LESSONS FROM LIME DATA: HOW CITIES CAN USE SHARED MICROMOBILITY DATA FOR TRANSPORTATION PLANNING AND POLICY

League of American Bicyclists' Mobility Insights Competition Report
September 2024

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About

League of American Bicyclists

Since 1880, the League of American Bicyclists has been people-powered, with a goal to make bicycling safer and easier as a means of transportation and recreation. Today, the League continues to improve lives and strengthen communities through bicycling. We are more than 200,000 members and supporters strong with more than 1,000 state and local advocacy groups and bike clubs as well as thousands of businesses, universities, and communities together leading the movement to create a Bicycle Friendly America for everyone. For more information, go to bikeleague.org.

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Lime

Lime's mission is to build a future where transportation is shared, electric and carbon-free. As a leading global provider of shared electric vehicles, Lime partners with cities to deploy electric bikes and scooters to serve any trip under five miles. A Time Magazine 100 Most Influential Companies and Fast Company Brand that Matters, Lime has powered more than 700 million rides in more than 280 cities across five continents, spurring a new generation of clean alternatives to car ownership. Learn more at li.me.

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Acknowledgements

Thank you to our partners, Hank Duncan and Andrea de La Rosa from the City of Bloomington, Indiana and Ted Randell and Greg Matlesky from the District Department of Transportation in Washington, DC, for their contributions to the report.

Letter from the League of American Bicyclists

For more than 140 years, the League of American Bicyclists has been the national grassroots advocacy organization leading the movement to create a Bicycle Friendly America for everyone. Our Bicycle Friendly Community (BFC) program, in particular, exists to provide the tools, motivation, and roadmap for communities to make bicycling safer, easier, and more accessible for all.

Since the 1990s, the League has worked with nearly 900 communities across the nation through the BFC program – providing these places with guidance and recommendations to shape their policies, plans, programs, and infrastructure. As new data, new technology, and new best practices surface, our standards for what it means to be a 'Bicycle Friendly Community' must also evolve to meet the moment.

The two communities that were selected for the 2024 Lime Mobility Insights Competition both originally joined the BFC program in 2003 as Bronze-level communities, long before automated data collection or 'shared micromobility' were part of the application. Both Bloomington, Indiana, and Washington, DC, have advanced to Gold-level status in the BFC program today, thanks to years of local advocacy and thanks to investments in better bicycling by the cities themselves. But in both cases, as in every community across the country, our work isn't done, and there is still room to improve.

The insights we've gained from Lime's data for both DC and Bloomington, outlined in this report, help to demonstrate exactly why communities of all shapes and sizes must continue to make these investments — we can see very clearly that building better infrastructure, and establishing policies to support that infrastructure, has had real-world consequences in helping more people to make trips on two wheels, and do so safely. The data available to DC, Bloomington, and other cities with Lime systems is a powerful tool to make the case for these continued investments.

Whether your community has a shared micromobility system or not, the implications of this research are clear, and we encourage every local bike advocate and decision maker to consider the potential impact of similar investments in bicycling where you are.

Bill Nesper, Executive Director, League of American Bicyclists

Executive Summary

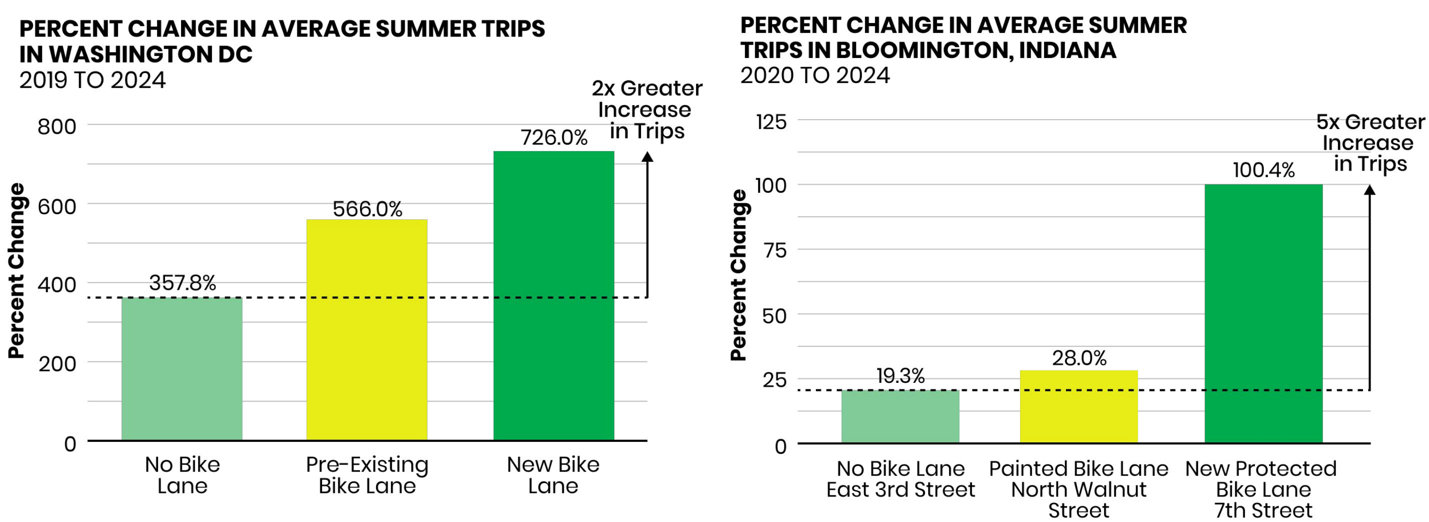
Lime, together with the League of American Bicyclists, introduced a Mobility Insights Competition in 2024, with the goal of partnering with two jurisdictions in the U.S. to **leverage Lime's extensive data to address transportation challenges and enhance safety for *all* road users**. Through a competitive application process, Lime and the League of American Bicyclists selected Washington, DC and Bloomington, Indiana as the 2024 partner cities.

Working with practitioners from both cities, the Mobility Insights research team identified **3 key insights, along with policy and planning implications:**

1 Shared micromobility users strongly prefer bike lanes, especially protected infrastructure

In Washington DC, Lime trips increased by twice as much between 2019 and 2024 on streets with new bike infrastructure as on streets with no bike infrastructure - a statistical analysis suggests that the installation of a new bike lane led to an average of 20 additional Lime trips per day. This preference for riding on bike infrastructure is also shown in overall travel patterns: while only 1 in 10 street segments in DC have a bike lane, 40% of Lime trips take place on a bike lane. Similar patterns were observed in Bloomington, where about a quarter of street segments have bike infrastructure, yet these lanes account for nearly 60% of Lime trips. Specifically in Bloomington, the installation of a protected bike lane saw a 100% increase in trip volumes, over 5 times that of streets without bike lanes.

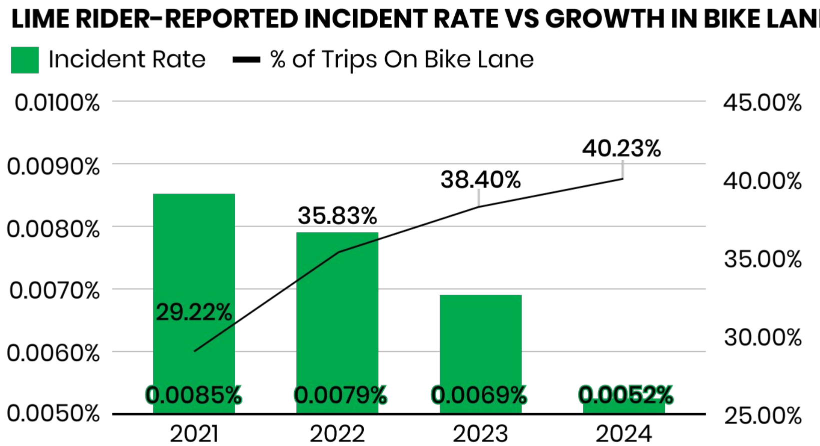
Figure 1. Larger Increases in Lime Trips on Streets with New Bike Lanes Compared to No Bike Lane



2 Safety outcomes are improving, thanks to better infrastructure

In both Washington, DC and Bloomington, rider-reported safety incidents are rare, occurring on less than 0.02% of trips. In DC, rider-reported safety incidents have fallen by 39% between 2021 and 2024. The District's rapid installation of bike lanes likely played an important role, as Lime riders' usage of bike lanes increased by 38% during this same time period, a nearly identical percent change as the reduction in rider-reported safety incidents (see Figure 2). Rates of rider-reported safety incidents in Bloomington remained relatively consistent between 2021 and 2023, but have decreased by 71% to date in 2024.

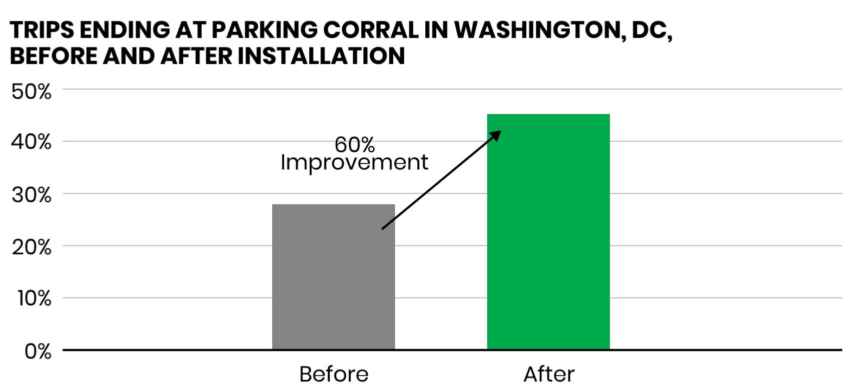
Figure 2. Decreased Lime Rider-Reported Incident Rate Per Trip in Washington, DC, Coincides with Increase in Bike Lane Use



3 Provide parking corrals, and riders will use them

In Washington, DC, local regulations require that dockless shared scooter and bicycle trips end with the rider physically locking the vehicle to a bike rack or other infrastructure. Where the city has installed additional parking corrals, parking concentration has increased by 60%. Success factors include being well marked, placing parking corrals on-street, and locating corrals at pedestrian crossings to improve visibility at intersections. In Bloomington, Indiana, riders are required to park in mandatory parking zones within the downtown area and on the Indiana University campus. Bloomington has followed parking best practices by providing a high density of parking locations so it is easy for riders to find parking. Analyzing data on blocked parking attempts by riders - when a user is prevented from ending their trip because they aren't located at a designated corral according to GPS - the research team identified a set of proposed locations for additional parking corrals to further improve parking compliance.

Figure 3. Increased Concentration of Lime Parking After the Installation of Parking Corrals in Washington, DC



Policy and Planning Implications

The 2024 Mobility Insights Competition cities provide excellent templates for other cities to follow, especially with respect to bike and scooter parking. In Washington, DC, the District Department of Transportation (DDOT) has swiftly installed thousands of bike racks over the last 3 years, while in Bloomington, the city implemented a dense parking corral network in the downtown.

For cities looking to follow Washington, DC, and Bloomington, Indiana's leadership, or to benefit from Lime's experience in nearly 300 cities around the world, Lime can provide support in developing parking plans and analyzing safety trends, as well as partner on grant applications to fund bike parking and dedicated infrastructure.

REFLECTIONS FROM HANK DUNCAN, BICYCLE AND PEDESTRIAN COORDINATOR, CITY OF BLOOMINGTON, INDIANA:

The City of Bloomington has focused on two key aspects of shared micromobility: pedestrian accessibility and rider safety. With the implementation of parking corrals and a mandatory parking policy in downtown, Bloomington has seen higher parking compliance than ever before, prompting a desire to further expand this program into other high-use areas of the city.

Above all else, the City's recent Vision Zero ordinance has created the momentum needed to upgrade and expand Bloomington's bicycle and pedestrian infrastructure to truly create a low-stress network. Partnerships like the Mobility Insights Competition are essential to the progress needed to foster a community that encourages walking and rolling, and the findings of this report will be instrumental in the push for safer streets in Bloomington.

REFLECTIONS FROM TED RANDELL, DISTRICT DEPARTMENT OF TRANSPORTATION MICROMOBILITY COORDINATOR, SUSTAINABLE TRANSPORTATION PROGRAMS:

Safety's importance and emphasis in the District is best encapsulated by the District's Vision Zero program, which focuses heavily on vulnerable roadway users and high-injury networks when considering policy, design, and roadway user education strategies. While there is much work to be done, the data in this report reveals an improvement in the incident rate of shared micromobility users as the overall percentage of trips on bike lanes has grown.

Identifying safety gaps in the roadway network where design choices could be considered and a deeper understanding of the who, why, where, and how safety incidents involving shared micromobility are occurring will help inform programmatic choices and ultimately equip riders with more protection when sharing the roadways.

Additionally, information on the growth in ridership, bike lane usage, and parking compliance data for shared micromobility will help our Shared Fleet Device program justify needed investments, scope regulatory focus, and determine areas to focus future research.

Introduction

Lime, together with the League of American Bicyclists, introduced a Mobility Insights Competition in 2024, with the goal of partnering with two jurisdictions in the U.S. to identify and address specific transportation issues that exacerbate the risks for vulnerable road users.

This initiative provided a unique opportunity for participating jurisdictions to harness Lime's extensive datasets, including detailed trip and safety analytics, and leverage expert guidance from both Lime's team of transportation professionals and the League's policy advisors. The aim was to develop targeted, data-driven strategies that will significantly enhance road safety, reduce incidents, and promote a more inclusive and secure transportation environment for pedestrians, cyclists, and micromobility users.

Data Utilization: Participants worked with experts at Lime to harness Lime's data, including but not limited to Mobility Data Specification (MDS), General Bikeshare Feed Specification (GBFS), and safety data. This data provided invaluable insights into user behavior, traffic patterns, and micromobility usage trends.

Expert Collaboration: Jurisdictions worked with Lime's in-house team of transportation planners, engineers, and academic researchers, who assisted the selected jurisdictions with data interpretation and implementation of findings to optimize urban transportation planning.

Infrastructure Planning Support: The League and Lime sought to partner with jurisdictions in the process of developing or updating comprehensive transportation plans or Vision Zero Action Plans. By integrating micromobility data, jurisdictions can make informed decisions on infrastructure development, prioritizing safety, accessibility, and equity.

Research Questions

In consultation with staff from the City of Bloomington and Washington, DC, the research team identified the following three questions as the focus of the Mobility Insights partnership:

1. **Bike lanes:** Do shared micromobility riders show a preference for bike facilities?
2. **Safety:** How are safety outcomes evolving over time? Are we seeing improvements related to bike facility investments?
3. **Parking:** Do parking investments affect parking behavior? Where are the best locations for additional parking?

Methods

Influence of bike infrastructure on trip routes, volumes

Understanding where Lime trips are taken requires matching trip routes to a street network map. For this purpose, the research team relied on the widely-used, open-source tool, OpenStreetMap (Ferster et al., 2020). To identify how many Lime trips were taken on individual street segments, the research team examined the GPS "breadcrumb" route of every Lime trip taken during the summer months (June through August) from 2019 through 2024 and identified if the path passed through the street segment provided by OSM. For more details on this methodology, see the Appendix.

The research team worked with staff at the District Department of Transportation and the City of Bloomington Department of Planning and Transportation to identify and extract data on the location of bicycle infrastructure as well as when it had been installed. In conjunction with Lime trip data, the bike infrastructure location and installation date information allowed the research team to examine how Lime trip volumes changed after the installation of bike infrastructure. We focused the analysis on painted bike lanes and protected bike lanes, and we did not include other bike facilities (e.g. sharrows, neighborhood greenways, etc.).

To accurately understand the effect of adding bike infrastructure, it is important to compare a street with new bike infrastructure to a street that is otherwise similar (e.g. same number of lanes, same speed limit) but where the city did not add a bike lane. Therefore, for each street segment in Washington, DC, and Bloomington, the research team extracted OSM's segment attribute data on the speed limit for cars and the number of travel lanes. In addition to identifying comparison streets based on speed limits and travel lanes, the research team imposed additional requirements on the proximity to the street with a new bike lane. The comparison street had to be more than a quarter mile away from any other bike infrastructure (not just the focus street), which ensured that the analysis excluded any comparison of immediately-adjacent streets, where riders might simply divert their route - confounding the analysis. At the same time, the comparison street could be no further than one mile away from the segment with the new bike lane, to attempt to control for similar land uses and activity densities. Washington, DC, had sufficient OSM data on the segment attributes, which allowed us to conduct a robust difference-in-differences analysis to quantify the effect of adding a bike lane, while Bloomington, Indiana, did not have sufficient OSM data to perform this statistical analysis.

Improving micromobility safety

Lime users can report safety incident data in a number of ways. When a Lime user is involved in an incident such as a crash or fall while using Lime, they are encouraged to report it directly on the app or to contact Lime by phone. An additional form is available on Lime's website for any third party involved in a safety incident with a Lime vehicle. Lime also works with the police in the event of a safety incident to report and retrieve incident data involving its vehicles.

Using rider-reported safety incident data, the research team compared the number of incidents reported to the number of trips taken to calculate a per-trip incident rate. The research team further broke down the rider-reported incident rate on an annual basis, to understand trends over time. We also compared safety trends over time against data showing the proportion of Lime trips spent on bicycle facilities over the same time period. Finally, the research team examined how rider-reported incident rates varied by where incidents occurred, to examine whether the provision of bike infrastructure is associated with better safety outcomes.

Planning for parking

The analysis of parking differed for the two cities, as Bloomington and Washington, DC, have implemented different regulations governing how riders should park shared scooters and bicycles. In Washington, DC, riders are required to physically lock the shared scooter or bike to a bike rack or street furniture (often called "lock-to" requirements). While the District Department of Transportation has installed "parking corrals" - micromobility parking areas generally located on-street, where car parking is typically provided - DDOT does not require riders to park in the corrals. In Bloomington, Indiana, in the downtown area and on Indiana University campus, riders are required to end their trips at designated parking locations.

For Washington, DC, we compared where riders parked before and after corrals were installed, to understand the natural "clustering" that occurs within corrals, even absent a mandate that riders use the corrals. In particular, we compared trips ending within 20 meters of a parking corral location - a reasonable margin of error, given GPS drift - versus trips ending within 50 meters - a distance from which it is reasonable to expect riders to be able to see a parking corral (see Figure 4 for an illustration).

For Bloomington, Indiana, we analyzed parking using two methods. The first was using the same methodology as above in Washington DC, but we did not compare parking corrals before and after

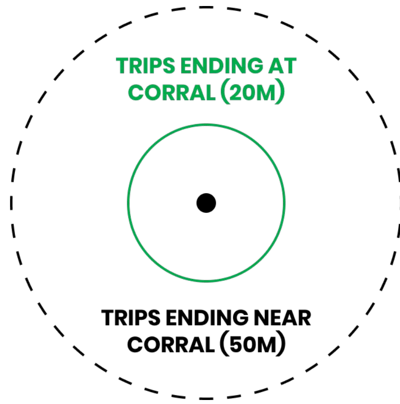


Figure 4. Parking Corral Analysis Methodology for Washington, DC

installation. Instead, we used the ratio to highlight where parking compliance is highest and where parking corrals see the most demand. The second method was to compare parking corral density with the rate of blocked parking attempts - Lime's data on where riders had attempted to park but were restricted from doing so, because it was not in one of the designated parking areas. By comparing parking density with blocked parking, we are able to better understand at what parking density blocked parking spikes. We are able to use this information to develop a set of recommendations for the installation of future designated parking areas.

In Washington, DC, we also provided recommendations on where additional parking corrals could be installed. Recommendations were developed using Lime's hourly vehicle location data and trip end locations. Parking demand was calculated by determining the average hourly maximum number of vehicles deployed within Washington, DC, aggregated to 300 meter x 300 meter hexagon grid cells. Using the average hourly maximum vehicle count, we were able to determine how much parking would be needed to accommodate the maximum amount of vehicles that cluster at locations throughout the city. Trip end data was used to further refine parking recommendations. Trip end locations were clustered to identify hotspots within each hexagon grid where there is the highest demand.

Results

Bike lanes

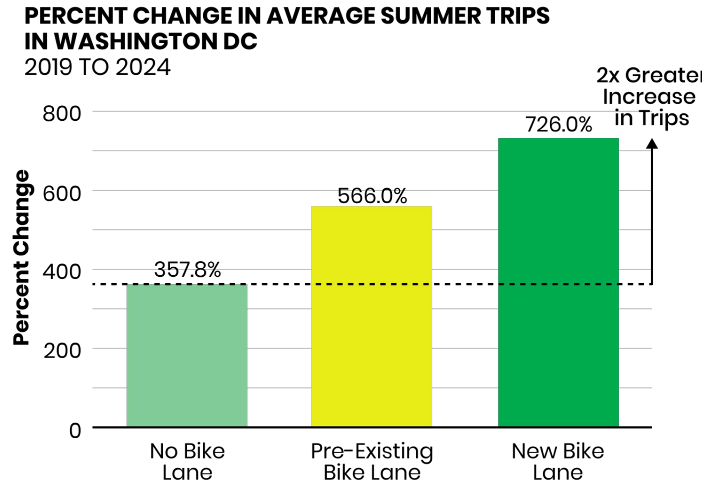
WASHINGTON, DC

In Washington, DC, ridership increased on all facilities as DDOT grew the shared micromobility program from 3,600 vehicles available in 2019 to nearly 19,000 in 2024, a 400% increase in availability. During that time, DDOT also installed nearly 41 miles of new bike lanes. As a result of these investments and program changes, shared dockless micromobility trips in Washington DC increased 6.6% from 2019 to 2023 and 128% from 2020 to 2023, marking a return to and continued growth from pre-pandemic levels. 2020 ridership dwindled to below 3 million trips in 2020 while 2024 boasted 6.7 million rides on dockless bikes and scooters.

However, Lime ridership did not increase evenly across all streets over that time span. As described in the methods, we compared trip volumes on streets with new bike lanes to comparison streets that had similar characteristics but no change in bike infrastructure (see Figure 6 for a map of the selected streets for analysis). On streets where new bike lanes (protected and painted) were installed between 2020 and 2023, Lime trip volumes increased twice as much from 2019 to 2024 as on streets without bike lanes (see Figure 5).

In this analysis, it is important to establish strong evidence that the increases in trip volumes were a result of the addition of a new bike lane - not simply because the street was already popular or well-placed. One important step is to assess whether "treatment" streets (with bike lanes added) had similar trends in ridership as "control" segments (where no bike lanes are present) before the introduction of the bike lane.

Figure 5. Percent Change in Lime Trips Between 2019 and 2024 During the Summer Months in Washington, DC

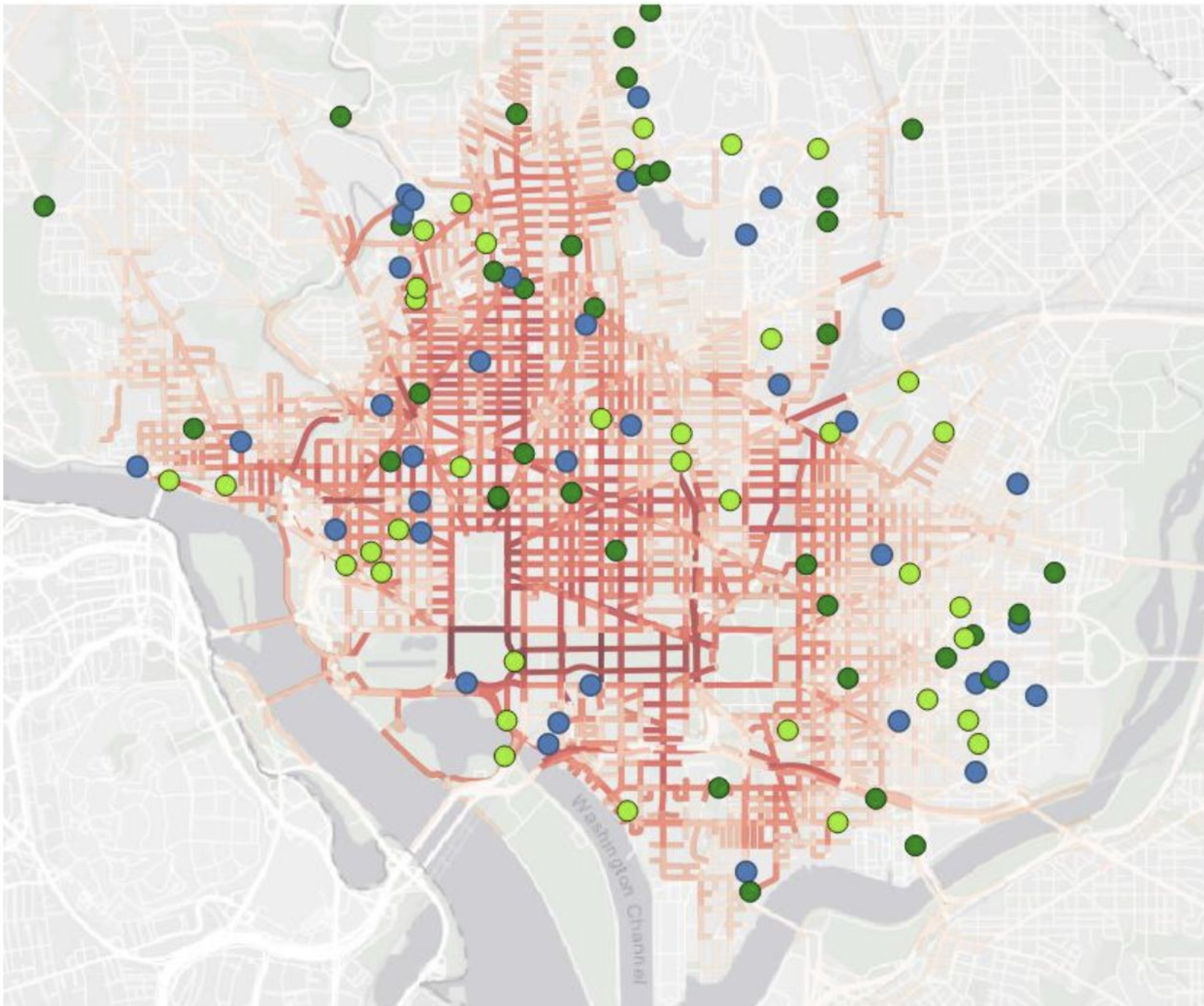


Trip volumes increased by 726% on streets with new bike lanes, more than doubling the 357% increase seen on streets without bike lanes.

Figure 7 shows how, on average, the treatment and control streets had similar trends in trip volumes in 2019 and 2020, but trip volumes diverged from 2021 onward - providing strong evidence that the introduction of bike lanes caused the increases. Over the 5 year observation period, trip volumes on segments with a bike lane installed in 2020 increased by about 780%, nearly 1.5 times more than the trip increases experienced on matched segments without bike lanes (507% increase).

Figure 6. Map of Trip Volumes in Washington, DC and Selected Locations for Comparison

2024 Summer Trip Volumes
Washington, DC



Segment Type

- New Bike Lanes
- No Bike Lanes
- Pre-Existing Bike Lanes

Summer Trip Volumes (In Thousands)

- <2
- 2 - 5
- 5 - 8
- 8 - 13
- 13 - 18
- 18 - 24
- 24 - 32
- 32 - 48
- 48 - 84
- 84+

Figure 7. Lime Trip Volumes in Washington DC for Streets with Bike Lanes Installed in 2020 (green) Compared to Streets Without a Bike Lane (grey)

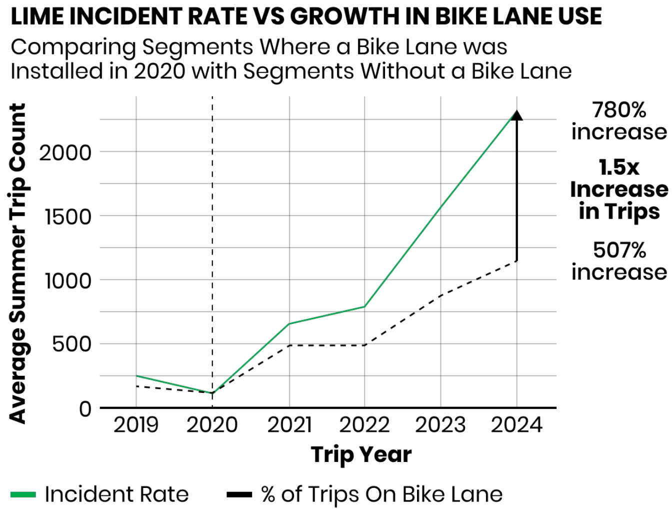
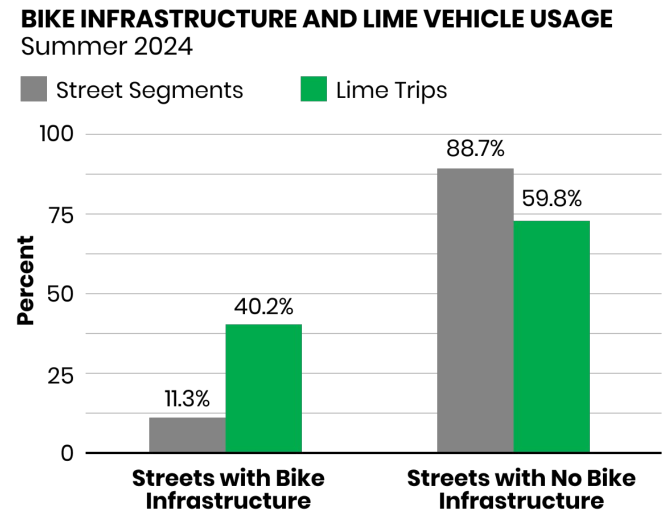


Figure 8. Percentage of Streets Segments With and Without Bike Infrastructure Compared to Lime Trip Volumes in Washington, DC



The trends in trip volumes over time across different facility types show how strongly Lime riders prefer to use bike infrastructure. To paint that preference in stark relief, we compared the percentage of trip volumes occurring on bike lanes with the availability of bike lanes (see Figure 8).

This comparison reveals that while only about 1 in 10 street segments in Washington, DC, have bike infrastructure, 40% of trip volumes are on segments with bike infrastructure, four times the actual availability.

One of the most robust ways to establish the effect of policy and planning efforts such as the installation of bicycle infrastructure, is to run a difference-in-differences statistical analysis. For the purpose of this study, the difference-in-differences statistical method compared trends over time on streets where bike lanes were added to trends over time on streets without bike lanes, while accounting for other considerations, such as changes in fleet sizes or the effects of the COVID pandemic on travel demand.

The difference-in-differences statistical analysis identified a strong, positive effect of adding bike infrastructure on Lime trips. On average, a street that had bike infrastructure added saw 1,800 more Lime trips in the summer months than would be expected, compared to trends in Lime trip volumes on streets that had no bike infrastructure installed. This equates to an average of 20 additional Lime trips every day compared to a street with no bike lane, not to mention the likely additional trips taken by other shared micromobility companies (e.g., Capital Bikeshare) and personally-owned bicycles and scooters.

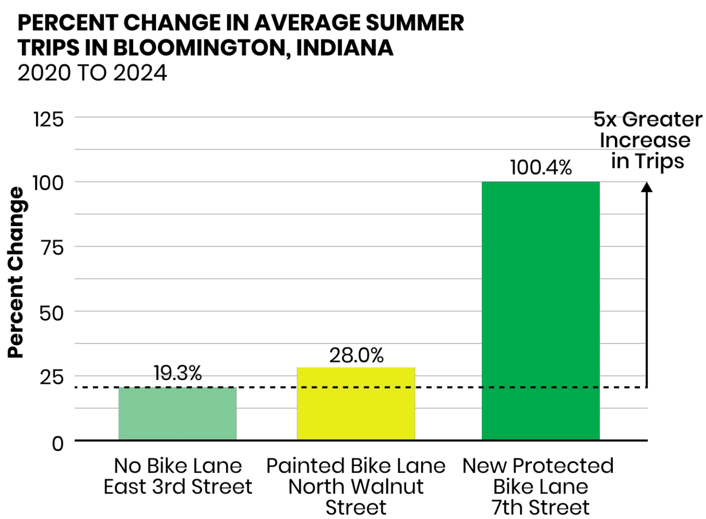
BLOOMINGTON, INDIANA

We observed similar overall patterns in Bloomington, Indiana, as in Washington, DC. Since 2020, Bloomington has added 9.3 miles of bike facilities, focusing primarily on multi-use paths and neighborhood greenways. The most notable project, however, is the 7-Line protected bike lane that now serves as the primary bike corridor connecting downtown Bloomington with the Indiana University campus along East 7th Street. Completed in 2021, it ranked as one of the five best new bike lanes in the US according to People for Bikes (Haggerty, 2023).

Because of the limitations of OSM data in Bloomington, we focused on the streets in the downtown area, rather than analyzing streets throughout the entire city. In particular, we focused on the 7-Line and how this bi-directional protected bike lane impacted ridership. As a comparison case, we chose East 3rd Street, where no bike lane exists, but also serves as a primary east-west connector through downtown Bloomington. The other comparison street we chose, with a pre-existing painted bike lane, was North Walnut Street, which is the main north-south arterial and passes through the core of the downtown commercial area, similar to the 7-Line (see Figure 11).

Lime trip volumes on the 7th Street protected bike lane increased by 100% between 2020 and 2024, compared to a 19% increase on the control segment (E 3rd Street) and a 28% increase on the pre-existing painted bike lane (N Walnut Street) over that same time span (see Figure 9). In other words, Lime trip volumes increased by 5 times more on the protected bike lane compared to a similar street without a bike lane.

Figure 9. Change in Trip Volumes in Bloomington, Indiana, between 2020 and 2024



Building on this analysis, we compared the proportion of trip routes that took place on bike lanes to the proportion of street segments with bike lanes. Similar to Washington, DC, in Bloomington, bike lanes are heavily utilized by riders. Although only a quarter of street segments have bike infrastructure, nearly 60% of Lime trips occurred on bike lanes - over twice as many trip routes as available infrastructure (see Figure 10).

The high percentage of trips on bike lanes despite their comparatively smaller proportion of total street segments indicates that riders prefer to take their trips on streets where bike infrastructure is present.

Figure 10. Percentage of Streets Segments With and Without Bike Infrastructure Compared to Lime Trip Volumes in Bloomington, Indiana

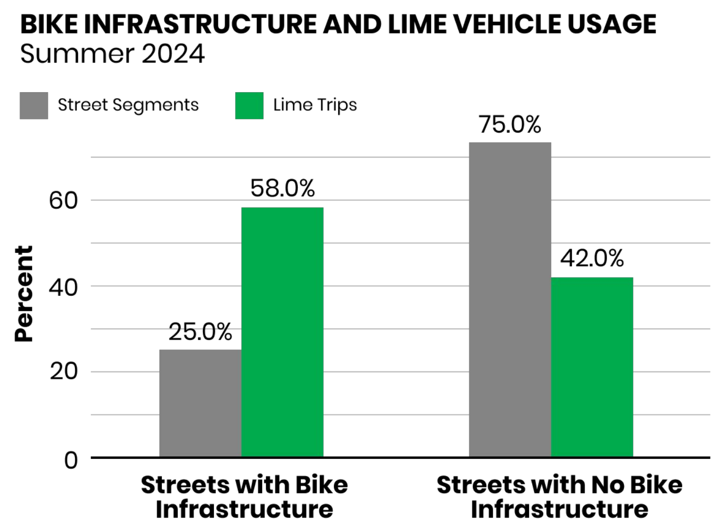
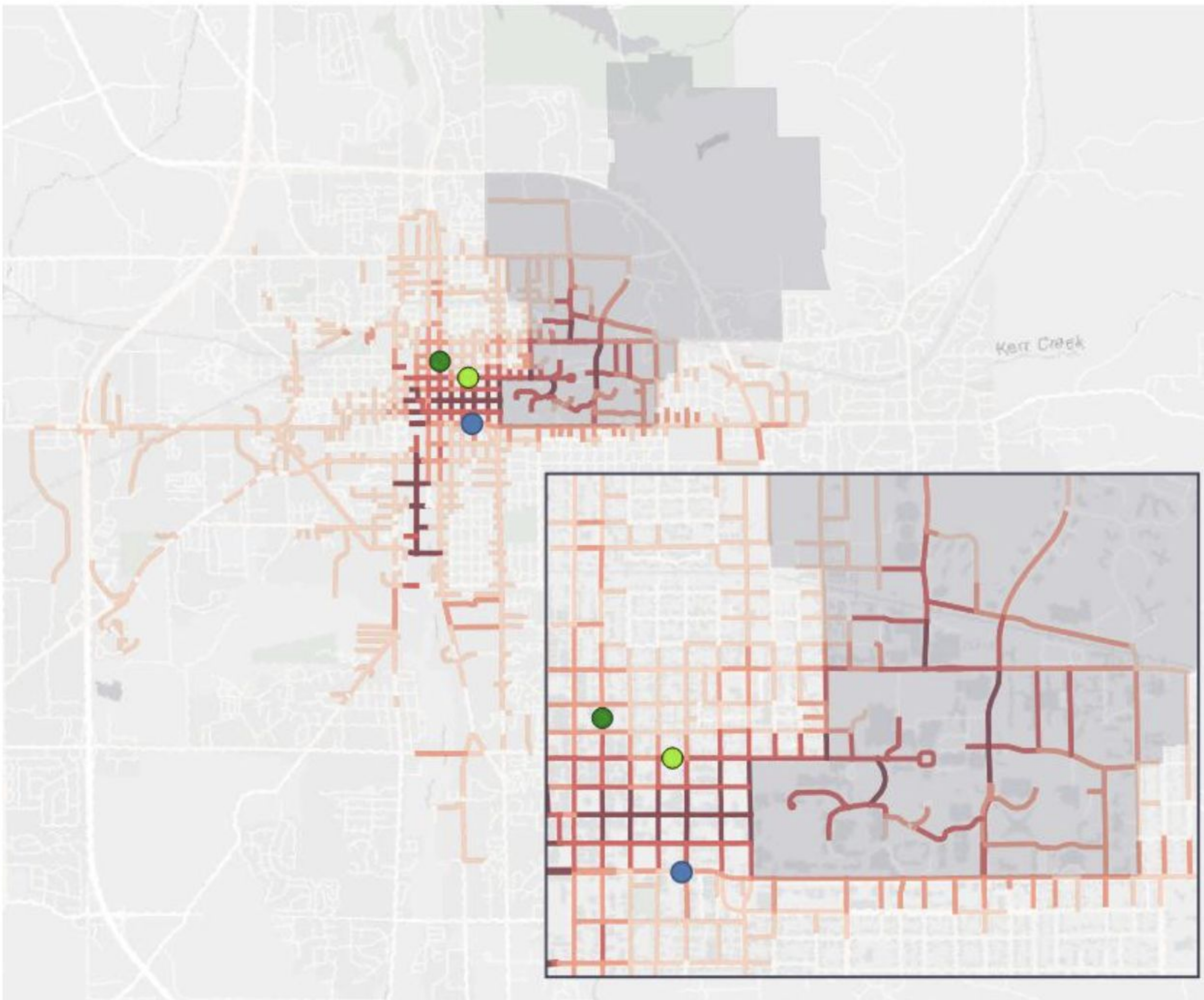


Figure 11. Map of Trip Volumes in Bloomington, Indiana and Selected Locations for Comparison

2024 Summer Trips
Bloomington, IN



Segment Type

- New Bike Lane
  7th Street
- No Bike Lanes
  E 3rd Street
- Pre-Existing Bike Lanes
  N Walnut Street

Summer Trip Volumes

- 1 - 100
- 100 - 300
- 300 - 600
- 600 - 1000
- 1000+

Indiana University

SUMMARY

In both Washington, DC, and Bloomington, Indiana, Lime riders displayed a clear preference for bicycle facilities, closely mirroring evidence from decades of research for personally-owned bicycling (Pucher et al., 2010). Although only a small (but growing!) fraction of streets in both cities have bike infrastructure, riders made heavy use of what was available, with trip volumes on streets with bike lanes double or quadruple the relative availability - similar to patterns seen in other cities, like New York City (New York City Department of Transportation, 2022).

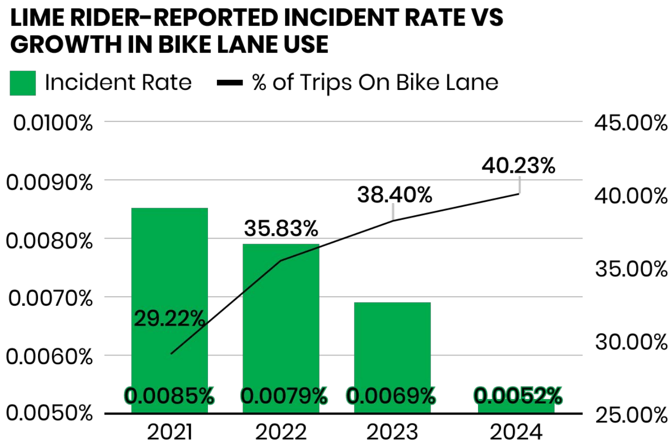
Consistent with this preference, trip volumes increased at a greater rate on street segments with new bicycle infrastructure installed, compared to streets without bike lanes. This finding replicates previous Lime analyses in London, Paris, and Berlin (Haydu, 2020), as well as recent academic research focusing on West Coast cities (Boarnet et al., 2023).

Safety

WASHINGTON, DC

Over the course of the Washington, DC, Lime program, 99.99% of trips have been incident free. Since 2021, rider-reported safety incidents have fallen every year in Washington, DC, with a 39% total reduction between 2021 and 2024. The District's rapid installation of bike lanes likely played an important role, as Lime riders' usage of bike lanes increased by 38% during this same time period, a nearly identical percent change as the reduction in rider-reported safety incidents (see Figure 12).

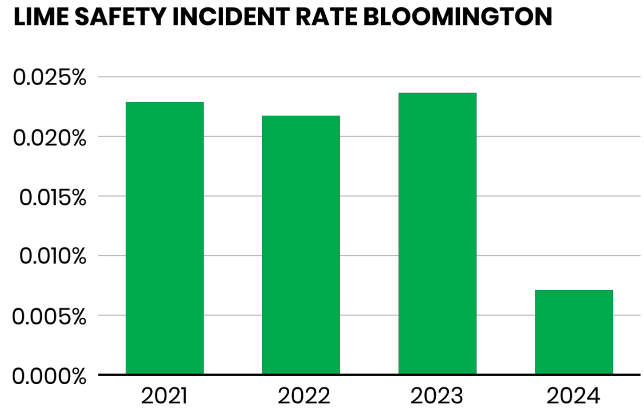
Figure 12. Lime Rider-Reported Safety Incident Rate per Trip and Growth in Bike Lane Use between 2021 and 2024 in Washington, DC



BLOOMINGTON, INDIANA

Since 2021, 99.98% of Lime trips in Bloomington have been incident free. For the 0.02% of Lime trips in Bloomington where a rider reported a safety incident, the majority (>90%) did not require any medical attention. Rates of rider-reported safety incidents in Bloomington remained relatively consistent between 2021 and 2023, but have decreased substantially in 2024 (see Figure 13).

Figure 13. Lime Rider-Reported Safety Incident Rate per Trip between 2021 and 2024 in Bloomington, Indiana



SUMMARY

Shared micromobility safety outcomes are improving globally, as seen in the two cities featured in this report and shown in external studies and reports. For example, a 2024 report from the International Transport Forum (ITF) found a 26% reduction in shared electric scooter incident rates between 2021 and 2022 and that "most reported micromobility crashes result in only minor injuries" (International Transport Forum, 2024). Further reinforcing the findings of this report, the ITF analysis found that "the presence, quality and continuity of bicycle or other micromobility infrastructure contribute to safety outcomes. This is especially the case for infrastructure separated from car traffic and for low-speed streets" (International Transport Forum, 2024).

Parking

WASHINGTON, DC

In Washington, DC, local regulations require that dockless shared scooter and bicycle trips end with the rider physically locking the vehicle to a bike rack or other infrastructure. The city has installed “parking corrals” - bike racks installed in-street, often at intersections - but does not mandate that dockless micromobility trips end at these corrals. The District Department of Transportation has a robust bike and scooter parking program, including a Bike Parking Guide and a process for residents and business owners to request new public racks via the District’s 311 system (District Department of Transportation, 2018; District Department of Transportation, 2022). Since 2021, DDOT has installed over 1,000 bike racks every year, including many located within parking corrals.

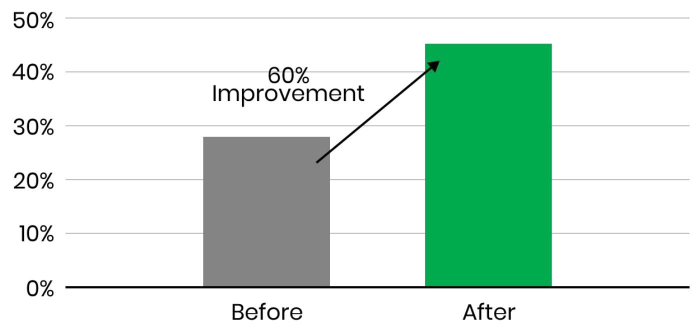
As DDOT has installed parking corrals, riders have put them to good use. Parking has become concentrated at parking corrals, with a 60% increase in trips ending at the corral location compared to before the corral was installed (see Figure 14).

Furthermore, Lime data shows that parking improved at 93% of locations where parking corrals were installed.

Figure 15 below shows how parking corrals varied geographically. Corrals in the core of the city experienced the most use. Compliance and improvements to compliance were more evenly distributed throughout Washington, DC.

Figure 14. Percent of Lime Trips Ending at Parking Corral Locations, Before and After Installation

TRIPS ENDING AT PARKING CORRAL IN WASHINGTON, DC, BEFORE AND AFTER INSTALLATION



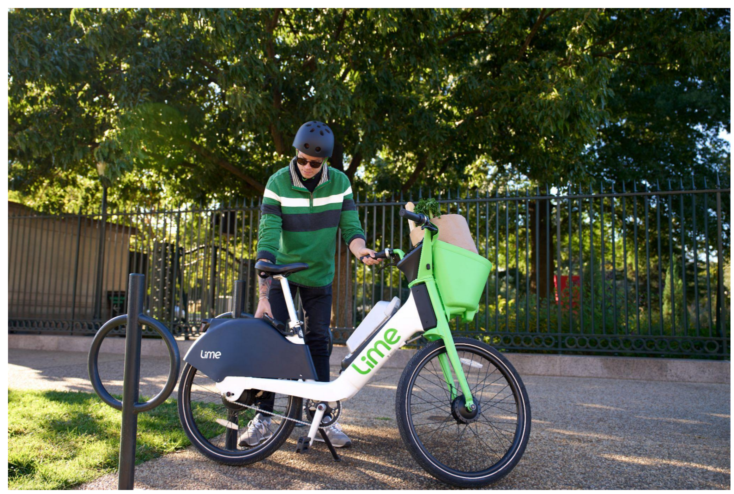
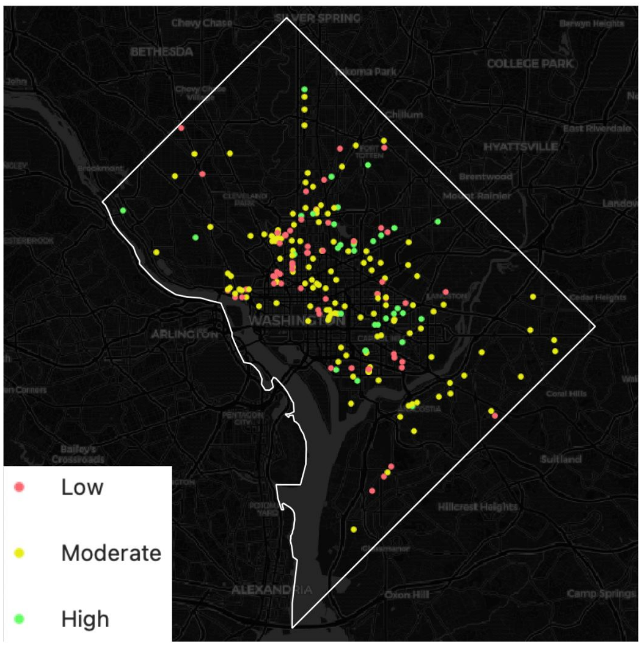
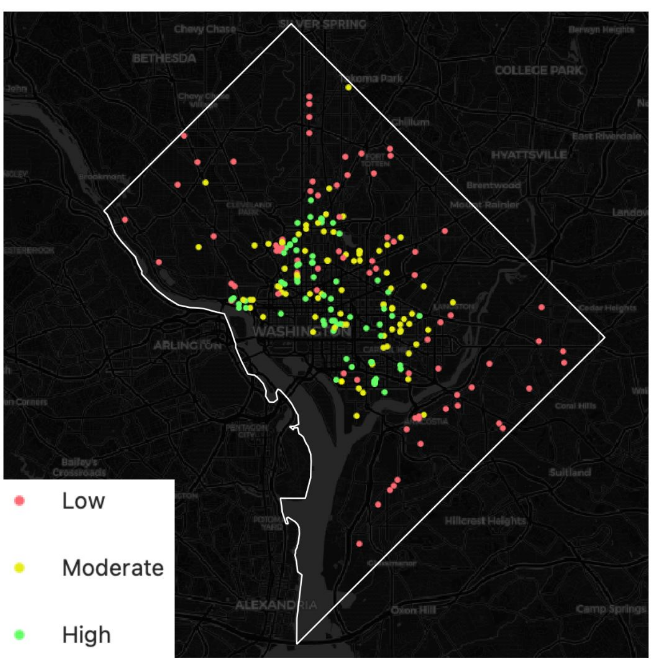


Figure 15. Parking Corral Performance Along Three Measures in Washington DC: (A) Trip Volume, (B) Compliance, and (C) Compliance Change

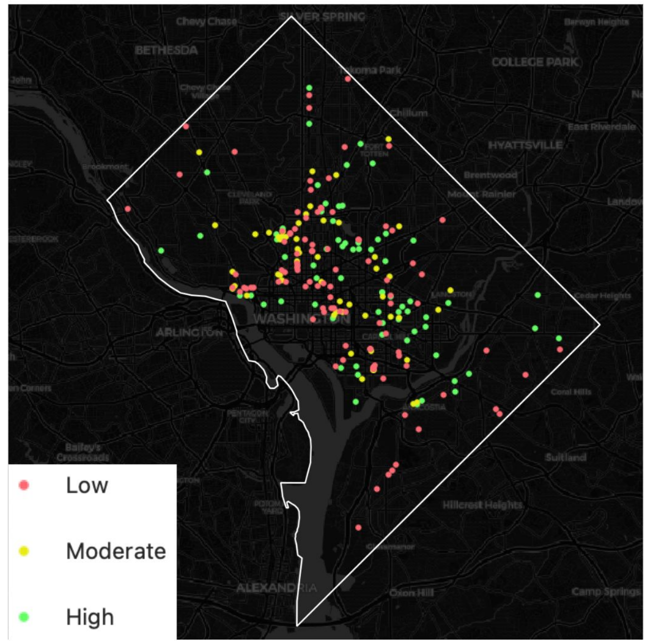
(A) Trip Volume



(B) Compliance



(C) Compliance Change



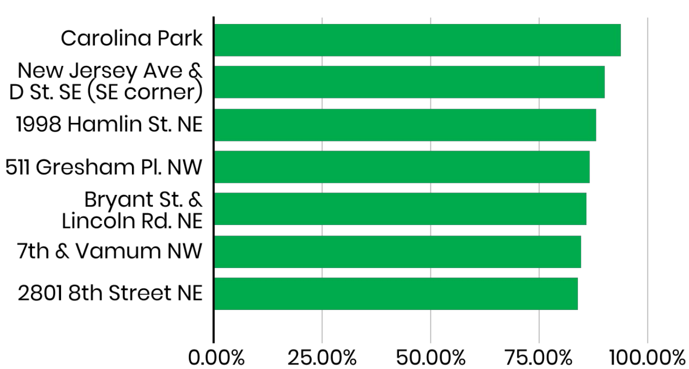
Some parking corral locations had especially high rates of usage (see Figure 16). Three factors stood out as the primary reasons for high usage in these locations:

1. **Locating on-street:** These high-use corrals were all located on-street. On-street corrals provide multiple benefits including: ease of access when finishing a trip, minimizing conflicts between riders and pedestrians, and maintaining pedestrian right of way.
2. **Providing intersection daylighting:** The second factor that stood out is that many high-use parking corrals were placed at the intersection ahead of the pedestrian crosswalk. This placement provides 'daylighting' by removing cars parked adjacent to a crosswalk, thus improving drivers' visibility of pedestrians at intersections. Research shows that improving visibility at intersections improves safety outcomes (Bella & Silvestri, 2015).
3. **Positioning along high-volume bike routes:** The third factor that stood out is that many high-use locations were placed along a bike lane or bike route which makes parking intuitive and highly visible to riders along high traffic corridors.

All three of these factors improve parking compliance and utilization as well as increase the safety of pedestrians and riders.

Figure 16. Parking Corrals with the Highest Rate of Parking within the Corral in Washington, DC

PARKING CORRALS WITH BEST PARKING AFTER INSTALL



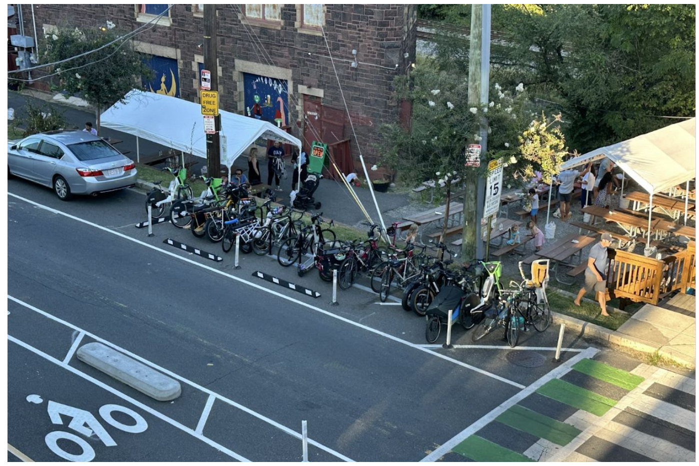
In residential settings, like Carolina Park and Hamlin St NE, the parking corrals are highly visible and provide a clear alternative to parking on the sidewalk, which is often narrow in a residential setting (see Figure 17, photo A). Along bike paths and high volume routes, parking corrals were placed at the intersection, providing better sightlines for improved pedestrian safety via "daylighting" at crosswalks (see Figure 17, photos B and C). For example, at the intersection of New Jersey Ave & D Street SE (SE Corner) (see Figure 17, photo B), a popular bike lane leading to the United States Capitol ends at a no parking zone, forcing riders to either ride elsewhere or park at this location. Because of the parking restrictions near the Capitol and high tourist demand, DDOT provided parking corrals on either side of the intersection, both of which experience high parking volumes. In other, more commercial settings, such as 2801 8th Street NE (see Figure 17, photo D), the parking corrals were located just outside of popular destinations such as the Dew Drop Inn.

Figure 17. Parking Corrals in Residential Neighborhoods: (A) Carolina Park, (B) New Jersey Ave & D Street SE (SE Corner), (C) 4th and Douglas NE, and (D) 2801 8th Street NE.

(A) Carolina Park

(B) New Jersey Avenue & D Street SE

(D) 2801 8th Street NE



(C) 4th & Douglas Streets NE

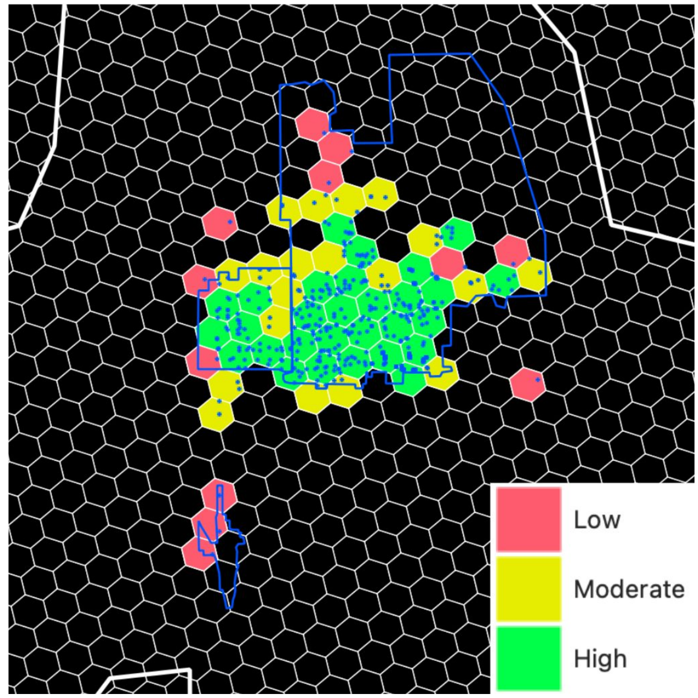
BLOOMINGTON, INDIANA

In the downtown area of Bloomington, Indiana, riders are required to park in mandatory parking zones (see Figure 18). The City has implemented a high density of parking corrals, exceeding the minimum threshold recommended by recent research of 25 parking locations per square kilometer (Meng et al., 2024). Within downtown Bloomington, the City has provided 61 parking corrals per square kilometer and on the Indiana University campus there are 52 parking corrals per square kilometer.

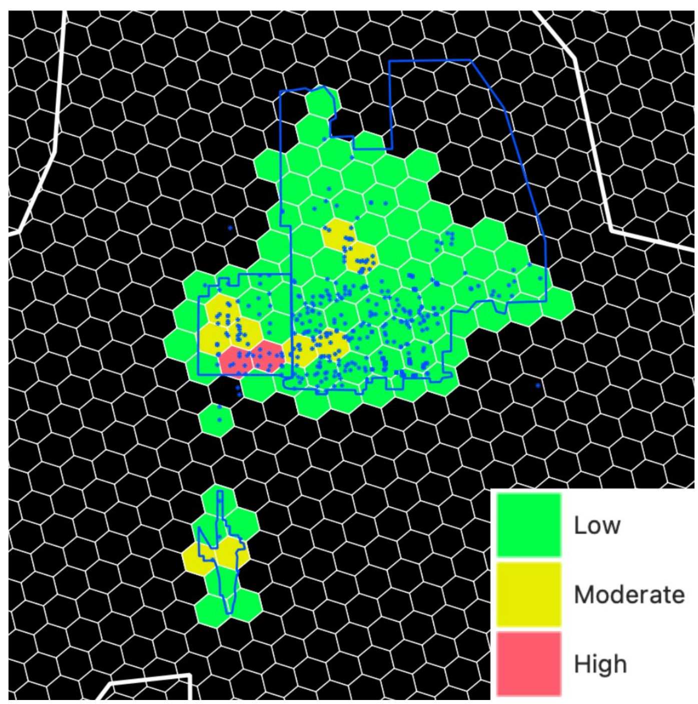
Figure 18, Map A highlights where parking corrals are located within the city and where there are high densities of parking corrals (green) and low densities of parking corrals (red) or no parking corrals (black). Figure 18, Map B shows where blocked parking events occur. Green indicates a low amount of blocked parking attempts, red signifies many blocked parking attempts, and black represents no blocked parking attempts, as vehicles are able to park anywhere. Blocked parking attempts are instances where a rider tries to park their vehicle and end their ride, but are prevented from doing so by the Lime app because their GPS coordinates indicate that they are not at a designated corral. These blocked attempts inform Lime where there is demand to park, but no parking infrastructure available.

Figure 18. Bloomington, Indiana's Mandatory Parking Zones and Blocked Parking Attempts: (A) Parking Density and (B) Blocked Parking Events

(A) Parking Pin Density



(B) Blocked Parking Events



As was found in previous research (Meng et al., 2024), higher parking density leads to better parking performance. Figure 19 below shows the parking density (on the x axis) and blocked parking events (on the y axis) using the same data as on the maps above. Each green dot in Figure 19 represents a hexagon with a parking density value and blocked parking value. On average, when parking density is low, blocked parking events are high, and blocked parking events decrease at higher levels of parking density. Furthermore, Figure 19 shows that blocked parking events continue to decline even after meeting the threshold of 25 parking spots per square kilometer suggested by previous research (Meng et al., 2024), and that even higher levels of parking improvement can be achieved by adding between 75 and 100 parking spots per square kilometer.

Bloomington's high density of parking corrals ensures high rates of parking compliance at designated locations. Seven of the top ten parking corrals are located within the City of Bloomington and three are on the Indiana University campus (see Figure 20). Four of the top ten parking corrals are located along the B-Line, a 3.1 mile multi-use trail that acts as the primary north-south connector for cyclists and pedestrians through the city.

Figure 19. Blocked Parking Events vs Parking Corral Density

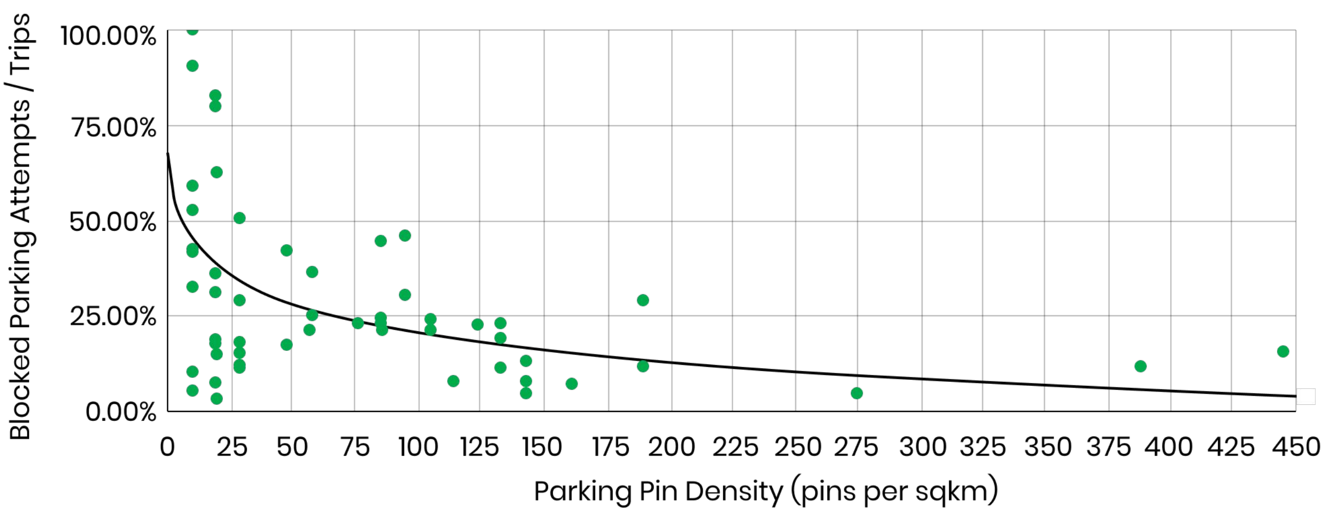


Figure 20. Parking Corrals with the Highest Rate of Parking within the Corral in Bloomington, Indiana

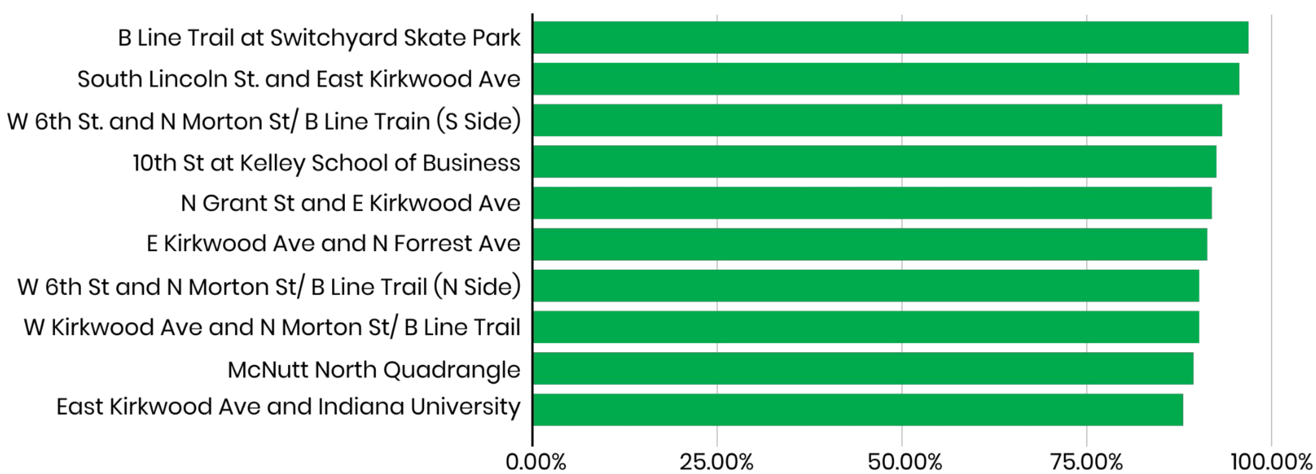
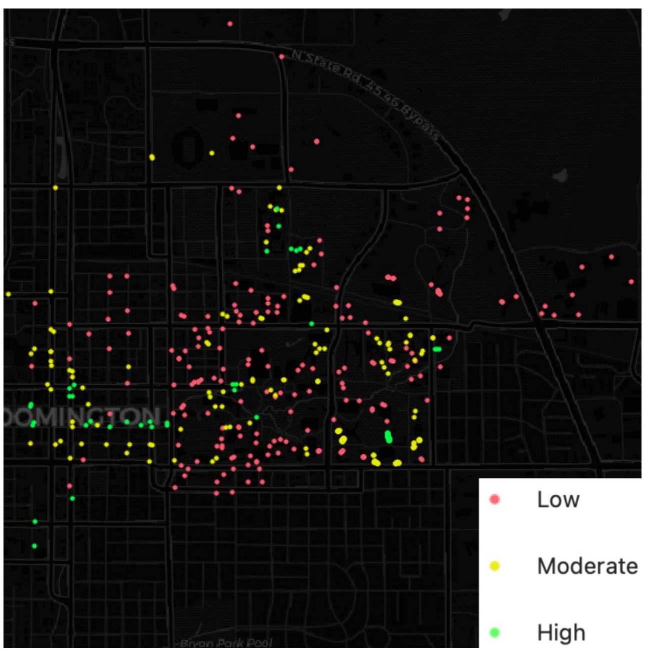


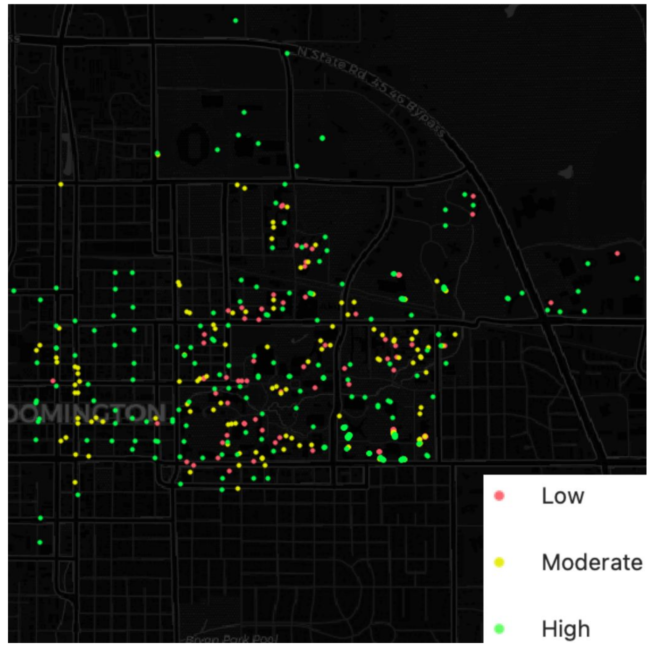
Figure 21 shows how parking corral use and compliance varied geographically. Corrals along the B-Line Trail and on Kirkwood Ave (See Figure 21, C) experienced the most use in downtown Bloomington. On the Indiana University campus, the residence halls, the Memorial Union, and the business school were popular destinations. Compliance was more evenly distributed throughout Bloomington and the Indiana University campus, but as shown in Figure 19, riders parked better in areas with high parking density.

Figure 21. Bloomington, Indiana's Parking Corral (A) Usage, (B) Compliance, and (C) Example Parking Corral at W Kirkwood Ave and B-Line

(A) Trip Volume



(B) Parking Clustering



(C) Parking Corral at W Kirkwood Ave and B-Line

SUMMARY

Increasing parking at corrals has multiple benefits. Riders have a better sense of where they can end trips, as well as where to find an available vehicle to start their next trip. Parking concentrated at corrals also increases the efficiency of shared micromobility operations and can cut down on VMT from operations.

Finally, cities benefit from tidier parking that is more likely to be compliant, leaving ample room in the right of way for pedestrian travel.

In addition to building well designed corrals as discussed above, providing adequate parking supply is also critical for parking compliance as described in University of Oregon research (Meng et al., 2024), which found that increased parking density leads to increased parking compliance. Sixty-five parking locations (corrals or racks) per square mile (25 parking locations per square kilometer) was found to be the minimum density of parking corrals needed to meaningfully improve parking compliance.

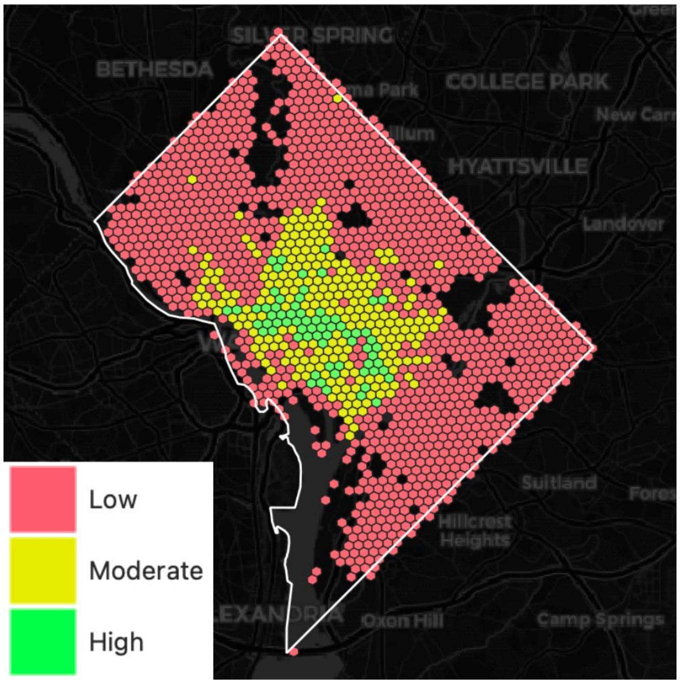
Lime is able to support cities on developing adequate parking density by providing parking recommendations using Lime's vast rider data. As shown in Figure 22 for the case of Washington, DC, Lime is able to calculate the average operational vehicles throughout the city, which can guide the city on how much parking supply is needed for a typical day. As shown in Figure 22(A), the average number of operational vehicles varies across the city, which can in turn inform how many parking corrals are needed to meet demand. For example, if a neighborhood has an average of 12 vehicles, and 4 vehicles per operator can fit in a corral, then 3 parking corrals would be needed in that neighborhood. As illustrated in Figure 22(B), Lime's policy analytics team can also use trip end locations to identify precisely where parking demand is highest within a neighborhood and then suggest specific locations for corrals that maximize demand and minimize distance between corrals (using K-Means clustering or other methods). When parking corrals are created across the city, these locations can be ranked to develop a comprehensive parking plan (see Figure 22(C)).

Cities can use the design principles discussed earlier in this section to build parking corrals at locations that both improve pedestrian safety while making parking convenient and intuitive for micromobility riders.

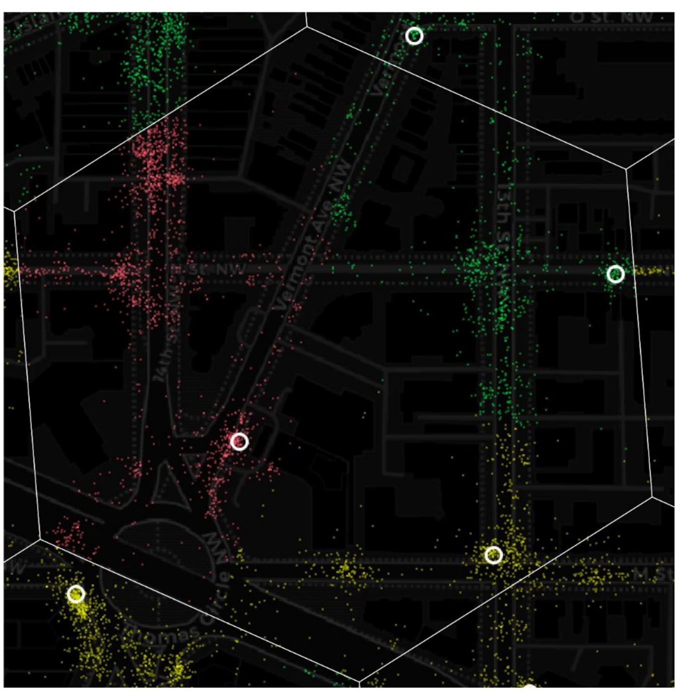
Finally, cities can also refer to the League of American Bicyclists' Bike Parking resources page, which provides best practice examples from Washington, DC, and other Bicycle Friendly Communities (Neptune, 2023).

Figure 22. Maps of (A) Average Operational Vehicles, (B) Trip Clusters and Recommended Parking Locations, and (C) Recommended Parking Locations in Washington, DC.

(A) Average Operational Vehicles



(B) Trip Clusters and Recommended Parking Locations



(C) Recommended Parking Locations Across Washington DC

Policy and Planning Implications

The 2024 Mobility Insights Competition provided Washington, DC, and Bloomington, Indiana, with specific insights into bike infrastructure, safety, and parking to improve safety and access for all travelers in those jurisdictions.

The two cities also provide excellent templates for other cities to follow. For example, Washington, DC, provides a strong example for other cities regarding bike and scooter parking. DDOT has a Council mandate to build 1,000 bike racks every year for 3 years, and the proliferation of this “agnostic” parking infrastructure benefits dockless bike and scooter riders as well as those using personally-owned bicycles and scooters. Likewise, when Bloomington, Indiana, implemented a mandatory parking regime, city staff developed a planned network of parking corrals that ensured sufficient parking within a 1 to 2 minute walk of destinations in the downtown area (Jackson & Duncan, 2023), exceeding the amount recommended in a recent Urbanism Next report (Meng et al., 2024).

For cities looking to follow Washington, DC and Bloomington, Indiana’s leadership, or to benefit from Lime’s experience in nearly 300 cities around the world, Lime can provide support in developing parking plans and analyzing safety trends, as well as partner on grant applications to fund parking and bike lane infrastructure.

WASHINGTON, DC

Reflections from Ted Randell, District Department of Transportation Micromobility Coordinator, Sustainable Transportation Programs:

The District is encouraged by the research findings, recommendations, and partnership with private operators and research institutions to produce insights into the growth and subsequent impacts of shared micromobility on the District's roadways and road users. Government and industry access to ridership, safety, and compliance data helps address universal issues within the industry. Transportation data drives the work of policymakers, tech developers, engineers, and others. As the industry and data matures, so will understanding of how to apply these learnings at scale to improve transportation networks.

Safety's importance and emphasis in the District is best encapsulated by the District's Vision Zero program, which focuses heavily on vulnerable roadway users and high-injury networks when considering policy, design, and roadway user education strategies. As a newer mode that generates more potential conflicts and exposure of users to high-injury corridors, micromobility needs to be part of the safety conversation. While there is much work to be done, the data in this report reveals an improvement in the incident rate of shared mobility users as the overall percentage of trips on bike lanes has grown. Although shared micromobility is a nascent industry, the granularity of its data is revealing critical information about the importance of dedicated bicycle facilities for safety outcomes, even as ridership has soared. Geolocating incident reports is a logical next step in this research that would help contribute to safety dashboards and drive corridor-based approaches to protecting roadway users.

DDOT is excited to see the continuance of safety research from private operators whose data is historically absent from the data managed by jurisdictions and pulled from police reports, hospital records, or self-reported incidents. Identifying safety gaps in the roadway network where design choices could be considered and a deeper understanding of the who, why, where, and how safety incidents involving shared micromobility are occurring will help inform programmatic choices and ultimately equip riders with more protection when sharing the roadways.

Additionally, information on the growth in ridership, bike lane usage, and parking compliance data for shared micromobility will help our Shared Fleet Device program justify needed investments, scope regulatory focus, and determine areas to focus future research.

BLOOMINGTON, INDIANA

Reflections from Hank Duncan, Bicycle and Pedestrian Coordinator, City of Bloomington, Indiana:

In this new world of dockless shared micromobility, the City of Bloomington understands that there is no perfect system. All communities are working to enhance the effectiveness of these programs while mitigating the unintended consequences that come with them. Accessibility in any community is paramount, and it was apparent that a mandatory parking policy in Bloomington would be needed to keep pedestrian space clear, particularly in downtown. When implementing this policy, staff emphasized the need to reduce improperly parked scooters without restricting riders to the point of inconvenience, so we aimed to construct at least one corral every one to two blocks to minimize walking distance to the rider's final destination. With over 60 designated parking corrals per square kilometer in the downtown area, the City was able to achieve this density by converting underutilized areas in the public right-of-way into corrals, such as yellow curbed on-street spaces, sidewalk bulbouts, and other non-utilized areas of the sidewalk. Without removing any motor vehicle parking or pedestrian space, the City was able to create room for this new mode of sustainable transportation.

Since this policy's implementation, community stakeholders both internal and external to the City have commented on the significant improvements to the downtown streetscape, and Lime's data supports these claims. Parking compliance has never been higher, and with Lime's help, the City hopes to implement parking corrals in more effective locations to maximize compliance and minimize street clutter both in the downtown and other high-use areas of Bloomington.

Above all else, the City of Bloomington aims to create safe streets for all users. In April of 2024, the City adopted a Vision Zero ordinance to eliminate traffic fatalities and severe injuries on City roadways. This major step towards safe streets has created the much-needed momentum towards upgrading and expanding Bloomington's cycling and pedestrian infrastructure. The City understands that there is a long way to go, but every piece added to the puzzle of low-stress networks is crucial to truly prioritizing walking and rolling long-term. The momentum towards positive change has begun, and the more people that begin to walk, bike, and scoot around Bloomington creates a snowball effect that will forever shift our community's culture of micromobility for the better.

Vision Zero is an ambitious goal, so partnerships like these are essential to the incremental progress needed to foster a community that supports and encourages comfortable walking and rolling. The findings of this report will be instrumental in the push to further connect and expand Bloomington's low-stress bike network.

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Appendix - Methodological Details

Map Matching

To identify whether a trip passed through a particular street segment (i.e., the stretch of a street between two intersections, typically a street block), we used Open Street Maps data and the GPS trajectories of Lime trips. We counted a trip as being taken on a street segment if the trip's GPS trajectory (i.e. the "breadcrumb" connecting each GPS point to the next GPS point across the entire trip) passed within 10 meters of the centroid (i.e. middle point) of each street segment. To focus on months with high trip volumes, for the purposes of the bike lane analysis, we only examined trips taken during the five summers between 2019 and 2024 (June to August).

Furthermore, we utilized bike lane data from the municipalities (Washington, DC, and Bloomington, IN), which included bike lane attributes such as the type of bike lane, and the installation date. We conducted a spatial join of the bike lane data with the street segment data to include this additional data on presence and timing of bike lanes.

The final dataset resulted in an observation for each street segment for every year from 2019 to 2024, detailing trip volumes, the presence of bike infrastructure, and, if applicable, bike lane ID, infrastructure type, and installation date. This dataset enabled us to conduct our analysis on the utilization of bike lanes over time.

Difference in Differences Analysis

MATCHING METHODOLOGY

To ensure an accurate comparison between new bike lanes (treatment) and bike lanes without infrastructure (control), we wanted to take into account other road attributes that impact rider comfort and safety, such as speed limits and number of lanes. Each new bike lane in Washington, DC, installed between 2020 and 2023 was matched to a street segment without bike infrastructure that had a similar speed limit and number of lanes. We refined this comparison further by selecting street segments located more than a quarter mile from the bike lane, but within a mile from the bike lane.

TIME AND TREATMENT VARIABLES

For the difference-in-differences (DID) analysis, the "dependent" or "outcome" variable was the number of trips taken during the summer months in Washington, DC, on a particular street segment in a certain year. To conduct the DID analysis, we created both a "time" variable - indicating whether the bike lane had been installed or not - and an "experimental group" variable - to reflect whether the observation was of the street segment where a bike lane was added (treatment) or the matching street segment with no bike lane (control).

For street segments with a new bike lane installed, each segment is assigned a '0' for the "time" variable for observations before the installation date and a '1' for observations that took place after the bike lane installation date. Observations from the installation year were assigned an 'NA' for the "time" variable. Each control (or matched) segment was assigned a '0', '1', or 'NA' for the "time" variable based on the timeline of its matched treatment segment, to ensure we are capturing the "before" and "after" periods consistently for both groups.

Lastly, all segments where a bike lane was installed after 2019 and before 2024 are assigned a '1' for the "experimental group" variable, and all matching control segments are assigned a '0'.

Both the time and the experimental group variables were included in the regression, as well as an "interaction term" - in other words, the time variable multiplied by the experimental group variable. In the DID analysis, the coefficient for the interaction term is the main focus. We also included a "year" variable, to account for what year the observation came from, which accounted for broad changes that occurred over time.

We used a linear regression for the DID analysis. Although the dependent variable is a count variable, the counts were sufficiently high to avoid using a more traditional count regression, like poisson or binomial regression. We selected a linear regression DID because it has many advantages in terms of straightforward interpretation and well-documented properties.

DIFFERENCE-IN-DIFFERENCES REGRESSION RESULTS

The "difference-in-differences estimator" is the key coefficient of interest in a difference-in-differences analysis, and it is indicated in bold in Table 1. It represents the difference in the time trends for the treatment group (streets where bike lanes were installed between 2020 and 2023) and the control group (streets where no bike lanes were installed). In the case of Lime trips taken in Washington, DC, the model estimates suggest that **1,804 more trips were taken during summer months on streets where bike lanes were added**, compared to the average trend on streets where no bike lanes were added.

The difference-in-differences analysis took into account annual trends as well. The regression coefficients for the different years, compared to a 2019 baseline, illustrate the changing situation for Lime, and shared micromobility more generally, in Washington, DC, over time. In 2020, trips were greatly reduced due to the onset of the COVID pandemic. Subsequently, average trip volumes increased in subsequent years as the number of permitted scooters and bicycles increased and COVID policies shifted.

While the year-by-year trend changes are captured by the year of observation variable, our treatment and interaction terms highlight the impact of bike lane installation, independent of broader changes happening from year to year. The lack of significance for the treatment term implies that the treatment and control segments were not significantly different before the bike lanes were installed, which suggests that observed differences in trip volumes after the installation are likely attributable to the installation of bike lanes. The significance of the interaction term suggests that the presence of bike lanes increases trip volumes over time. These findings are consistent with our observation from Figure 7, displaying the differences in the change in trip volumes overtime between segments with a bike lane installed in 2020 vs. segments where no bike lane was installed. More specifically, we are able to see the gap between our treatment and control group grow over time:

- After installation, from 2020 to 2021, our treatment and control group grew significantly: 815% and 593% respectively.
- In the following years, the treatment group's trip volumes saw an increase of 23% from 2021 to 2022, compared to a 3% decrease for the control group, and over the 5 year period, saw a 780% increase, compared to a 507% increase for its matched segments without bike lanes.

TABLE 1. DIFFERENCE-IN-DIFFERENCES REGRESSION COEFFICIENTS

Characteristic	Beta	95% CI	p-value
Intercept	438	-9.6, 885	0.055
Year of Observation			
2019	–	–	–
2020	-357	-928, 214	0.2
2021	161	-500, 823	0.6
2022	874	58, 1,689	0.036
2023	1,891	985, 2,796	<0.001
2024	2,933	2,041, 3,825	<0.001
Time	-842	-1,636, -48	0.038
Experimental Group	173	-322, 667	0.5
Time x Experimental Group	**1,804**	**1,134, 2,474**	**<0.001**