest Absolute Gains, 2015-2018



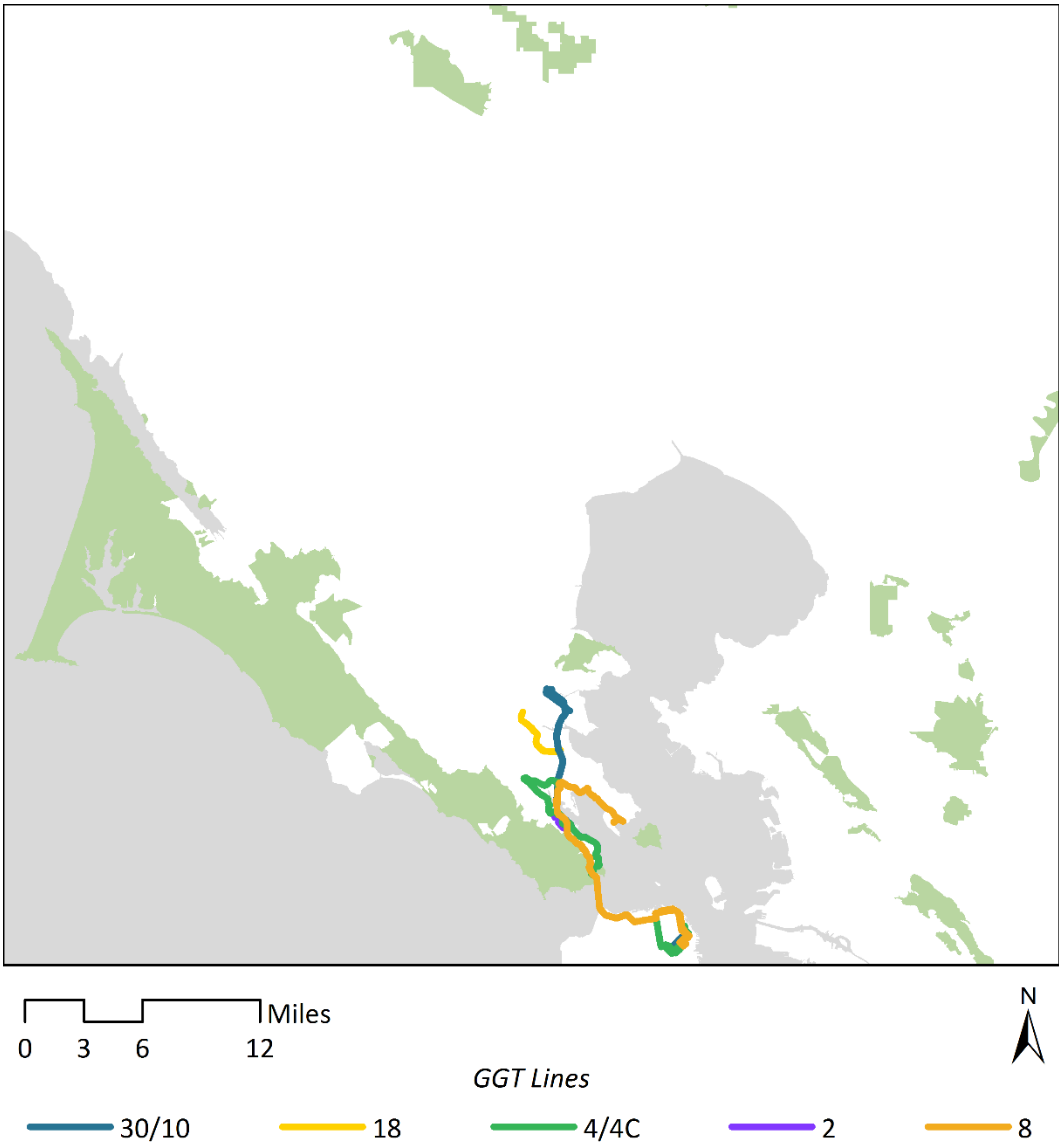
Data source: GGBHTD, 2019b, 2019a; CaliDetail, n.d.; and Esri, 2010

Table 8-3. GGT Lines with the Largest Percentage Gains, 2015-2018

LINE	PERCENT CHANGE IN ANNUAL BOARDINGS, 2015-2018
30/10 (regional)	+59%
18 (commute)	+22%
8 (commute)	+11%
2 (commute)	+5%
4/4C (commute)	+4%

Data source: GGBHTD, 2019b

Figure 8-9. GGT Lines with the Largest Percentage Gains, 2015-2018



Data source: GGBHTD, 2019b, 2019a; CaliDetail, n.d.; and Esri, 2010

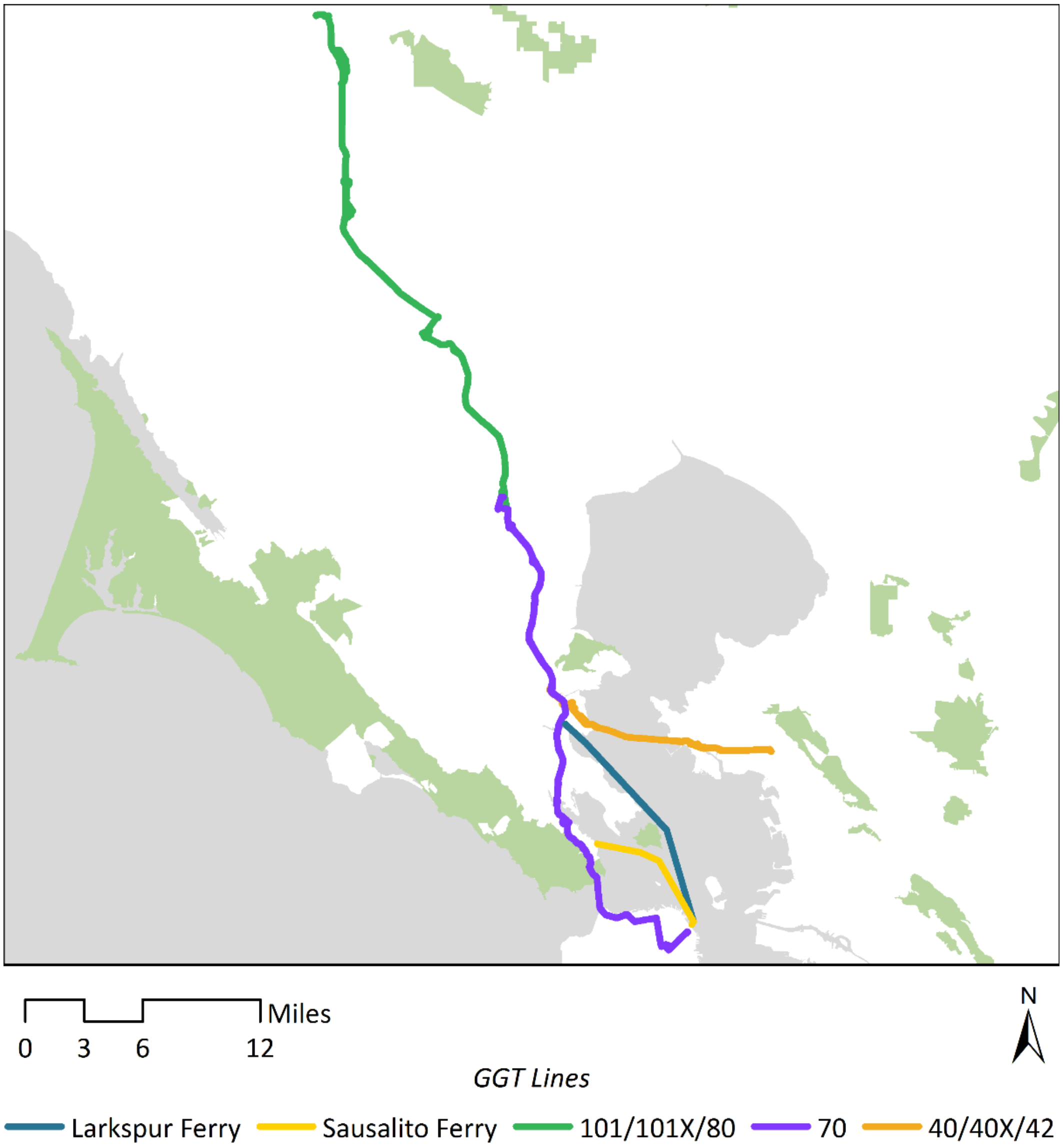
In absolute terms, GGT's greatest ridership losses come from its most-popular routes, including two of its ferries (See Table 8-4 and Figure 8-10). Aside from the ferries, long regional routes reaching deep into the North Bay, like routes 101 and 70, account for much of GGT's losses. Declines on Lines 101 and 70, however, are not indicative of overall transit use trends along the US-101 corridor. The opening of SMART appears to have lowered ridership on GGT's parallel bus routes (though SMART's second year of operation has, like GGT, seen both patronage declines and weekday peaking (Fixler, 2020)). Similarly, when Marin Transit increased service along the corridor—coordinated with a decrease in frequency on GGT Line 70 (Downing, 2020)—ridership on Marin Transit's 35, 36, and 71/71X routes jumped a combined 28 percent between Fiscal Years 2015 and 2018 (Marin Transit, 2015, 2018). In other words, the corridor may not be losing riders overall, but many riders, especially those beginning and ending their trips in the North Bay, are likely shifting away from GGT (Downing, 2020). And, as noted above, the recent wildfires have also likely played a role, decreasing ridership, for instance, on GGT's 101 route.

Table 8-4. GGT Lines with the Largest Absolute Losses, 2015-2018

LINE	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, 2015-2018
40/40X/42 (regional)	-42,676
101/101X/80 (regional/commute)	-45,565
Larkspur-San Francisco (ferry)	-72,648
Sausalito-San Francisco (ferry)	-140,498
70 (regional)	-392,115

Data source: GGBHTD, 2019b

Figure 8-10. GGT Lines with the Largest Absolute Losses, 2015-2018



Data source: GGBHTD, 2019b, 2019a; CaliDetail, n.d.; and Esri, 2010

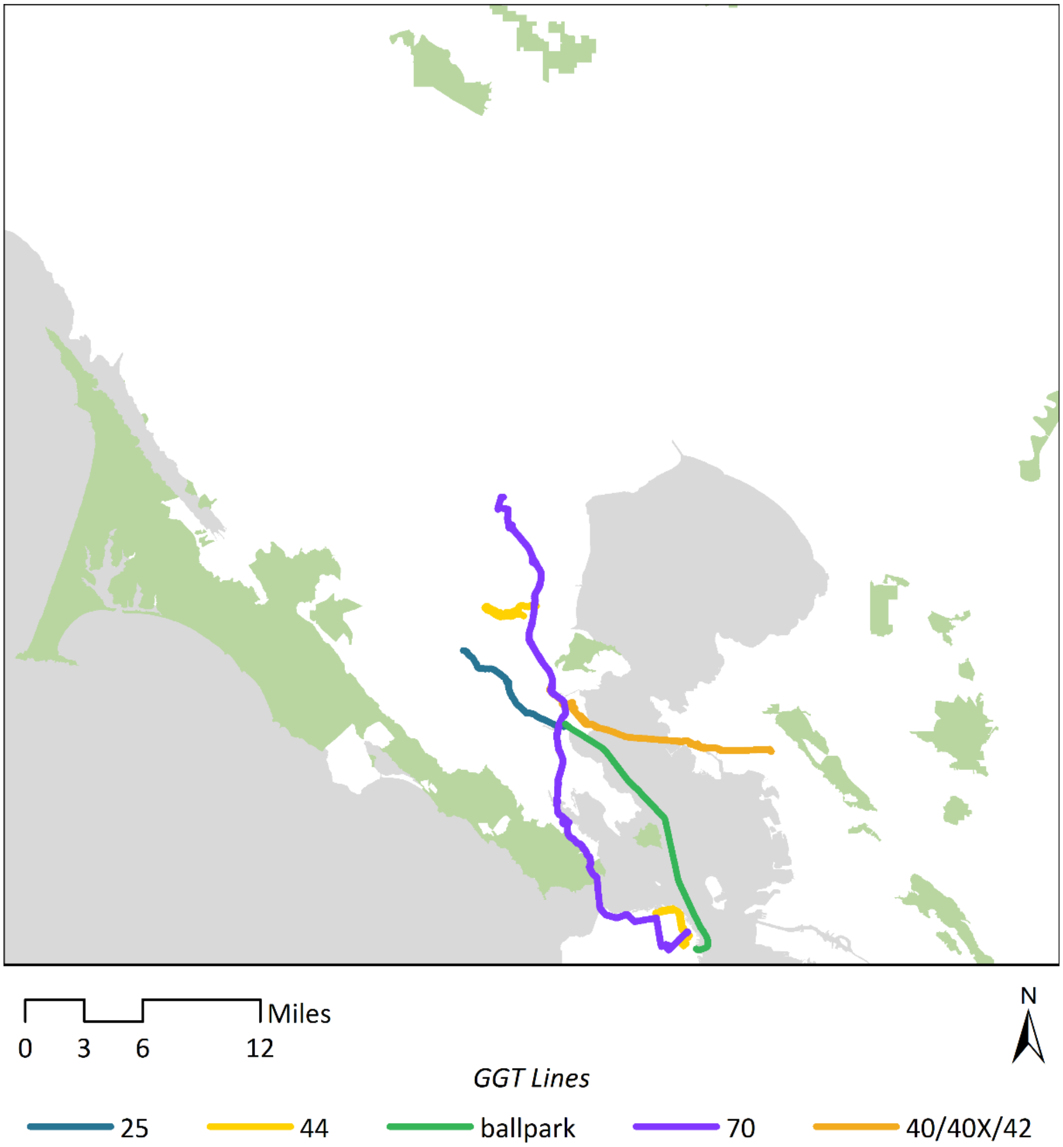
The lines with the largest relative losses are a mixed bag, including one shuttle and one special service (See Table 8-5 and Figure 8-11). One route with significant relative and absolute losses, the 40/40X, is GGT's only service to connect to the East Bay. It is yet another example of line operating outside of the region's major job centers that has lost much of its patronage, particularly off-peak. Finally, GGT's special ferry service to Oracle Park for games and concerts has lost significant patronage as well.

Table 8-5. GGT Lines with the Largest Percentage Losses, 2015-2018

LINE	PERCENT CHANGE IN ANNUAL BOARDINGS, 2015-2018
40/40X/42 (regional)	-18%
25 (shuttle)	-20%
44 (commute)	-21%
ballpark special (ferry special)	-30%
70 (regional)	-49%

Data source: GGBHTD, 2019b

Figure 8-11. GGT Lines with the Largest Percentage Losses, 2015-2018



Data source: GGBHTD, 2019b, 2019a; CaliDetail, n.d.; and Esri, 2010

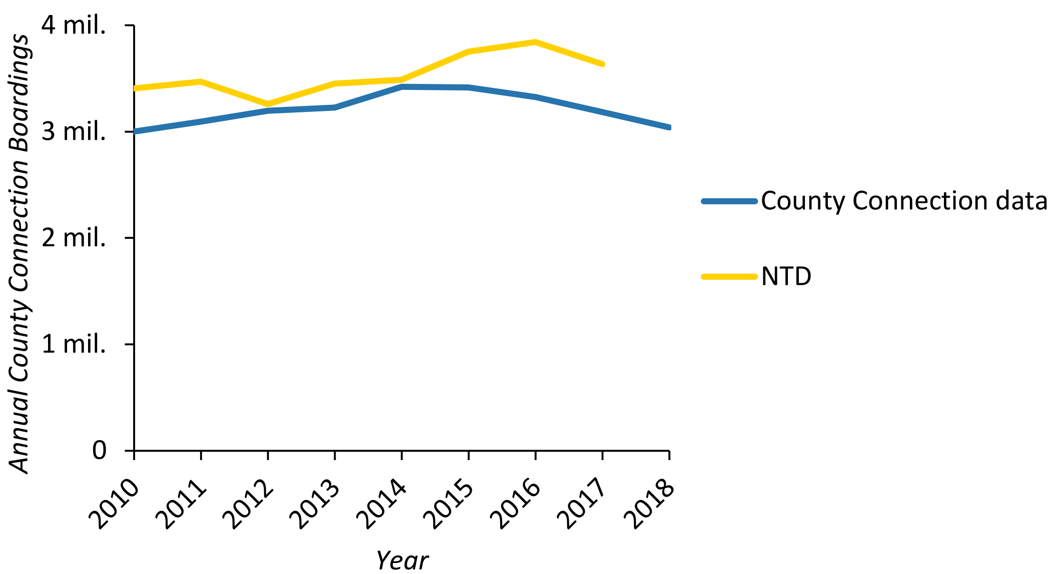
9. County Connection Ridership Trends

9.1. Overview and Data Validation

The Central Contra Costa Transit Authority, the eighth-largest operator in the Bay Area by 2018 boardings, was selected to represent the roughly dozen and a half smaller transit operators in the region. While the largest of these small operators, County Connection is likely emblematic: placing between the small operators that have gained patronage and those that have lost it, County Connection had nearly the same total ridership in the NTD in 2017 as in 2014 (FTA, 2019). Serving largely suburban and exurban communities in Central Contra Costa County, County Connection is only one of the eight agencies profiled herein without any service in the three largest Bay Area cities (San José, San Francisco, and Oakland (U.S. Census Bureau, 2019a)). Unlike the largely intra-urban operators like Muni and AC Transit, on which declines have occurred relatively evenly across the system, and commuter systems like BART and GGT, on which declines are focused at peak times and in commute directions, County Connection has seen moderate peaking (County Connection, 2019b).

County Connection Staff provided us a dataset of boardings, service hours, and headways by day of the week, time of day, and route (County Connection, 2019b). We matched the data to information on the County Connection website on route types, cost, and frequency (County Connection, 2019c); when peak or off-peak headways are given as a range, we took the average of the high and low of each range. The internal data unfortunately do not track that closely with year-to-year changes in the NTD (See Figure 9-1), meaning that findings in this section should be compared only with caution to findings in other sections.

Figure 9-1. County Connection Annual Ridership: NTD versus Internal County Connection Data

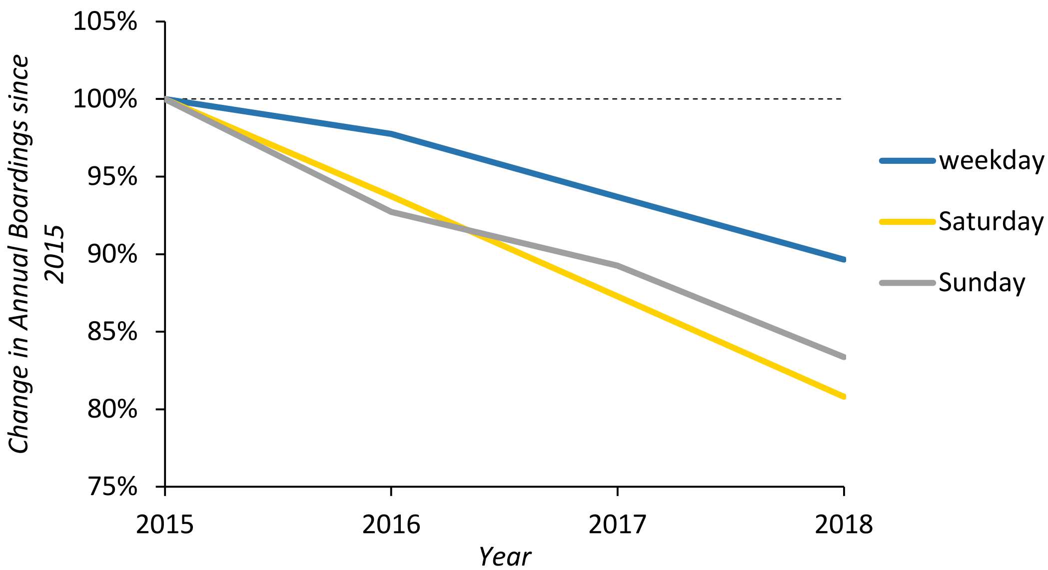


Data source: County Connection, 2019b and FTA, 2019

9.2. Breakdown by Time and Frequency

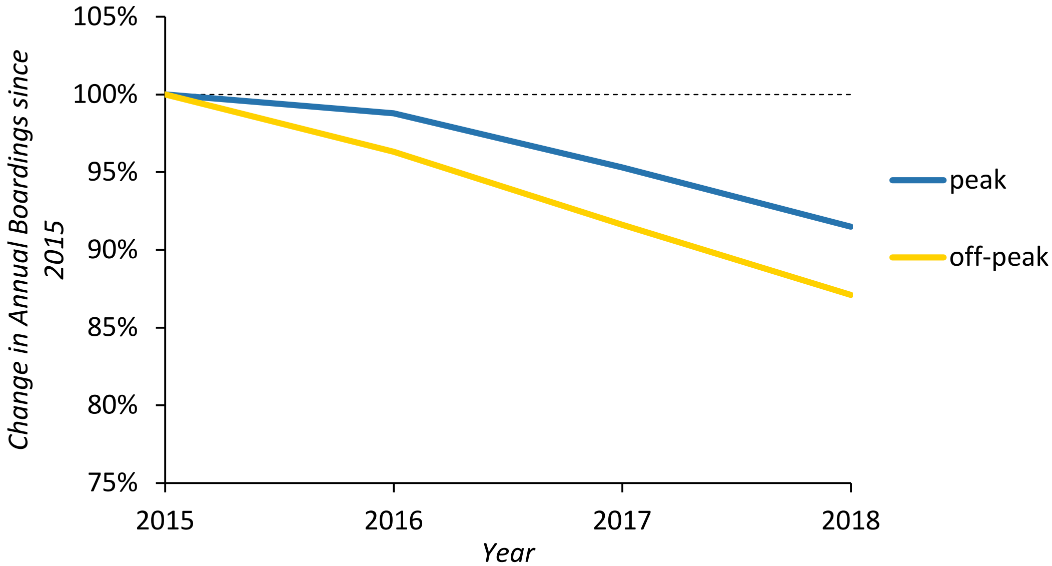
County Connection has seen greater declines on weekends and at off-peak times than on weekdays and at peak times, respectively, but not dramatically so. As to the former, County Connection lost ten percent of its boardings on weekdays between 2015 and 2018, compared to 19 percent losses on Saturday and 17 percent losses on Sunday (See Figure 9-2). The differences are less stark when comparing weekday peak-hour losses (9%) to all off-peak-hour losses (13%) (See Figure 9-3). But these off-peak losses are concentrated at certain times of day. Midday and early afternoon ridership has fallen only slightly more than peak ridership, but early morning, late night, and weekend ridership have declined more steeply (See Figure 9-4). In other words, the further away from peak commute times, the more severe the losses.

Figure 9-2. Change in Annual County Connection Ridership by Weekday



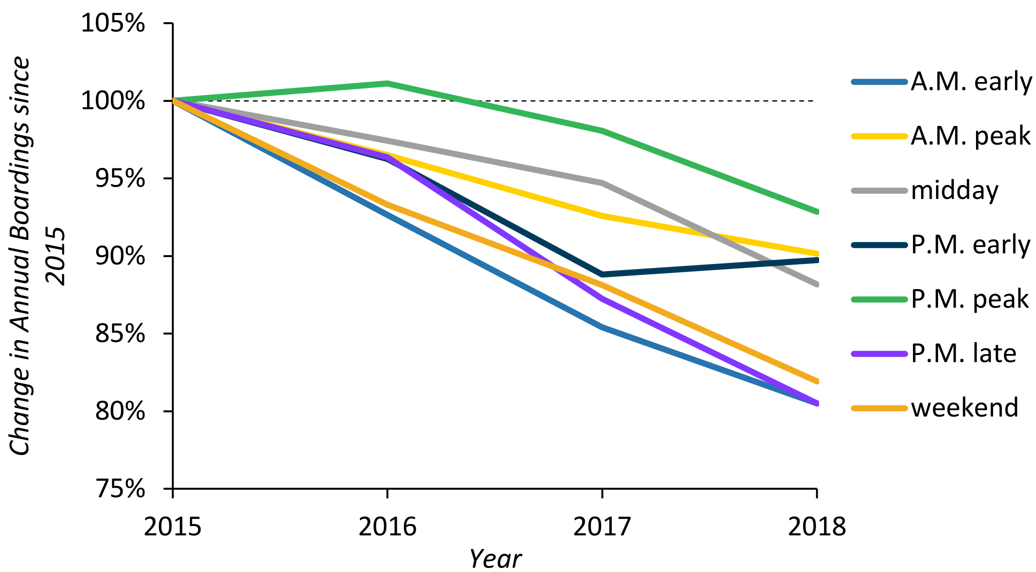
Data source: County Connection, 2019b

Figure 9-3. Change in Annual County Connection Ridership: Peak versus Off-peak



Data source: County Connection, 2019b

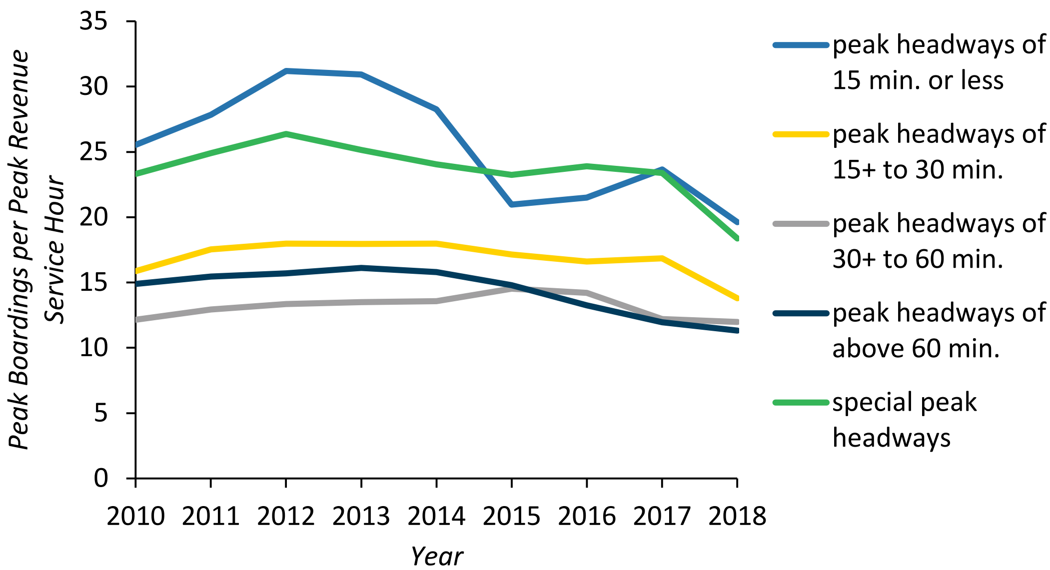
Figure 9-4. Change in Annual County Connection Ridership by Time of Day



Data source: County Connection, 2019b

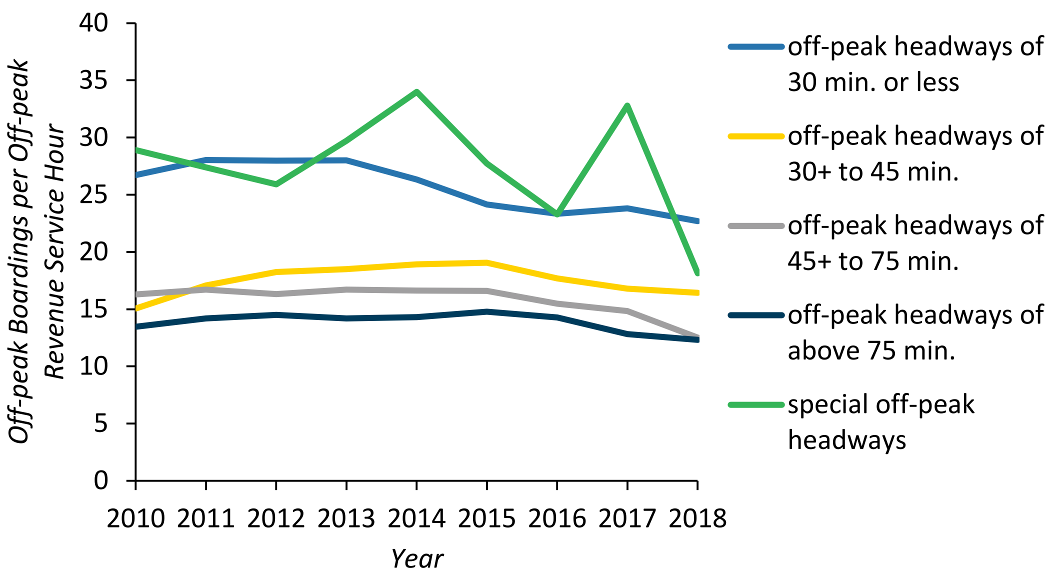
Transit use trends are more consistent across lines with different headways. Figure 9-5 displays the peak productivity (peak boardings per peak revenue service hour) of categories of lines, broken down by the lines' peak headways. Figure 9-6 shows the off-peak productivity (off-peak boardings per off-peak revenue service hour), divided by the lines' off-peak headways. Again, we use productivity here, rather than raw ridership, to account for service changes. Other than routes with special headways, trends in peak and off-peak productivities since 2015 have generally moved in parallel: slightly downward, with some bumps, across routes of different headways. Lines with more frequent headways have had the same trends in boardings per service hour as lines with less frequent headways. The one difference that stood out is in Figure 9-5: changes in peak productivity on high-frequency peak routes fell dramatically between 2012 and 2015, as peak productivity on other routes rose. The reason for this specific trend is beyond the scope of this report, but given that it occurred before County Connection and the Bay Area's overall ridership declines, it likely has not contributed to the current slump.

Figure 9-5. County Connection Peak Productivity by Peak Frequency



Data source: County Connection, 2019b

Figure 9-6. County Connection Off-peak Productivity by Off-peak Frequency



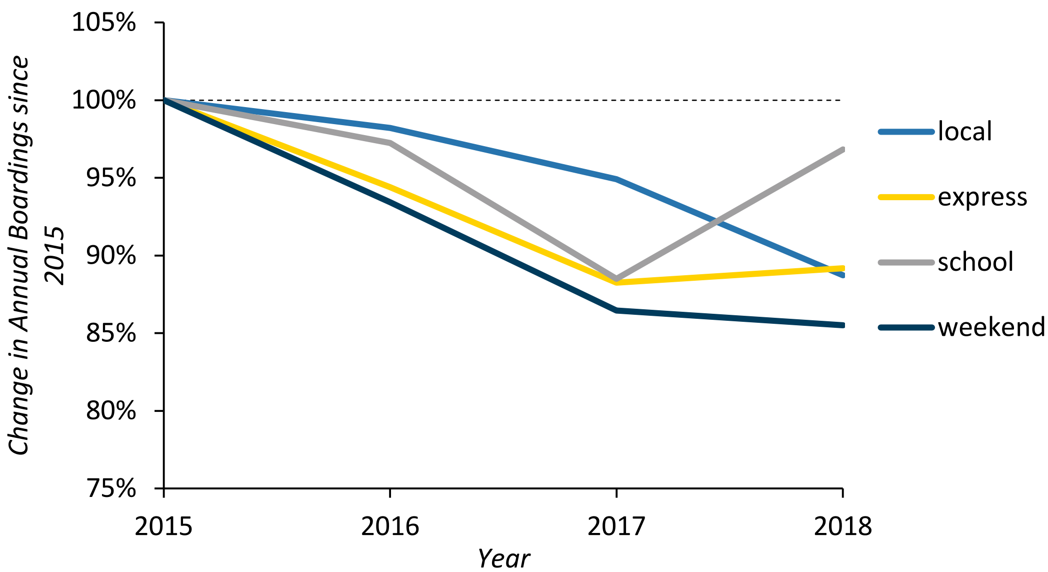
Data source: County Connection, 2019b

9.3. Breakdown by Line

With relatively low ridership numbers compared to the other agencies profiled herein (The line with the most trips in 2018, for instance, carried less than 700 boardings per day (County Connection, 2019b).), small absolute changes on County Connection lines can have large percentage effects. Thus, in the tables and figures below, large percentage increases or decreases on County Connection lines do not have the same regional effects as on other operators. Nonetheless, key geographic trends on County Connection may prove applicable to other small operators across the region.

Over three quarters of 2018 boardings occurred on local routes, whose ridership dropped 11 percent between 2015 and 2018, falling more steeply each year (See Figure 9-7). Express lines saw a similar decrease, though their decline began earlier. Other route types have also seen patronage fall, though they carry a small share of County Connection riders.

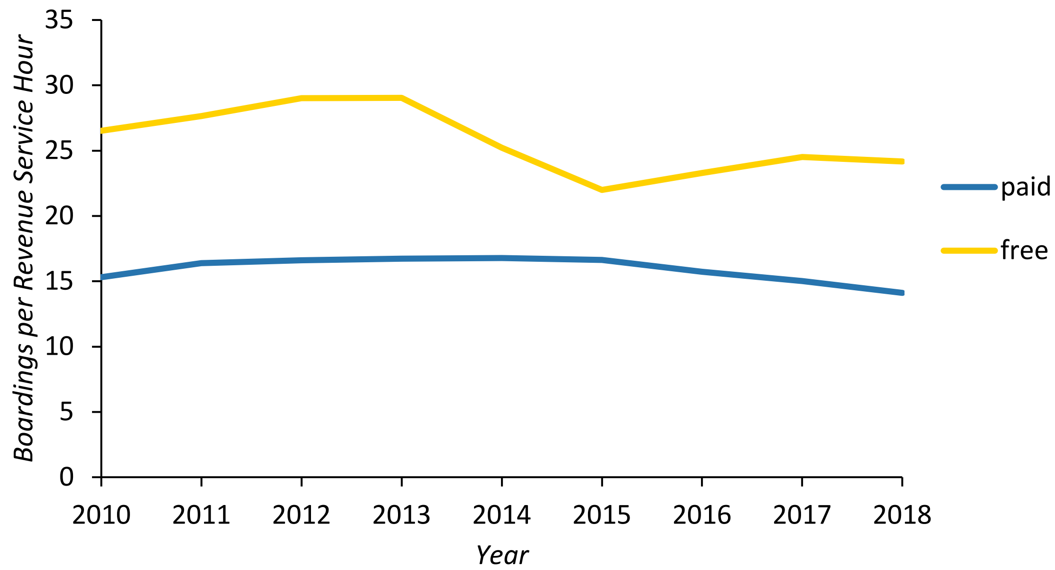
Figure 9-7. Change in Annual County Connection Ridership by Route Type



Data source: County Connection, 2019b

Three of County Connection's current routes are free: Line 4 has long been fare-free, while Line 5 became free in 2014 and Line 7 in 2015. These free routes—the former two in central Walnut Creek, the latter a shuttle to the Shadelands business park—have, summed together, gained in ridership since 2015, as the system overall lost boardings. Even controlling for service increases by examining productivity, we find that free routes carry more boardings per service hour than routes with fares and have become more productive since 2015 (following a decline from 2013 to 2015) (See Figure 9-8). Of course, this simple division fails to control for geographic and service differences between the free and paid routes, so we can make few generalizations therefrom. But these specific free lines appear to be increasingly more productive than their paid counterparts.

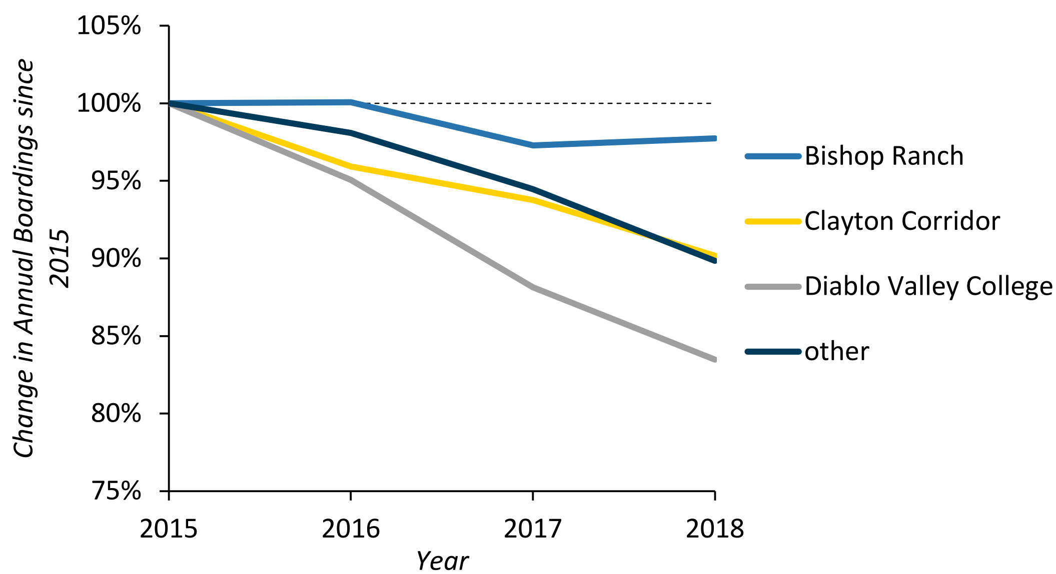
Figure 9-8. Change in Annual County Connection Productivity by Fares



Data source: County Connection, 2019b

County Connection's dataset includes three special categories of routes serving special destinations (See Figure 9-9). The four express routes that serve the Bishop Ranch office park have held onto most of their ridership in recent years. The single line on the Clayton Corridor, Line 10, closely tracks the rest of the system's patronage trends. Finally, the ten lines that currently or once served Diablo Valley College have lost 17 percent of their ridership in just three years.

Figure 9-9. Change in Annual County Connection Ridership: Special Route Categories



Data source: County Connection, 2019b

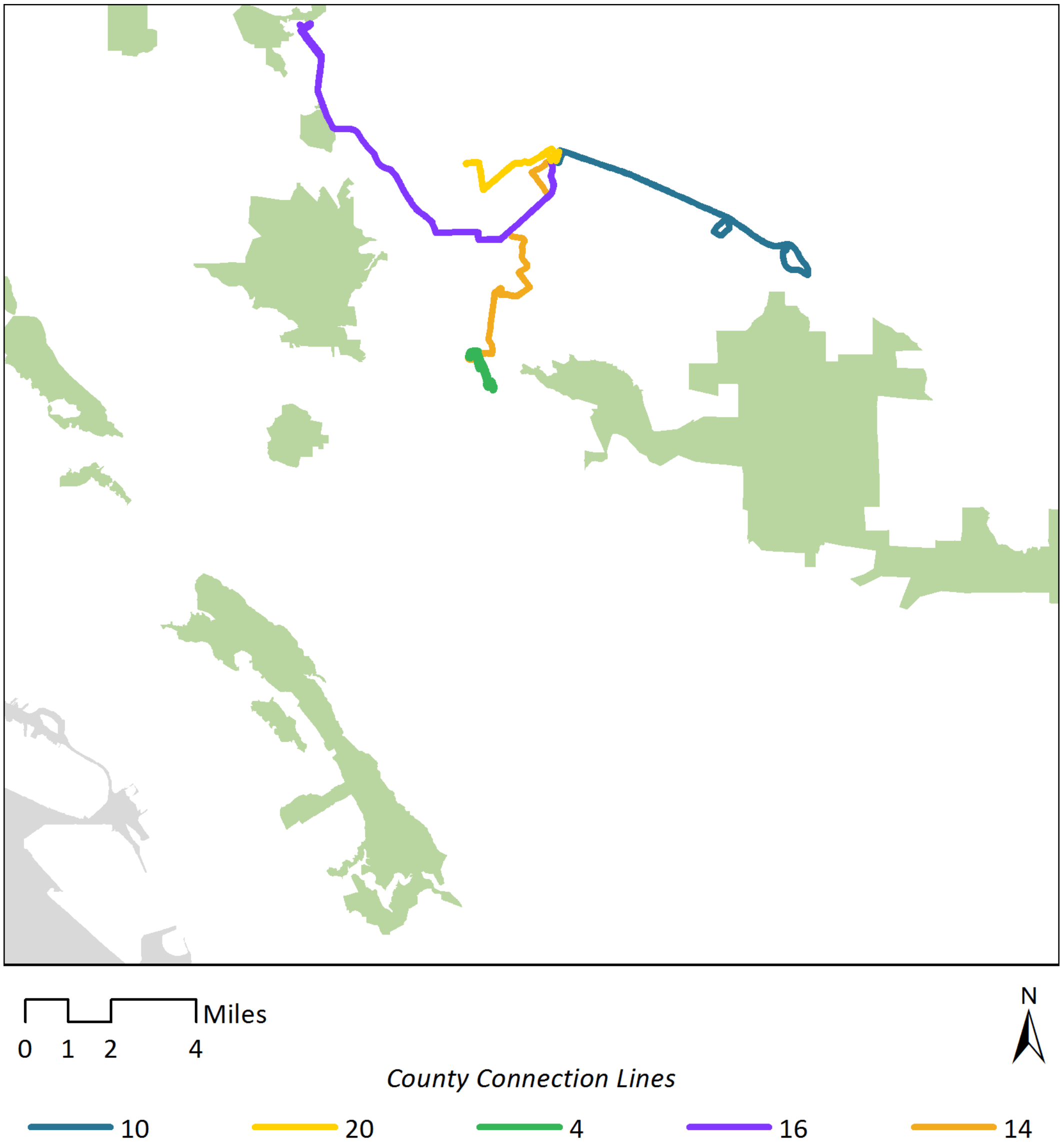
Like AC Transit and VTA, County Connection's most-ridden routes have lost the most boardings (See Table 9-1 and Figure 9-10). The top four lines by annual boardings in 2018 are the bottom four lines by absolute change in boardings between 2015 and 2018, with the fifth-busiest line not far behind. The operator may be experiencing some peaking issues by time of day and day of the week, but the busiest lines are actually losing riders rapidly.

Table 9-1. County Connection Lines with the Most Boardings, 2018

LINE	ANNUAL BOARDINGS, 2018	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, 2015-2018	
10 (local)	253,971	-27,671	52nd out of 55
20 (local)	225,874	-54,617	54th out of 55
4 (local)	179,956	-80,335	55th out of 55
16 (local)	164,687	-28,310	53rd out of 55
14 (local)	133,465	-23,155	49th out of 55

Data source: County Connection, 2019b

Figure 9-10. County Connection Lines with the Most Boardings, 2018



Data source: County Connection, 2019b, 2019a; CaliDetail, n.d.; and Esri, 2010

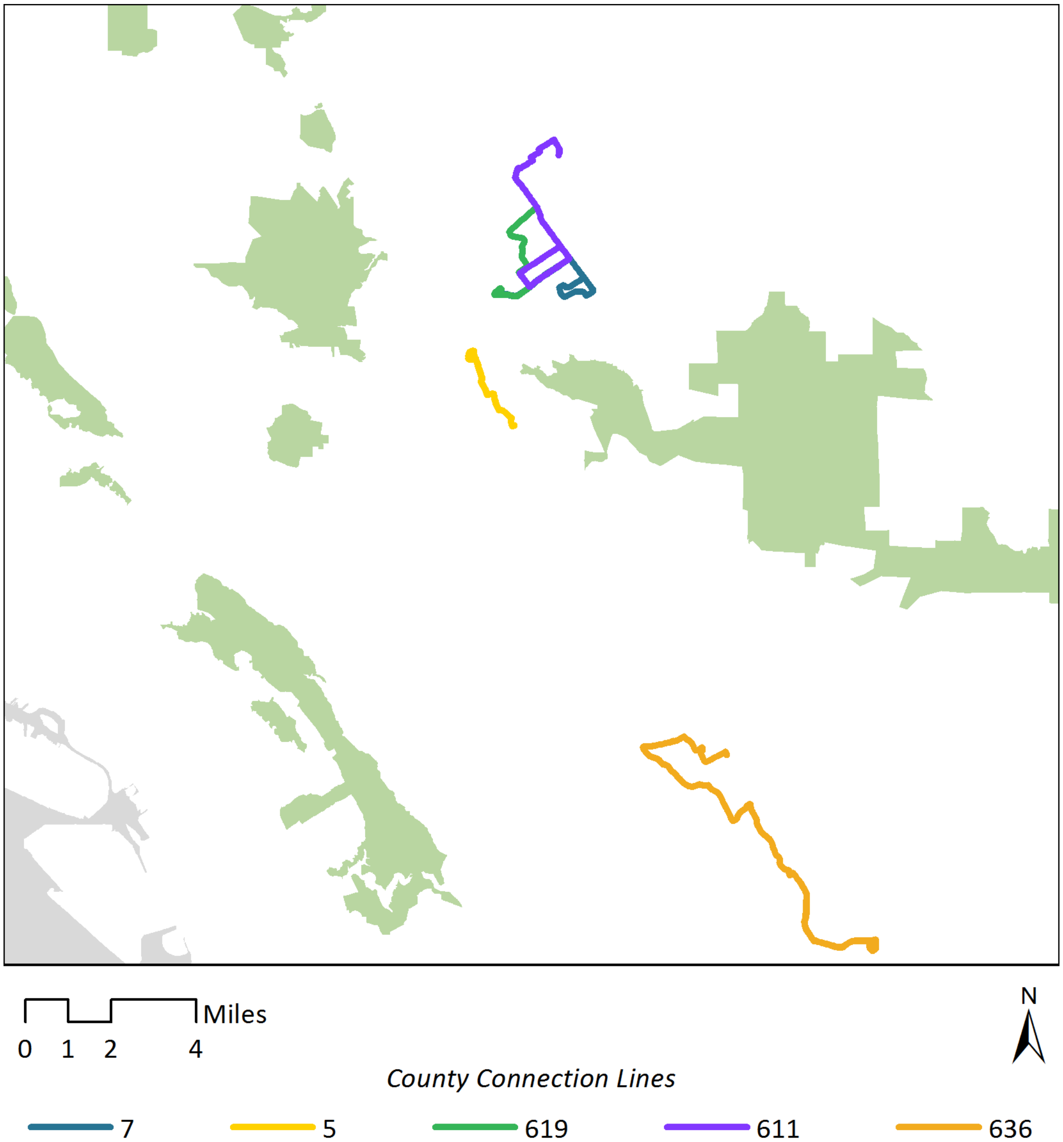
The lines that have gained the most trips are listed in Table 9-2 and Figure 9-11. The top two lines by absolute gains are routes with BART connections in Walnut Creek and Concord, both of which relatively recently have seen service increases and become fare-free, followed by three school routes connecting to Mount Diablo Unified School District schools. Three of these five routes also top the list of lines with the greatest percentage gains between 2015 and 2018, most of which are school routes (See Table 9-3 and Figure 9-12).

Table 9-2. County Connection Lines with the Largest Absolute Gains, 2015-2018

LINE	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, 2015-2018
7 (local)	+45,564
5 (local)	+16,791
619 (school)	+2,936
611 (school)	+2,706
636 (school)	+2,308

Data source: County Connection, 2019b

Figure 9-11. County Connection Lines with the Largest Absolute Gains, 2015-2018



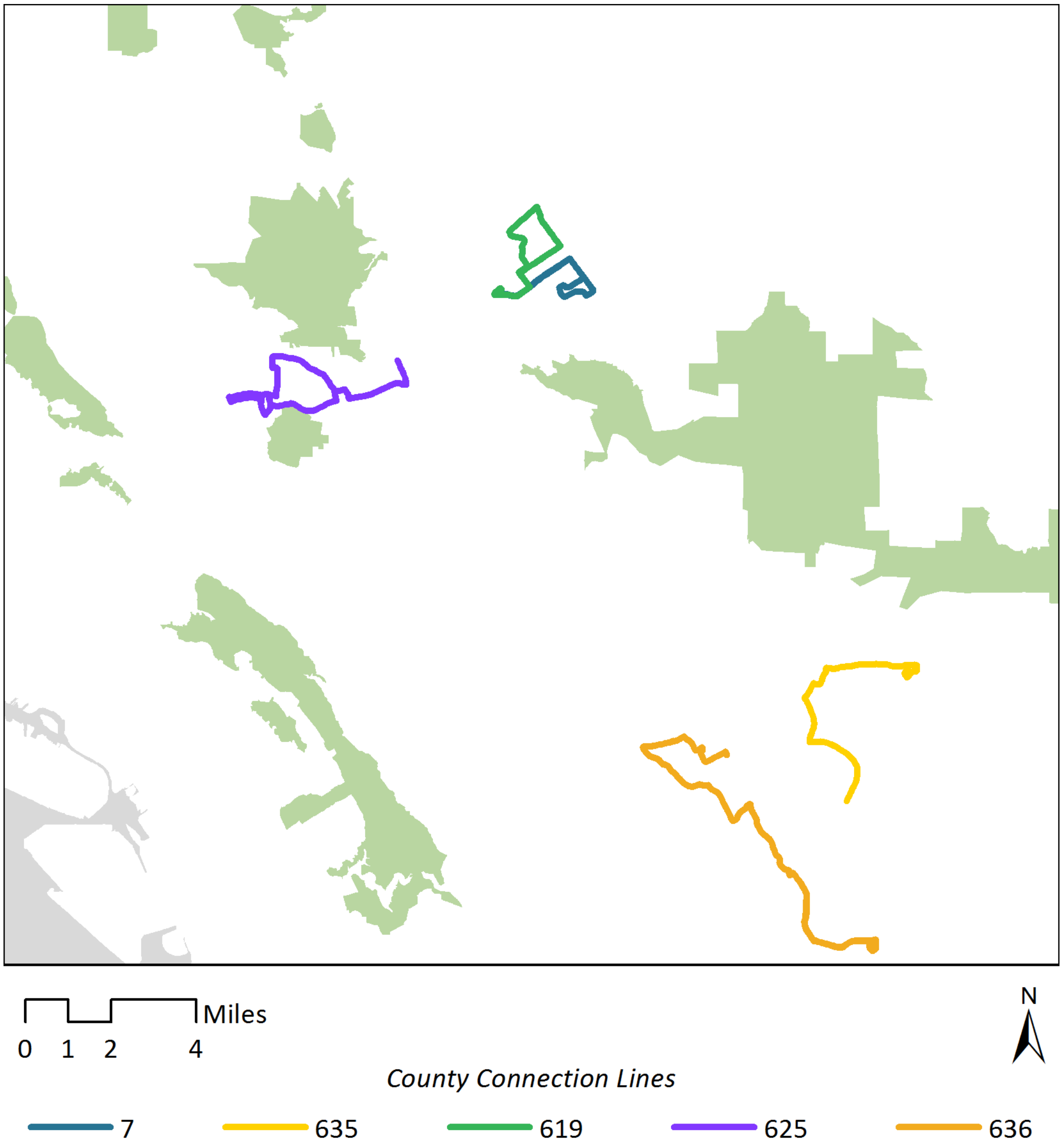
Data source: County Connection, 2019b, 2019a; CaliDetail, n.d.; and Esri, 2010

Table 9-3. County Connection Lines with the Largest Percentage Gains, 2015-2018

LINE	PERCENT CHANGE IN ANNUAL BOARDINGS, 2015-2018
7 (local)	+71%
619 (school)	+64%
635 (school)	+57%
625 (school)	+31%
636 (school)	+27%

Data source: County Connection, 2019b

Figure 9-12. County Connection Lines with the Largest Percentage Gains, 2015-2018



Data source: County Connection, 2019b, 2019a; CaliDetail, n.d.; and Esri, 2010

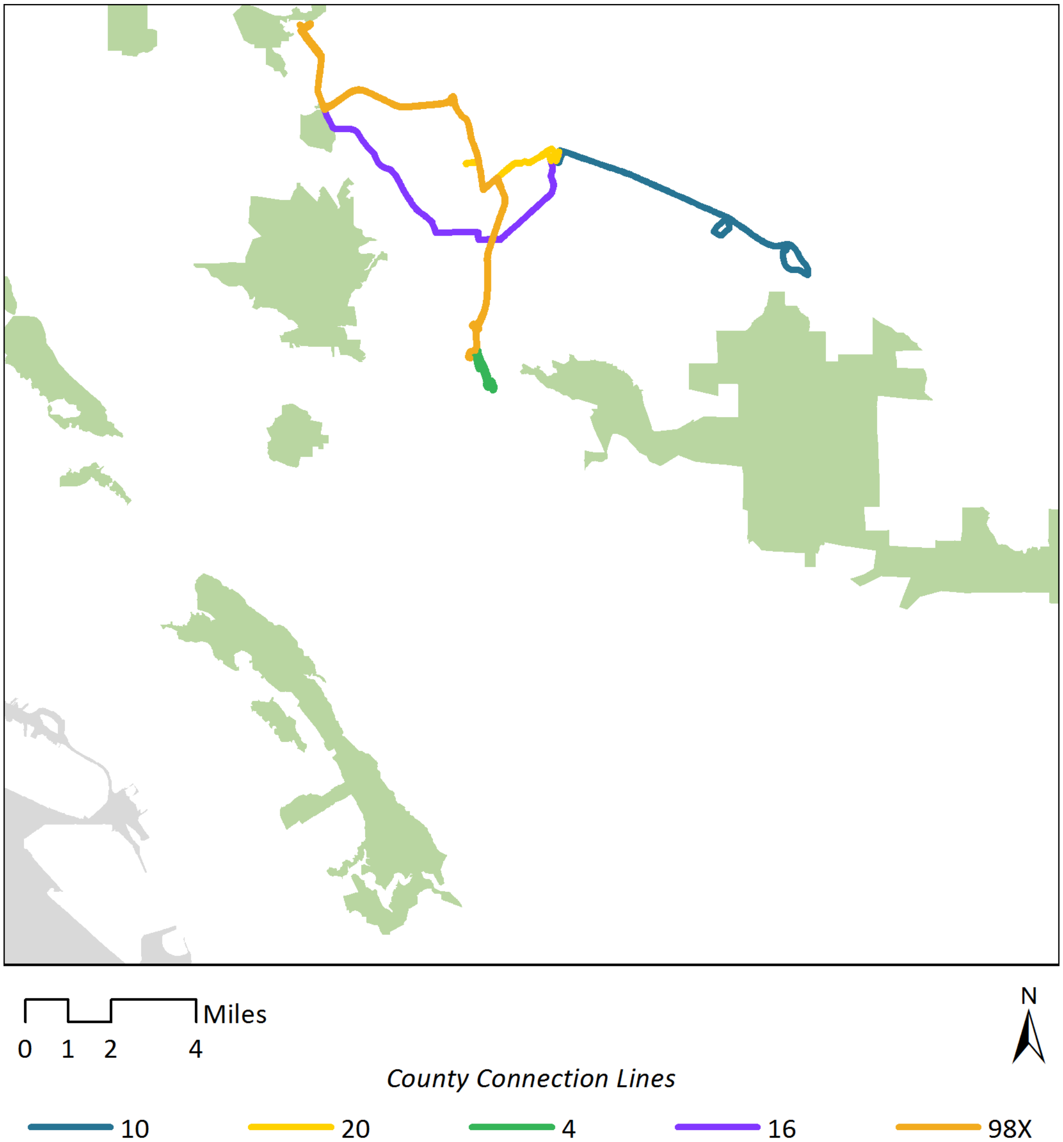
As mentioned above, the lines with the most substantial losses are County Connection's largest lines, along some of its major corridors (See Table 9-4 and Figure 9-13). The line with the most losses is Line 4, Walnut Creek's Downtown Trolley, has had far worse ridership trends than the two other free lines in the system. Line 4 also appears in the list of lines with the largest percentage losses, joining three school routes in the Mount Diablo Unified School District and an express route (See Table 9-5 and Figure 9-14).

Table 9-4. County Connection Lines with the Largest Absolute Losses, 2015-2018

LINE	ABSOLUTE CHANGE IN ANNUAL BOARDINGS, 2015-2018
98X (express)	-26,211
10 (local)	-27,671
16 (local)	-28,310
20 (local)	-54,617
4 (local)	-80,335

Data source: County Connection, 2019b

Figure 9-13. County Connection Lines with the Largest Absolute Losses, 2015-2018



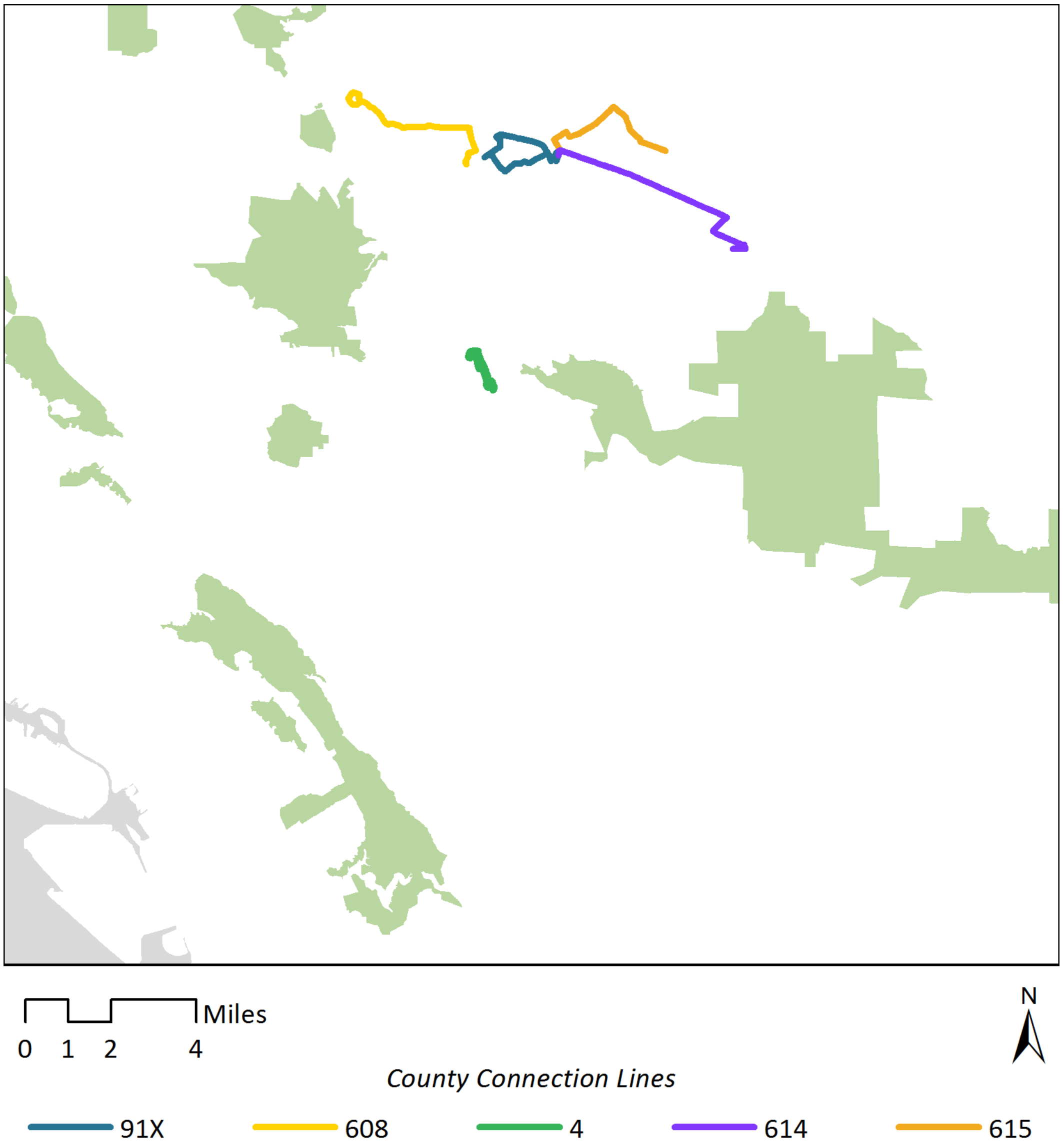
Data source: County Connection, 2019b, 2019a; CaliDetail, n.d.; and Esri, 2010

Table 9-5. County Connection Lines with the Largest Percentage Losses, 2015-2018

LINE	PERCENT CHANGE IN ANNUAL BOARDINGS, 2015-2018
91X (express)	-30%
608 (school)	-31%
4 (local)	-31%
614 (school)	-32%
615 (school)	-61%

Data source: County Connection, 2019b

Figure 9-14. County Connection Lines with the Largest Percentage Losses, 2015-2018



Data source: County Connection, 2019b, 2019a; CaliDetail, n.d.; and Esri, 2010

Conclusion

10. Conclusion

Bay Area ridership faces two intertwined but distinct problems: absolute patronage losses and peaking. These issues are correlated, and many of the same causes, like changing residential locations, are behind both. Yet in surveying the ridership landscape of the top eight Bay Area transit agencies, we see cross-cutting divisions.

Caltrain, for instance, has experienced over the past decade both tremendous growth (56% growth, the highest relative growth of the operators profiled herein) and acute peaking. Despite some worrisome overall trip losses in the past two years, BART also falls into this category. Its patronage growth propped up the whole region in the years after the Great Recession, even as its ridership increasingly concentrated on weekday transbay commute trips.

Meanwhile, Muni, SamTrans, and AC Transit have experienced little peaking, with ridership trends on weekends and low-frequency lines tracking relatively closely. To be sure, even these operators have seen some peaking by various measures, but not nearly to the degree of BART or Caltrain. Yet their overall ridership trends differ dramatically. Muni's ridership is bumpy but high, as riders likely shifting within the agency from local services and slower modes to express services and faster modes. SamTrans ridership, though, has fallen, both recently and over the past decade; AC Transit's trip counts have dropped even more steeply.

Finally, VTA and GGT have experienced both peaking and ridership losses. Even here, though, there is nuance: VTA's ridership is growing at peak times, but not on its busiest lines. GGT, meanwhile, represents the only clear-cut case of an agency-wide decrease in revenue service hours and miles, as ridership has also plunged. Amidst all this, low-ridership operators like County Connection have seen only moderate peaking and only moderate ridership losses.

Job growth and its relation to urban form may explain these differences. While not a perfect classification, the three most clearly commute-oriented operators— the rail operators Caltrain and BART, along with GGT—have witnessed the most severe peaking. As other pressures depress off-peak trip-making on these operators, employment growth has sustained or even increased their ridership at their peak hours and on their faster services. Thanks to BART's rich origin-destination data, our statistical models show that station-area jobs do indeed have the greatest influence on ridership on BART, an influence that has grown over time.

Though they certainly also carry commuters, agencies like Muni and AC Transit also bear many short, non-work trips as well, given their location in the region's urban cores. This may explain why their peaking has been less acute. However, employment growth in San Francisco has outpaced growth in the parts of the East Bay that AC Transit serves—explaining in part why, despite neither having sharp peaking, AC Transit has lost a far greater share of its ridership than Muni. Lacking a clear commuter orientation and a large urban center, operators like County Connection have not experienced extremes of either peaking or ridership change.

Yet on all agencies, we see at least some evidence of peaking. All told, off-peak and non-commute trip types account for a large, disproportionate share of the region's losses. The resulting dependence on peak trips both incurs high costs—procuring vehicles and hiring workers needed only for peak periods is inefficient (Taylor, Garrett, and Iseki, 2000)—and depresses passenger satisfaction—due to overcrowding and other such issues (See Volume I, Chapter 9). Expanding capacity to address the problems caused by peaking is also neither easy nor cheap. For instance, to better handle peak-hour crush loads, BART is presently working to upgrade capacity in the Transbay Tube, with the goal of increasing peak-period frequencies from the current 23 trains per hour to 30 trains per hour. Current detailed cost estimates peg the price of the project at $3.5 billion (Watry, 2019). In addition, longer-term plans are underway to add an additional tube under San Francisco Bay; preliminary estimates for this project range from $5 to $12 billion (MTC, 2017). Other operators may not be planning such large projects, but the same fiscal realities apply.

The implications of peaking for regional transit policy are many. As they tie into other themes, causes, and issues in Bay Area transportation, we discuss them in a fuller context at the conclusion of Volume I, Chapter 17.

Sources

AC Transit. (2016, June 15). Service Changes Effective Sunday, June 26. *AC Transit*. Retrieved September 6, 2019, from http://www.actransit.org/2016/06/15/service-changes-june-2016/.

AC Transit. (2018). *Route Performance*. AC Transit.

AC Transit. (2019a). *AC Transit: East Bay Bus Rapid Transit*. Retrieved September 6, 2019, from https://brt.actransit.org/.

AC Transit. (2019b, April 27). GTFSFall18. *AC Transit*. http://www.actransit.org/wp-content/uploads/GTFSFall18.zip.

Aratani, L. (2016, October 1). Metro's Multimillion-dollar Mystery: Where Have Our Riders Gone? *Washington Post*. Retrieved September 22, 2019, from https://www.washingtonpost.com/local/trafficandcommuting/metros-multimillion-dollar-mystery-where-have-our-riders-gone/2016/10/01/2949d226-85b8-11e6-92c2-14b64f3d453f_story.html.

Barmann, J. (2017, February 24). Overcrowded BART Trains Likely Causing Drop In Ridership, Ironically. *SFist*. Retrieved July 31, 2019, from https://sfist.com/2017/02/24/overcrowded_bart_trains_likely_caus/.

BART. (2018a). System Map. *Bay Area Rapid Transit*. Retrieved September 11, 2019, from https://www.bart.gov/system-map.

BART. (2018b, November 15). New Transbay Rail Crossing: Program Overview + Project Contracting Plan. *Bay Area Rapid Transit*. Retrieved September 11, 2019, from https://www.bart.gov/sites/default/files/docs/6-A%20%20New%20Transbay%20Rail%20Crossing%20Update%20Presentation.pdf.

BART. (2019a, January 24). *2018 Customer Satisfaction Study*. Presented at the Board Workshop 2019, San Francisco. Retrieved July 24, 2019, from https://www.bart.gov/sites/default/files/docs/Customer%20Satisfaction%202018.pdf.

BART. (2019b). BART to Antioch: East Contra Costa BART Extension. *Bay Area Rapid Transit*. Retrieved September 11, 2019, from https://www.bart.gov/about/projects/ecc.

BART. (2019c). Geospatial Data. *Bay Area Rapid Transit*. Retrieved July 30, 2019, from https://www.bart.gov/schedules/developers/geo.

BART. (2019d). *Parking Statistics 2019*. BART.

BART. (2019e). Ridership Reports. *Bay Area Rapid Transit*. Retrieved July 19, 2019, from https://www.bart.gov/about/reports/ridership.

BART. (2019f). *Station Count Data*. BART.

BART. (n.d.-a). BART Historical Timeline: Achievements Over the Years. *Bay Area Rapid Transit*. Retrieved August 30, 2019, from https://www.bart.gov/sites/default/files/docs/bart-historical-timeline.pdf.

BART. (n.d.-b). *Station Data Summary*. BART.

CaliDetail. (n.d.). UCLA Common Collaboration and Learning Environment Shared System.

California Open Data. (2019, February 27). CA Geographic Boundaries. *California Open Data Portal*. Retrieved August 30, 2019, from https://data.ca.gov/dataset/ca-geographic-boundaries.

Caltrain. (2018a). *Annual Passenger Counts by Train*. Caltrain.

Caltrain. (2018b). Ridership. *Caltrain*. Retrieved September 9, 2019, from http://www.caltrain.com/about/statsandreports/Ridership.html.

Caltrain. (2018c, April 13). Schedules. *Caltrain*. Retrieved September 9, 2019, from http://www.caltrain.com/schedules.html.

Caltrain. (2019, September 23). CT-GTFS. *Caltrain*. http://www.caltrain.com/Assets/GTFS/caltrain/CT-GTFS.zip.

Civil Grand Jury of Santa Clara County. (2019, June 18). *Inquiry into Governance of the Valley Transportation Authority*. Civil Grand Jury of Santa Clara County. Retrieved September 24, 2019, from http://www.scscourt.org/documents/CGJ%20VTA%20Final%20Report%20-%2006.18.19.pdf.

Clemens, P. (2017, February 24). Golden Gate Ferry to Commence Tiburon-San Francisco Commute Service on March 6th, 2017. *Golden Gate Bridge, Highway, and Transportation District*. Retrieved September 18, 2019, from http://goldengate.org/news/ferry/golden-gate-ferry-to-commence-tiburon-commute-service.php.

County Connection. (2019a). Google Transit. *County Connection*. http://cccta.org/GTFS/google_transit.zip.

County Connection. (2019b). *Ridership by Route and Time Period FY19*. County Connection.

County Connection. (2019c). Routes. *County Connection*. Retrieved September 6, 2019, from https://countyconnection.com/routes/.

Downing, R. (2020). [Personal communication].

Erhardt, G. (2016). Fusion of Large Continuously Collected Data Sources: Understanding Travel Demand Trends and Measuring Transport Project Impacts (PhD diss.). University College London, London. Retrieved July 25, 2019, from https://www.dropbox.com/sh/z16unyvcxy4ug78/AADxjVHsqdetibWXtaNmE9TAa?dl=0&preview=Erhardt+Thesis-Final.pdf.

Esri. (2010, November 2). USA Parks. *Esri Data and Maps*. Retrieved August 30, 2019, from https://www.arcgis.com/home/item.html?id=578968f975774d3fab79fe56c8c90941.

Fitzgerald Rodriguez, J. (2016, September 8). Historic Muni Streetcar Shortage Highlights Driver Training Woes. *San Francisco Examiner*. Retrieved August 29, 2019, from https://www.sfexaminer.com/news/historic-muni-streetcar-shortage-highlights-driver-training-woes/.

Fitzgerald Rodriguez, J. (2018, June 21). Geary Bus Rapid Transit Gets Environmental "Green Light to Advance" from Feds. *San Francisco Examiner*. Retrieved August 29, 2019, from https://www.sfexaminer.com/news/geary-bus-rapid-transit-gets-environmental-green-light-to-advance-from-feds/.

Fixler, K. (2020, January 3). SMART Ridership Declined in Second Year, but Weekday Use Growing, Newly Obtained Records Show. *Press Democrat* (Santa Rosa, CA). Retrieved February 3, 2020, from https://www.pressdemocrat.com/news/10518434-181/smart-ridership-declined-in-2nd.

Freemark, Y. (2019). Route Miles for U.S. and Canada Rail Systems. *The Transport Politic*. Retrieved July 30, 2019, from https://www.thetransportpolitic.com/databook/route-miles-for-us-and-canada-rail-systems/.

FTA. (2019, December 16). The National Transit Database (NTD). *Federal Transit Administration*. Retrieved January 7, 2020, from https://www.transit.dot.gov/ntd.

GGBHTD. (2018). Golden Gate Bus and Ferry Services. *Golden Gate Bridge, Highway, and Transportation District*. Retrieved September 16, 2019, from http://goldengatetransit.org/services/.

GGBHTD. (2019a). GTFSTransitData. *Golden Gate Bridge, Highway, and Transportation District*. https://realtime.goldengate.org/gtfsstatic/GTFSTransitData.zip.

GGBHTD. (2019b). *UCLA Last Five Years*. GGBHTD.

Guerra, E., and Cervero, R. (2011, July 1). Cost of a Ride. *Journal of the American Planning Association*, *77*(3), 267–290. https://doi.org/10.1080/01944363.2011.589767.

Guerra, E., Cervero, R., and Tischler, D. (2012). Half-mile Circle: Does It Best Represent Transit Station Catchments? *Transportation Research Record: Journal of the Transportation Research Board*, *2276*(1), 101–109. Retrieved July 30, 2019, from https://journals.sagepub.com/doi/10.3141/2276-12.

Healy, M. (2016). BART: The Dramatic History of the Bay Area Rapid Transit System. Berkeley, CA: Heyday.

Hoang, L. (2017, May 5). VTA's Transit Service Redesign Plan is Approved. *Valley Transportation Authority*. Retrieved August 30, 2019, from http://vtaorg.force.com/News-and-Media/Connect-with-VTA/VTAs-Transit-Service-Redesign-Plan-is-Approved#.XWmF4yhKiUk.

Houston, M. (2015, September 22). Yogi Berra Dies at 90: Here Are Some of His Greatest Quotes. *Los Angeles Times*. Retrieved July 31, 2019, from https://www.latimes.com/sports/sportsnow/la-sp-sn-yogi-berra-turns-90-quotes-20150512-story.html.

Jaffe, E. (2013, January 11). Silicon Valley Can't Get Transit Right. *CityLab*. Retrieved September 24, 2019, from http://www.theatlanticcities.com/commute/2013/01/silicon-valley-cant-get-transit-right/4374/.

KTVU Fox 2. (2017, October 19). Golden Gate Transit Offers Free Bus Rides to and from Sonoma County through Sunday. *Fox 2 KTVU*. Retrieved January 24, 2020, from https://www.ktvu.com/news/golden-gate-transit-offers-free-bus-rides-to-and-from-sonoma-county-through-sunday.

Manville, M., Taylor, B., and Blumenberg, E. (2018, January). *Falling Transit Ridership: California and Southern California*. University of California, Los Angeles Institute of Transportation Studies. https://www.scag.ca.gov/Documents/ITS_SCAG_Transit_Ridership.pdf.

Marin Transit. (2015). *System Performance Summary for FY 2014/15*. Marin Transit.

Marin Transit. (2018). *System Performance Summary for FY 2017/18*. Marin Transit. Retrieved January 24, 2020, from https://marintransit.org/sites/default/files/inline-files/FY18%20Annual%20Performance%20Report.pdf.

MTC. (2017, September). *Bay Area Core Capacity Transit Study: Final Report*. MTC. Retrieved July 31, 2019, from https://mtc.ca.gov/sites/default/files/CCTS_Final_Report.pdf.

MTC. (2019, February 13). *Transit Sustainability Project (TSP) Performance Report Update* (File #18-0955). MTC. Retrieved November 15, 2019, from https://mtc.legistar.com/View.ashx?M=F&ID=7026672&GUID=D7368E47-1953-49E9-ABB6-7E588D02CBC3.

Richards, G. (2017, January 6). VTA Proposes Biggest Transit Overhaul since 2008. *Mercury News*. Retrieved August 30, 2019, from https://www.mercurynews.com/2017/01/06/vta-proposes-biggest-transit-overhaul-since-2008/.

Rosenberg, M. (2012, December 26). Twenty-five Years Later, VTA Light Rail among the Nation's Worst. *Mercury News*. Retrieved September 24, 2019, from https://www.mercurynews.com/2012/12/26/25-years-later-vta-light-rail-among-the-nations-worst/.

Rudick, R. (2017, March 24). Pics from the Warm Springs/South Fremont BART Opening Celebration. *Streetsblog San Francisco*. Retrieved September 11, 2019, from https://sf.streetsblog.org/2017/03/24/pics-from-the-warm-springssouth-fremont-bart-opening-celebration/.

SamTrans. (2019a). *SamTrans 2011-2018 Ridership*. SamTrans.

SamTrans. (2019b). ST-GTFS. *SamTrans*. http://www.samtrans.com/Assets/GTFS/samtrans/ST-GTFS.zip.

SamTrans. (2019c). Timetables. *SamTrans*. Retrieved September 20, 2019, from http://www.samtrans.com/schedulesandmaps/timetables.html.

San Francisco Chronicle. (2020). Kincade Fire. *San Francisco Chronicle*. Retrieved January 24, 2020, from https://projects.sfchronicle.com/trackers/california-fire-map/2019-kincade-fire.

SFMTA. (2013, June 11). GTFS Transit Data. *SFMTA*. Retrieved August 29, 2019, from https://www.sfmta.com/reports/gtfs-transit-data.

SFMTA. (2015, April 3). Muni Forward Brings You More Service, Muni Rapid, New Map. *SFMTA*. Retrieved August 29, 2019, from https://www.sfmta.com/blog/muni-forward-brings-you-more-service-muni-rapid-new-map.

SFMTA. (2017, August 14). 7R Service to Become 7 Local Service. *SFMTA*. Retrieved August 29, 2019, from https://www.sfmta.com/travel-updates/7r-service-become-7-local-service.

SFMTA. (2018). Annual Ridership FY98-Present. SFMTA.

SFMTA. (2019a). Muni History. *SFMTA*. Retrieved August 30, 2019, from https://www.sfmta.com/getting-around/muni/muni-history.

SFMTA. (2019b, June 12). Muni System Map. *SFMTA*. Retrieved August 29, 2019, from https://www.sfmta.com/maps/muni-system-map.

Silicon Valley Transit Users. (2019, August). *Route to VTA Ridership Success*.

SMART. (2017, August 22). Grand Opening Celebration. *Sonoma-Marin Area Rail Transit*. Retrieved September 16, 2019, from http://sonomamarintrain.org/grand-opening.

Taylor, B., Garrett, M., and Iseki, H. (2000, January 1). Measuring Cost Variability in Provision of Transit Service. *Transportation Research Record: Journal of the Transportation Research Board*, *1735*(1), 101–112. https://doi.org/10.3141/1735-13.

Taylor, B., Miller, D., Iseki, H., and Fink, C. (2009, January 1). Nature and/or Nurture?: Analyzing the Determinants of Transit Ridership across U.S. Urbanized Areas. *Transportation Research Part A: Policy and Practice*, *43*(1), 60–77. https://doi.org/10.1016/j.tra.2008.06.007.

Thomas, T. (2015, December 1). *MTC Drive/Transit Time Skims*. MTC.

U.S. Census Bureau. (2011, September). Intercensal Estimates of the Resident Population: April 1, 2000 to July 1, 2010. *U.S. Census Bureau*. Retrieved July 31, 2019, from https://www2.census.gov/programs-surveys/popest/tables/2000-2010/intercensal/.

U.S. Census Bureau. (2018). Cartographic Boundary Files—Shapefile. *U.S. Census Bureau*. Retrieved July 30, 2019, from https://www.census.gov/geographies/mapping-files/time-series/geo/carto-boundary-file.html.

U.S. Census Bureau. (2019a). American Community Survey, U.S. Census, Intercensal Estimates, and Nonemployer Statistics. *American FactFinder*. Retrieved July 19, 2019, from https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census Bureau. (2019b). TIGER/Line Shapefiles. *U.S. Census Bureau*. Retrieved October 18, 2019, from https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html.

U.S. Census Bureau. (n.d.). Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES). *OnTheMap*. Retrieved July 30, 2019, from https://onthemap.ces.census.gov/.

Voulgaris, C., Taylor, B., Blumenberg, E., Brown, A., and Ralph, K. (2017). Synergistic Neighborhood Relationships with Travel Behavior: An Analysis of Travel in 30,000 U.S. Neighborhoods. *Journal of Transport and Land Use*, *10*(1), 437–461. https://doi.org/10.5198/jtlu.2016.840.

VTA. (2005, November 7). Santa Clara Valley Transportation Authority History. *Valley Transportation Authority*. Retrieved August 30, 2019, from http://vtaorg.force.com/sfc/servlet.shepherd/version/download/068A0000001FaML.

VTA. (2018). *APR15 to JUL18*. VTA.

VTA. (2019a). Routes. *Valley Transportation Authority*. Retrieved August 30, 2019, from https://www.vta.org/go/routes.

VTA. (2019b, May 10). VTA GTFS Data File. *VTA Open Data*. Retrieved August 30, 2019, from http://data.vta.org/datasets/5d8737b6593a47a280636679aa337966.

Walker, J. (2012). Human Transit: How Clearer Thinking about Public Transit Can Enrich Our Communities and Our Lives. Washington: Island.

Wasserman, J. (2019). *A Time and a Place for Every Rider?: Geographic and Temporal Changes in Bay Area Transit Ridership* (Master of Urban and Regional Planning Applied Planning Research Project). UCLA, Los Angeles. https://doi.org/10.17610/t6kw22.

Watry, D. (2019). [Personal communication].

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