Where Are Self-Driving Cars Taking Us?

Pivotal Choices That Will Shape DC's Transportation Future

Union of Concerned Scientists

Where Are Self-Driving Cars Taking Us?

Pivotal Choices That Will Shape DC's Transportation Future

Richard Ezike
Jeremy Martin
Katherine Catalano
Jesse Cohn

February 2019

Union of Concerned Scientists

Richard Ezike is the Mobility and Equity Kendall Science Fellow with the UCS Clean Vehicles Program. **Jeremy Martin** is a senior scientist and director of fuels policy for the program. **Katherine Catalano** is the national campaign coordinator for the program. **Jesse Cohn** is senior transportation planner at Fehr & Peers DC.

The Union of Concerned Scientists puts rigorous, independent science to work to solve our planet's most pressing problems. Joining with people across the country, we combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe, and sustainable future.

More information about UCS and the Clean Vehicles Program is available on the UCS website: *www.ucsusa.org*

This report is available online (in PDF format) at *www.ucsusa.org/AV-equity*

Designed by:
Bradie Bradshaw, Houston, TX
www.bradiebradshaw.studio

Cover photo: Ted Bobosh/
Creative Commons (Flickr)
Printed on recycled paper

[CONTENTS]

v Figures, Table, Boxes, and Case Studies

vi Acknowledgments

1 **EXECUTIVE SUMMARY**

CHAPTER 1

3 **Automated Vehicles for Underserved Communities**

3 Inequities in the Car-Based Transportation System

4 Defining Transportation Equity

5 Transportation Challenges in the DC Metro Area

CHAPTER 2

6 **AVs Providing Access to Jobs**

6 AVs Can Dramatically Increase Jobs Accessible by Car If Rides Are Pooled

8 Bridging the East–West Divide: Job Accessibility Is About More than Mobility

10 AVs Could Reduce the High Cost of Transportation

11 The High Fixed Costs of Car Ownership Are a Heavy Burden for Members of Low-Income Communities

CHAPTER 3

13 **AVs' Effect on the Future of Public Transit Is Uncertain**

14 Transit Investment Reduces Congestion and Preserves Mode Choice

15 Transit Accessibility Is Most Important for Members of Low-Income Communities

CHAPTER 4

17 **Pollution and Climate Change**

17 Transportation Is a Major Source of Air Pollution and Creates Inequitable Health Outcomes

18 AVs Increase Total Driving

19 AVs Could Increase Local Air Pollution, Especially in Disadvantaged Neighborhoods

CHAPTER 5

22 **Conclusions and Policy Recommendations**

22 What's at Stake

23 Best Case Scenario

23 Worst Case Scenario

23 Policy Recommendations

23 Recommendation 1: To Avoid Congestion, AV Deployment Must Prioritize the Movement of People over Vehicles by Encouraging Pooling

24 Recommendation 2: To Maintain Multimodal Access and Improve Equity, Mass Transit Must Be Modernized and Improved

25 Recommendation 3: To Reduce Pollution Associated with Increased Driving, AVs Must Be Powered Primarily by Electricity

26 References

[FIGURES, TABLE, BOXES, AND CASE STUDIES]

FIGURES

7 Figure 1. Jobs Accessible within a 45-Minute Commute

9 Figure 2. Change in Job Access by Car (compared with 2017), Landover vs. Bethesda

9 Figure 3. Change in Job Access by Transit (compared with 2017), Landover vs. Bethesda

10 Figure 4. Changes in Numbers of Jobs Accessible by Car, 2040 vs. 2017, without AVs

15 Figure 5. Job Accessibility by Car and Job Accessibility by Transit: Two Scenarios

16 Figure 6. Disparities in Jobs Accessible by Transit, Historic Anacostia vs. Cleveland Park

18 Figure 7. VMT Percentage Change from 2040 Baseline

19 Figure 8. Congested Vehicle Miles Traveled

20 Figure 9. Congested Vehicle Miles Traveled with Better Transit

21 Figure 10. Congested Vehicle Miles Traveled, Dumfries vs. Damascus

TABLE

22 Best and Worst Case Scenarios for AV Deployment, Compared with 2040 Baseline

BOXES

4 Box 1. Analysis of AV Study on Transportation Equity in the DC Metro Area

8 Box 2. Smart Growth and AVs in the DC Metro Area

12 Box 3. Universal Access to Pooled AVs

14 Box 4. First Mile/Last Mile Gap

19 Box 5. Electrifying Pooled AV Ride-Hailing Fleets: Three Revolutions

CASE STUDIES

9 Case Study 1: Landover and Bethesda

16 Case Study 2: Historic Anacostia and Cleveland Park

21 Case Study 3: Dumfries and Damascus

[ACKNOWLEDGMENTS]

This report was made possible by the generous support of the estate of the late Henry Kendall and the Kendall Science Fellowship program, the 11th Hour Project of the Schmidt Family Foundation, the William and Flora Hewlett Foundation, and UCS members.

This report describes and elaborates on analysis conducted by Jesse Cohn, Richard Ezike, Jeremy Martin, Matthew Ridgway, Kwasi Donkor, and Melissa Balding. This analysis was supported by the UCS Kendall Fellows program and through in-kind matching support from Fehr & Peers. The analysis is described in detail in the Cohn et al. 2019 paper presented at the Transportation Research Board meeting in January 2019, and Fehr & Peers provided additional data analysis and feedback during the drafting of this report. We received valuable feedback on study design and review of the draft report by the members of our steering committee and other reviewers, including Mark Moran and Sergio Ritacco of the Metropolitan Washington Council of Governments, Elizabeth Irvin of the Center for Neighborhood Technology, Gloria Jeff of the Minnesota Department of Transportation, Anita Cozart of PolicyLink, and Zoe Lipman of the Blue Green Alliance. Finally, this report benefited from review and discussion from all the members of the UCS Clean Vehicles Team, especially Don Anair, Deborah Moore, and Jimmy O'Dea.

Organizational affiliations are listed for identification purposes only. The opinions expressed herein do not necessarily reflect those of the organizations that funded the work or the individuals who reviewed it. The Union of Concerned Scientists bears sole responsibility for the report's contents.

Self-driving or automated vehicles (AVs) are moving from design and testing to commercial development with a promise to reshape our cities and towns. The technology's effect on people's lives will differ across the country and will depend on public policies that govern vehicles, roads, and transit systems.

AVs deployed primarily as part of a shared service that offers affordable pooled rides and complements a robust mass transit system could provide flexible mobility and access to opportunity for disadvantaged populations not well served by the current transportation system. AVs could accelerate a transition to increased electrification of vehicles, reducing the transportation sector's global warming emissions and local air pollution. However, without appropriate policy interventions, AVs could exacerbate the current transportation system's problems, resulting in increased congestion and pollution while perpetuating access inequities.

To shed light on these challenges and opportunities, the Union of Concerned Scientists partnered with the transportation firm Fehr & Peers to study several scenarios of the effect of AVs on the Washington, DC, metropolitan region transportation system in 2040. Using the travel demand model from the National Capital Region Transportation Planning Board, the regional metropolitan planning organization of the area, we studied how differences in vehicle occupancy and investments in mass transit would affect congestion and job access for different populations across the region. We compared the effect on low-income neighborhoods and communities of color in the region to understand how AVs may affect transportation equity and environmental justice.

Key findings include the following:

- AVs operated as part of higher-occupancy pooled fleets more than doubled the number of jobs accessible by a 45-minute car trip. In contrast, increased congestion led to a loss of 80 percent of this benefit if AVs were not pooled.
- Investments in a better transit system reduced congestion on roadways and doubled the number of jobs accessible by transit, ensuring that people retained the choice of whether to use a car or mass transit.
- The introduction of AVs caused the total amount of driving to increase by as much as 66 percent relative to the year 2040 with no AVs; however, the increase was only 46 percent in scenarios with policies to encourage pooling and transit investments. In the absence of a rapid transition to electric vehicles (EVs), this increased driving will exacerbate global warming.
- People living in low-income neighborhoods and communities of color were subjected to large increases in congested driving in all AV scenarios, with 6 to 12 times as much congested driving as in the projected 2040 regional average. Exposure in these neighborhoods was about 50 percent higher than in the region as a whole.

Our findings and other research demonstrate that policymakers must act as soon as possible to mitigate the risks and maximize the opportunities of AVs. The following policy

[*Policymakers must act as soon as possible to mitigate the risks and maximize the opportunities of AVs.*]

Photo: Library of Congress

recommendations can steer the DC metro region toward a more equitable, efficient, and clean transportation future:

To Avoid Congestion, AV Deployment Must Prioritize the Movement of People over Vehicles by Encouraging Pooling

If AVs fulfill their promise of providing more convenient, affordable transportation to a larger share of the population, they will dramatically increase demand for travel, potentially leading to increases in congestion. AVs deployed predominantly as part of shared transportation services that pool riders going to similar destinations can move more people in fewer vehicle trips than would AVs following today's prevailing single-occupancy usage patterns. Pooling AVs could thus reduce congestion that would otherwise compromise their potential benefits.

To Maintain Multimodal Access and Improve Equity, Mass Transit Must Be Modernized and Improved

Although AVs combined with pooling could make car trips more convenient, accessible, and affordable, high-capacity mass transit provides a complementary service, particularly because it would connect dense, urban job and housing centers while facilitating a healthier and affordable multimodal transportation system. Continued investment in and enhancement of high-capacity mass transit can ensure that AVs and mass transit complement one another and support smart growth goals.

To Reduce Pollution Associated with Increased Driving, AVs Must Be Powered Primarily by Electricity

In all our scenarios, AVs increased total driving and the increase was especially severe in low-income neighborhoods and communities of color. These increases can be limited by AV pooling and enhancing mass transit, but a rapid transition to EVs is also required to ensure AVs do not undermine efforts to reduce global warming and local air pollution.

f11photo/Shutterstock

At the heart of vibrant urban centers is a multimodal network of transportation options—driving, ride-hailing, public transit, biking, and walking—that enable all residents to access jobs, health care, shopping, and other opportunities in a convenient, affordable, and efficient way.

[CHAPTER 1]

Automated Vehicles for Underserved Communities

Automated vehicles (AVs) are coming and have the potential to reshape our transportation system, which has historically underserved many populations. This report summarizes new research on the potential for AVs to reduce these inequities. Insights drawn from this research can help decisionmakers make smart investments and policy decisions to ensure that self-driving technology evolves in a manner that will reduce vehicle pollution while creating a modern, more equitable, and more accessible transportation system.

The introduction of AVs into the transportation network could ameliorate some transportation conditions while exacerbating others. AVs may reduce crashes and provide a more convenient and comfortable travel experience. Combined with a shift to electric vehicles (EVs) and the replacement of personal cars with shared transportation services, AVs could dramatically change how people get to their desired destinations (Sperling 2018). The way cities, states, and the federal government implement their rollout will determine whether they improve accessibility, reduce air pollution, and reduce congestion—or promote sprawl, reduce accessibility, eliminate driver-related jobs, and increase global warming emissions and air pollution (Litman 2018).

This report strives to answer how AVs can help mitigate an inequitable transportation system and put the principles defined in the Union of Concerned Scientists (UCS) policy brief *Maximizing the Benefits of Self-Driving Vehicles* into practice (UCS 2017). UCS and Fehr & Peers modeled several future scenarios of the Washington, DC, metropolitan region (see Box 1, p. 4, for the study details). Our analysis provides important insights on how to leverage AV technology—along with vehicle electrification, pooled rides, and high-quality mass transit—to achieve a more efficient, equitable, and clean transportation system.

To understand how AVs may affect historically underserved populations, UCS and Fehr & Peers evaluated changes in a community's ability to access employment (measured by jobs accessible within a 45-minute commute) and exposure to pollution (measured by increases in vehicle miles traveled (VMT) and congestion). The research concludes that the greatest chance for positive outcomes occurs when AVs are electric, operate as a high-occupancy pooled service, and are combined with a robust mass transit system. In closing, we make several high-level policy recommendations based on these findings.

Inequities in the Car-Based Transportation System

Americans have access to multiple modes of transportation, including cars, buses, trains, scooters, bikes, and good, old-fashioned walking. Yet privately owned and operated cars have been the dominant source of personal mobility for the last half century. While the automobile era brought increased mobility (and economic opportunity) to many people, it also came with its share of negative consequences: inequitable access for people who could not afford a car, increases in global warming emissions and air pollution, congestion on roadways, suburban sprawl, and fatal crashes. Despite the consequences, people across the United States remain dependent on cars; 76 percent of the 153 million commuters in the country drive alone to work, and just under 9 percent carpool (US Census Bureau 2018).

In a car-dominated culture, those who lack access to a car are often unable to access jobs, healthy food, educational opportunities, and more. According to the US Census Bureau, approximately 11 million of the 119 million households in the country do not have access to a car (US Census Bureau 2018). The decentralization of jobs and housing that coincided with the growth of suburbs has made access to destinations difficult for people in traditionally disadvantaged groups, such as low-income communities, people with disabilities, and communities of color (Blumenberg and Waller 2003).

Defining Transportation Equity

Transportation is a basic requirement for maintaining a high quality of life in contemporary society. Investments and enhancements in the transportation system can revitalize urban areas in need of development. However, transportation development has historically skewed toward the building of suburban highways, which have fueled housing and job sprawl. Low-income neighborhoods and communities of color have witnessed highway projects cutting through their neighborhoods, isolating residents from businesses and each other, exposing them to higher risk of pedestrian injuries, air pollution, and noise pollution. In short, as defined by Dr. Robert Bullard, "transportation is a civil rights issue" (Bullard 2003).

PolicyLink, a national research and action institute that is focused on advancing racial and economic equity, generally defines equity as a "just and fair inclusion into a society in which all can participate, prosper, and reach their full potential" (PolicyLink 2018). It follows that transportation equity is the need for all to participate in a transportation system that provides safe and efficient access to destinations. Transportation equity has always been an invisible driver of equal opportunity and social change; conversely, lack of accessibility and affordability have long been linked to race and have served the purposes of segregation (Ezike 2016). When outright discrimination was outlawed by the Civil Rights Act of 1964, the car facilitated white flight out of city centers. Interstate highways designed to accommodate cars and suburban sprawl cut through and damaged neighborhoods of people of color, resulting in the concentration of environmental problems in the urban core and de facto segregation in suburban communities

BOX 1.

Analysis of AV Study on Transportation Equity in the DC Metro Area

UCS and transportation consulting firm Fehr & Peers conducted a study of the potential effects of AVs on transportation equity for low-income communities and communities of color in the DC metro area that was presented at the 2019 meeting of the Transportation Research Board and published in the meeting proceedings (Cohn et al. 2019). The study used a travel demand model that the TPB developed to make regional long-range plans and set policy. The study builds on early work conducted by Fehr & Peers to evaluate AVs' effect on future travel demand by adjusting the TPB's model to mimic AVs' anticipated effect. The later study extends this methodology by focusing on disparate effects on EEAs as a measure of transportation equity. The TPB defined EEAs in March 2017 (and updated them in June 2018) as part of an environmental justice initiative to define which areas of the region faced the greatest environmental risks. The TPB used census-level data to identify tracts that have significant concentrations of members from low-income communities and communities of color (TPB 2017). EEAs encompass a quarter of the region's households and residents and have a population density more than three times higher than the regional average. Forty-three percent of households within EEAs have an annual income below $50,000, compared with 24 percent for the rest of the region, and 25 percent of households in EEAs have no access to a car, compared with just 10 percent for the rest of the region.[1]

Our study focused on two variables likely to have a significant effect on transportation system performance and equitable access: AV occupancy and expansion of high-capacity mass transit. We explored performance measures, including job accessibility, congested driving, and travel times. The scenarios examined are described below:

- **2017 Baseline:** Reflects existing conditions.

1 *We obtained the demographic data by matching census data from the Annual Community Survey (US Census Bureau 2018) with EEAs. The boundaries of EEAs do not match perfectly with census tracts, but neighborhoods immediately adjacent to one another likely have very similar attributes, so we believe the demographic data is reasonably representative.*

(Marcantonio et al. 2017). The detrimental consequences of mass car ownership and highway development include inadequate and unsafe sidewalks, increased sprawl, and reduced access to jobs for those who live in the urban core; between 2000 and 2012, the proximity of job centers to low-income communities declined by 61 percent (Green 2015; Bullard 2003).

Transportation Challenges in the DC Metro Area

Metropolitan areas such as the Washington, DC, region face increasing challenges that could exacerbate an already inequitable transportation system. The DC metro area has a long history of segregation that is perpetuated in the structure of neighborhoods, access to opportunity, and transportation system investments and accessibility (CUMP 1999). According to the 2015 Urban Mobility Scorecard, in 2014 the average Washington, DC, auto commuter experienced 42 hours of delay traveling, and that delay wasted 19 gallons of fuel—equivalent to a week's worth of fuel for the average US commuter. In large metropolitan areas such as Washington, DC, commuters experienced congestion for six hours out of a 24-hour day (Schrank et al. 2015). Residents of low-income communities and communities of color have often been subject to disproportionate negative environmental effects from transportation and other sources of pollution (Kravitz-Wirtz et al. 2016). To quantify these disproportionate effects, the regional metropolitan planning organization, the National Capital Region Transportation Planning Board (TPB), mapped out equity emphasis areas (EEAs), which identify communities that have significant concentrations of low-income and/or minority populations. EEAs define "low-income households" as those whose income is 1.5 times the poverty line and focus specifically on African American, Asian, and Hispanic/Latino populations (TPB 2017).

- **2040 Baseline:** Acts as future baseline with no AVs, and projected growth based on TPB business-as-usual modeling.
- **No Pooling:** Represents 100 percent AV adoption, such that AV occupancy matches today's conditions (each vehicle generally occupied by one person). This scenario provides all households with access to at least one car, based on an assumption that private companies will provide AV ride-hailing services at reasonable cost.
- **Pooling:** Represents 100 percent AV adoption, but assumes that policies have been implemented to incentivize or mandate higher vehicle occupancy, also called pooling. The model does not distinguish between public or private control of pooled-ride services, but we have classified these pooled rides as part of the car mode, distinct from mass transit services.
- **No Pooling, Better Transit:** Includes transit service improvements (increased frequencies and speeds) that generally align with regional priorities for heavy rail, bus rapid transit routes, and express bus routes. It is assumed that these transit services would be automated. In addition, fares are reduced for all transit modes.
- **Pooling, Better Transit:** Represents an AV future in which AVs are pooled and there is a robust, affordable transit system. It applies the shared AV assumptions from Pooling and the transit assumptions applied in No Pooling, Better Transit.

All models have limitations, and this model is no different. Most fundamentally, because AVs are not now in widespread use, we approximated their effects based on only study variables the model examines. These include a detailed treatment of travel patterns, but not feedbacks between transportation system performance and land use, housing, employment, or other economic outcomes. Those feedbacks could be expected to respond to changes in transportation system performance, technology, and costs. Data on future housing and employment were based on regional forecasts, and they are the same for all 2040 scenarios. EEAs are statically based on the 2017 TPB analysis, although they would be expected to change over time. As such, the results should be understood as indicative of future trends but not quantitatively predictive. The forecasted trends are broadly similar to studies of other regions, which increases our confidence that the results are reasonable and provide useful insight into opportunities and challenges facing the region with the introduction of AVs (Cohn et al. 2019).

[**CHAPTER 2**]

AVs Providing Access to Jobs

Much of the US population relies on cars for access not only to their jobs, but also to educational opportunities, health care, food, and recreation. Our analysis shows that job accessibility is maximized when AVs carry more passengers per car and complement a strong transit system. Other related research highlights the importance of smart growth policies that encourage job and housing growth in dense communities that have access to transit. Moving to AVs will affect employment within the transportation sector as well; although our analysis does not focus on employment in detail, these changes could positively or negatively affect employment opportunities available depending on approaches undertaken. Moreover, while our study quantifies effects on access to jobs, improved access to mobility is also important for other opportunities.

Most travel in the DC metro area is by private car, with 67 percent of commuters driving to work and another 10 percent carpooling (US Census Bureau 2018). The area has an extensive regional transportation system, which also plays an important role in providing access to jobs and mobility, but that role varies for different populations. Many transit passengers use transit by choice, because it is more convenient, pleasant, or affordable than driving. Others are dependent on transit, having limited access to personal cars due to cost, disability, or age. Transit-dependent communities often face sharply diminished opportunities. For example, according to the model used in this analysis, a household currently with a car has access to six times as many jobs as a transit-dependent household. Even households that have access to one car may have sharply curtailed access, because some household members will be left without access when the car is in use. Improving access to jobs, education, health care, healthy food, and other opportunities is an important part of improving transportation equity.

Katherine Catalano/UCS

Rush hour commuters aren't the only people our transportation system should serve. Wayne Sylver is a professional server who, like many others in our region, can take the metro to work but not home late at night. He finds the bus ride takes too long, so he often opts to take an Uber or Lyft instead, adding hundreds of dollars to his annual transportation costs. AVs could help simplify his late-night commute significantly, but only if they are affordable.

AVs Can Dramatically Increase Jobs Accessible by Car If Rides Are Pooled

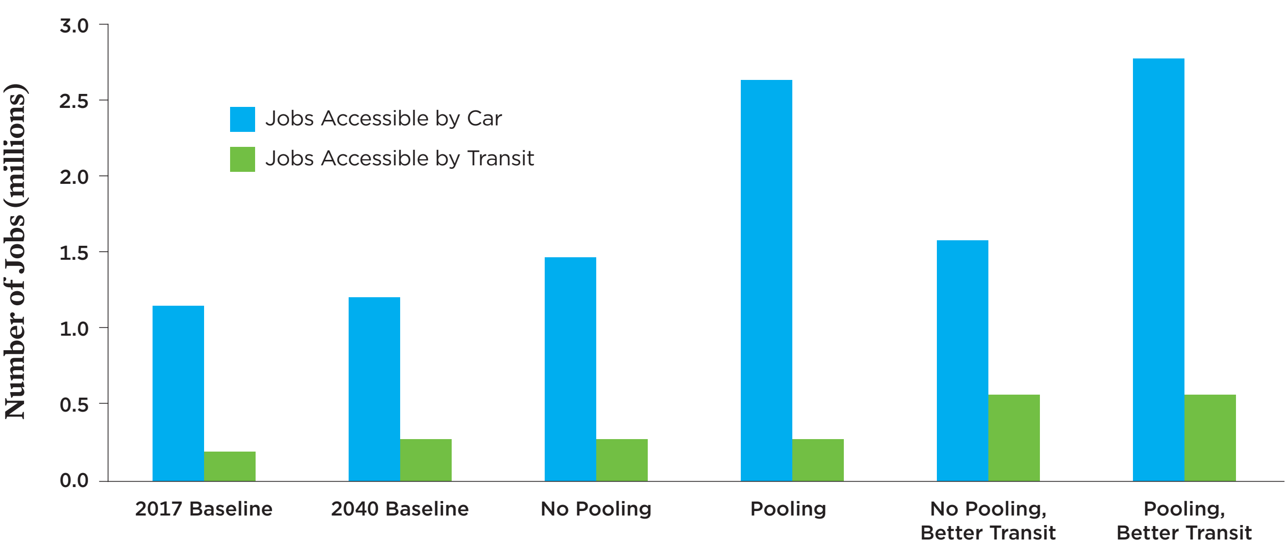
Figure 1 (p. 7) shows the number of jobs accessible within a 45-minute commute by car and by public transit in our scenarios. The 2040 baseline forecast without AVs predicts a 45 percent increase in jobs accessible by transit while the number of jobs accessible by car is largely unchanged. The improved transit accessibility is the result of decades of smart growth policy that has steered and will continue to steer job and housing growth toward activity centers close to high-quality transit (TPB 2014; GWC 2010; TPB 1998). Growth in activity centers gives residents more options for travel—including walking, biking, transit, and driving—while locating housing, jobs, shopping, and other destinations closer together decreases the distance people need to travel to meet their needs. Focusing growth in activity centers helps all residents of the region, whether they live in the activity centers or not, by reducing congestion, sprawl, and time spent in cars. Because transit is generally less expensive than travel by private car, increased access to jobs and housing by transit is especially valuable to lower-income communities. However, policy is also needed to ensure the availability of affordable housing near high-quality transit.

Adding AVs to the transportation system doubles the number of jobs accessible by car, provided the AVs are pooling passengers to increase average vehicle occupancy. (It is important to note that the model does not factor where the jobs are located, just whether the jobs are accessible. All scenarios have the same total number of jobs and locations of those jobs). If AVs principally operate as single-occupancy vehicles, the increase in traffic congestion cancels out 80 percent of the benefit, and job accessibility increases by only 20 percent in the No Pooling scenario. The increased accessibility created by pooling AVs could be significant for equitable mobility efforts—provided, that is, costs per ride are affordable and the services are accessible to all populations on an equitable basis (see discussion of costs later in the chapter).

[Twice as many jobs could be accessible by car if AVs are added to the DC transportation system—provided the AVs are pooling passengers.]

However, expanding accessibility by car without continuing to focus on transit also has the potential to set back the decades-long effort to move toward a more multimodal future. The modeling framework we use in this report does not include feedbacks between transportation and land use, so every 2040 scenario has the same distribution of jobs and housing. However, other research and experience have demonstrated the strong connection between car-based transportation and sprawl. If AVs make car travel more convenient and less expensive without simultaneous improvements occurring in the quality, cost, and convenience of mass transit, it is likely to encourage sprawl and undermine the progress made in smart growth (NCSG 2018). If mass transit improves together with car access through application of AV technology and public investment, continued progress toward smart growth goals is possible (see Box 2, p. 8).

FIGURE 1. Jobs Accessible within a 45-Minute Commute



AVs operated as part of pooled fleets more than double the number of jobs accessible by car, and a better transit system more than doubles the number of jobs accessible by transit.

BOX 2.

Smart Growth and AVs in the DC Metro Area

A recent study by the National Center for Smart Growth at the University of Maryland considered how AVs could affect development patterns in the DC metro area and the implications for transportation, the environment, and other key equity metrics (NCSG 2018). The study considered a corridor stretching from Baltimore, Maryland, to Richmond, Virginia. It evaluated several different illustrative scenarios to highlight key tradeoffs.

One scenario considered rapid adoption of AV technology with limited government regulation; it showed accelerated sprawl, with more development occurring away from regional cores and large losses of agricultural and forest lands. The sprawling development brings a 37 percent increase in VMT and 20 percent increase in global warming pollution, as well as a precipitous drop (41 percent) in transit mode share. An alternative scenario focused on sustainable development, with more development in inner suburbs, investments in transit, and rapid vehicle electrification; in this scenario, global warming pollution drops 56 percent, transit mode share increases by 22 percent, and daily travel costs for members of low-income communities fall 70 percent. The study highlights the complex interactions between transportation and land use policies, the influence of changing technology and travel costs, and the tradeoffs between competing policy objectives.

Smart growth strategies will need to adapt as new modes of transportation become available—not just AVs, but also shared bikes and electric scooters. Investing in mass transit together with encouraging AV pooling is a vital part of continuing to deliver the health, congestion, and other economic benefits of smart growth.

Bridging the East–West Divide: Job Accessibility Is About More than Mobility

One of the major regional transportation equity problems facing the DC metro area has been called the East–West divide. This problem is more than a transportation issue. It is part of a much broader concern associated with the region's division into the more prosperous western side, which enjoys a disproportionate share of economic growth and opportunity, and the eastern side, which carries a larger burden of poverty and social distress and is also home to a larger share of communities of color (CUMP 1999). The economic and racial segregation of the region has many negative consequences, but a specific consequence that manifests itself in transportation system performance is that a disproportionate share of recent and projected job growth occurs in the western side, leading to increased demand for travel into and through this area. These job opportunities are harder for communities in the eastern side to access. Moreover, projections show the problem is poised to worsen. Figure 4 (p. 10) shows changes in jobs accessible by car in the region between now and 2040. While overall regional job availability is expected to increase, the largest increase in accessible jobs is centered in the outer suburbs of Northern Virginia, while the greatest decrease occurs in the eastern side of the metro area, particularly in Prince George's County. We find that under baseline conditions, jobs accessible by car will decrease across the eastern side of the region by 6 percent and increase by 10 percent in the western side. And EEAs in the eastern side are even more heavily affected, with an 8 percent decrease in the number of jobs accessible by car.[2]

Our study finds that AVs may alleviate this divide problem somewhat by increasing effective highway capacity, thereby increasing job accessibility in the region's eastern side. However, the disparate growth in job accessibility remains the same in all scenarios, with the greater growth occurring in the western side. This is not surprising, because the root cause of disparate accessibility is not a lack of equitable mobility, but unevenly distributed opportunity. Our study does not consider changes in development patterns, and all our scenarios have the same job and housing distribution, so our scenarios' main effect is to change travel speed between east and west. A 2016 Washington Metropolitan Area Transit Authority (WMATA) study considered changes in development patterns and looked at how more balanced growth could affect the Metro system's performance, highway congestion, and the region's economic health (WMATA 2016). The study used an earlier version of the same

2 *We obtained these results on the East–West divide from the Cohn et al. 2019 analysis dividing the region into east and west following TPB 2006 with the exception that we classified all of Virginia as within the west.*

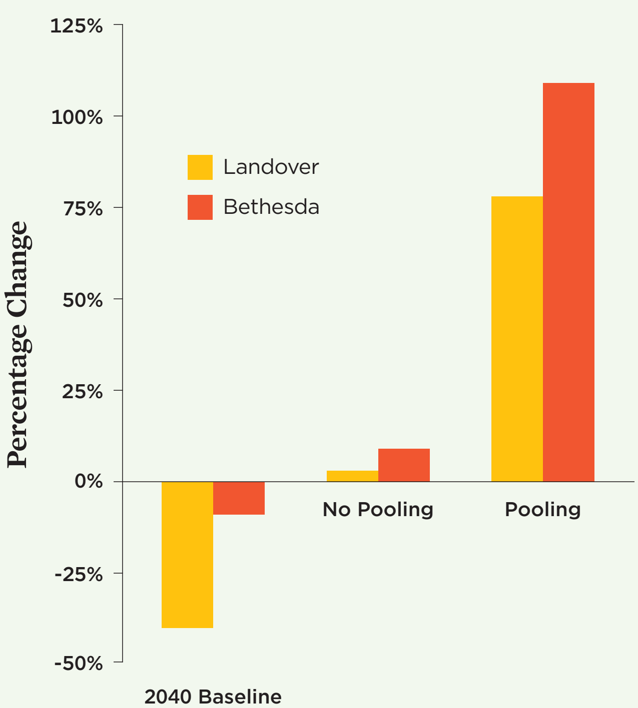
CASE STUDY 1.

Landover and Bethesda

Landover and Bethesda, Maryland, are communities of similar size and distance from Washington, DC, and they have similar access to public transit. But while Landover is an EEA, with a median income of $54,500 and a population that is 88 percent people of color, Bethesda is an affluent non-EEA with a median income of $124,400 and a population that is 19 percent people of color (US Census Bureau 2018). They provide a useful contrast to illustrate the impact of AV pooling on job accessibility.

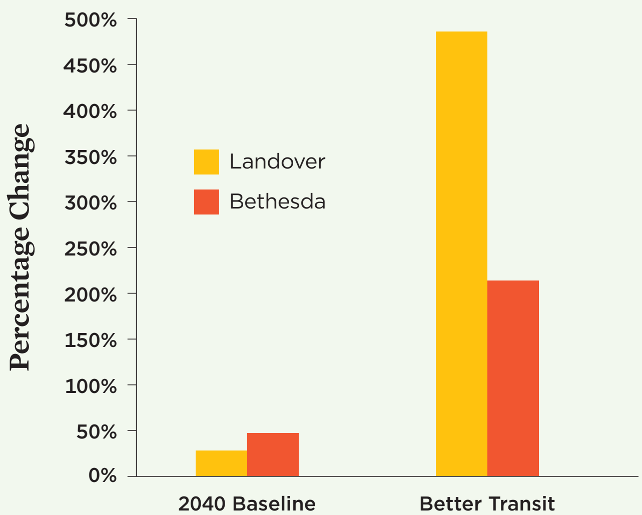
Figure 2 shows the change in jobs accessible by car in Landover and Bethesda compared with the 2017 baseline. In 2040, increased congestion is expected to decrease access to jobs accessible by car in both Landover and Bethesda, but the effect is much more dramatic in Landover.

FIGURE 2. Change in Job Access by Car (compared with 2017), Landover vs. Bethesda



AV pooling results in a significant increase in the number of jobs accessible by car in both Landover, an EEA, and Bethesda, a non-EEA.

FIGURE 3. Change in Job Access by Transit (compared with 2017), Landover vs. Bethesda



Better transit would significantly increase the number of jobs accessible by transit in both Landover, an EEA, and Bethesda a non-EEA.

Note: Access to jobs by transit is not significantly affected by AV pooling, so the No Pooling and Pooling scenarios have the same results.

The transition to 100 percent AVs in a No Pooling environment improves the situation for both communities, but the benefits in the Pooling scenario are even more pronounced, with the number of jobs accessible by car increasing by 78 and 109 percent, respectively.

These results show that implementing policies that increase average vehicle occupancy are key to increasing job accessibility. Both communities are also well positioned to benefit from better transit, with the No Pooling, Better Transit scenario showing the number of jobs accessible by transit more than doubling in Bethesda and increasing almost five-fold in Landover compared with the 2040 Baseline scenario (Figure 3).

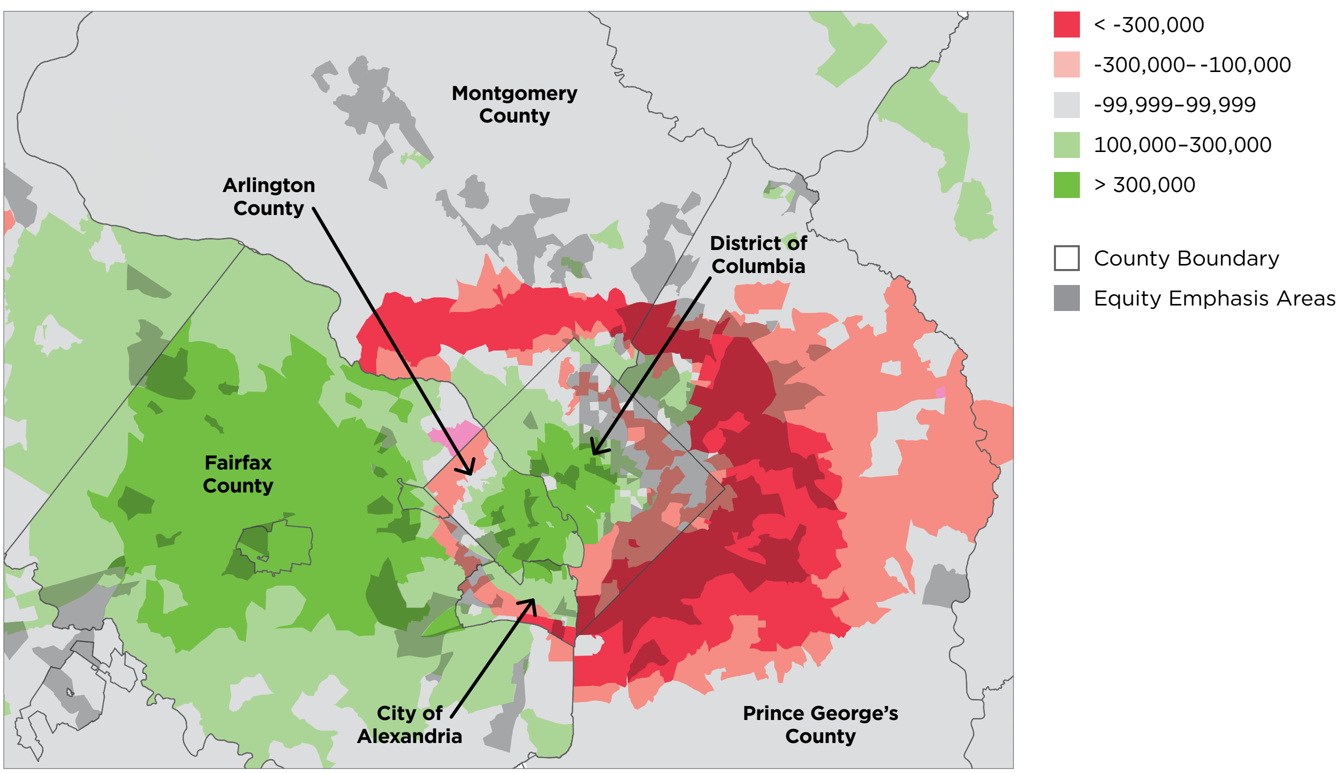
travel demand model our study used, and, like our study, considered the implications for 2040, so the results are quite complementary to ours. WMATA found that more balanced growth at the regional level would reduce total VMT by 12 percent and congested car travel by 26 percent, while increasing the number of households and number of jobs accessible by transit by 54 percent and 39 percent, respectively. WMATA has a strong interest in reducing the regional imbalance because it creates problems for the rail system, with underutilized lines in the eastern side increasing operating costs and leading to revenue shortfalls that local jurisdictions must make up. More balanced regional growth would increase Metrorail boardings by 73 percent, increasing the transit system's health and reducing the subsidy required from local jurisdictions while improving job and housing access equity across the region.

AVs Could Reduce the High Cost of Transportation

Transportation costs can restrict opportunities for people in low-income communities. Currently, transportation is the second largest household expense behind housing (BLS 2018). Rising housing costs in the DC metro area and many other large urban centers have displaced low-income communities from more accessible neighborhoods, which can restrict their mobility and increase their transportation costs (OPRD 2018). The DC metro area has relatively high housing and transportation costs, but because median household income is also high, the city is classified as more affordable than other large cities, with 61 percent of neighborhoods in the region rated as affordable according to an expanded measure of housing and transportation costs (CNT 2018). However, the region also

> ***Transportation costs can restrict mobility—and thus opportunities—for people in low-income communities.***

FIGURE 4. Changes in Numbers of Jobs Accessible by Car, 2040 vs. 2017, without AVs



Job accessibility by car is poised to worsen for residents living in the eastern side of the DC metro area in 2040.

Katherine Catalano/UCS

Our transportation system doesn't exist in a vacuum, and can combine with land use issues to make daily life more difficult. Tosin Fadeyi lives in Baltimore and commutes to DC, because in Baltimore she can find the combination of affordable housing and easy access to goods and services that is hard to come by in the DC metro area. This means her commute, a combination of commuter rail and metro, is more expensive than most. Not only that, but a delay in either mode can almost double her travel time. To really make transportation accessible in our region, we need to consider land use as well.

has a large degree of income inequality; many households, particularly households of color, have incomes far smaller than this median figure (Guzman 2017). For example, the median income of DC African American residents was $42,000 in 2017, which is less than a third that of white residents and unchanged in a decade in which white incomes rose by 15 percent (Lazere 2018). In 2012, 25.7 percent of African American residents and 22.1 percent of Hispanic residents, versus only 7.4 percent of white residents, lived at or below the poverty level (DCFPI 2014). Average yearly transportation costs in the region are $12,939, which is a major barrier for people living in poverty. (The poverty line in 2017 was $19,090 for a family of three). Within our study area, 43 percent of EEA households have an income below $50,000 and 25 percent have no access to a car, versus 24 percent and 10 percent, respectively, for non-EEA households.

How might AV technology affect transportation costs in our study's timeframe? Because AVs are not yet in widespread usage or in commercial use, estimates of their costs in 2040 are highly speculative. But experts have offered some projections. A Morgan Stanley analysis suggests that by 2030 the cost for a ride in an AV will be 50 cents per mile, which would be less than the current total per mile cost of driving an average car owned by the driver (AAA 2018; Morgan Stanley 2016). Johnson and Walker estimate that by 2035, the cost per mile would be 34 cents (Johnson and Walker 2016). A Deloitte analysis suggests the cost could fall to just 31 cents per mile (Corwin et al. 2015). Other analysts estimate that if these rides are pooled, the cost per passenger could fall to 20 cents per mile or less (Johnson 2015).

The High Fixed Costs of Car Ownership Are a Heavy Burden for Members of Low-Income Communities

Reducing the cost of mobility can benefit everyone, but for low-income populations the change in cost structure is even more important than the change in average per-mile costs. Moving from a transportation system based largely on personally owned and operated cars to purchasing transportation as a service paid by the ride can make mobility available to populations for whom private car ownership is unavailable or a financial burden. Today, the largest share of transportation costs for most people is the cost of owning a car, including the fixed costs of depreciation, insurance, license, registration, taxes, and finance charges. According to AAA, an average car driven 15,000 miles a year costs $8,849, or 59 cents a mile, two-thirds of which is the fixed costs (AAA 2018). High fixed costs are particularly burdensome for low-income households for at least three reasons: they experience higher capital costs, they encounter barriers to borrowing, and high fixed costs make driving fewer miles an ineffective strategy for saving money. For a family that lives at or below the poverty line, that cost is often too much to bear.

> ***Today, the largest share of transportation costs for most people is the cost of owning a car.***

In the DC metro area, transit fares vary considerably, with many of the regional bus systems charging a fare of $2 and Metro fares ranging from $2 to $6 depending on the distance and time of day. Lower fares are available for seniors, children, students, and people with disabilities. Transit provides a cost-effective alternative for some trips, but lost time and limited access to destinations impose indirect costs and

BOX 3.

Universal Access to Pooled AVs

Although cost restricts access to mobility, it is by no means the only barrier. People with disabilities are twice as likely as those without disabilities to lack access to adequate transportation, and many are unable to leave home because of transportation difficulties (AAPD 2012). People with disabilities are more likely to rely on public transit and paratransit services. The requirements of the Americans with Disabilities Act (ADA) apply unevenly to taxi and ride-hailing companies such as Uber and Lyft, and people with disabilities often find that services are slow and unreliable (NYLPI 2018). No major manufacturer produces a mass market vehicle that can accommodate a wheelchair user without costly modifications. If AVs and other transportation infrastructure are designed for universal access, they could dramatically improve the mobility of people with disabilities. But policy and smart design will be required to realize this opportunity.

Katherine Catalano/UCS

One often-touted benefit of AVs is their potential to increase mobility for those that currently cannot drive, but that will only be true if we design them to be accessible up-front. When Amy Currotto requests a wheelchair-accessible rideshare today, they are often in short supply and the wait can be prohibitive. This is largely because it is expensive and difficult to retrofit standard passenger vehicles. If early AVs aren't designed with her in mind, Amy knows she'll have to wait longer than most to take advantage of this new technology.

lost opportunities. Taxis and ride-hailing companies provide point-to-point rides without fixed costs, but these services typically cost $2 per mile or more (Johnson and Walker 2016). Thus, when a household without a car considers a job or educational opportunity that is not conveniently accessible by transit, they must choose between taking on the high upfront and carrying costs of car ownership, paying the high per-mile costs of taxis or ride-hailing service, or foregoing the opportunity altogether.

Pooled AV services must be accessible on an equitable and affordable basis—without physical barriers, discrimination, or bias—to all people.

The benefits of moving from car ownership to paying per mile are therefore greatest for low-income households or others least well served by the car ownership model. Based on projections, AVs are likely to reduce travel costs per mile for people who currently own cars by up to 50 percent. But flexible on-demand point-to-point rides at a cost of 20 to 40 cents per mile represent a savings of 80 to 90 percent compared with taxis or ride-hailing services. This reduction could be what makes a particular job or educational opportunity accessible. However, for this potential to be realized, pooled AV services must be accessible on an equitable and affordable basis without bias, discrimination, or physical barriers to all populations (see Box 3). New strategies will be required to assess and address bias, whether intentional, structural, or embedded within algorithms (Danks and London 2017).

Moreover, providing mobility access to more people at a lower cost is expected to sharply increase demand for travel, potentially leading to increased traffic congestion that could leave everybody worse off. Pooling riders into shared vehicles operated as a service under equitable rules is key to enabling more people to travel at a lower cost while limiting increases in congestion.

[**CHAPTER 3**]

AVs' Effect on the Future of Public Transit Is Uncertain

There are many unanswered questions regarding how AVs will interact with public transit systems. Our analysis shows that a strong transit system coupled with pooled AVs would provide the quickest travel times and greatest employment access while narrowing the job accessibility gap between EEAs and non-EEAs. However, when looked at from the other direction, will AVs hurt transit? If they do, what are the implications for equity?

While some transit riders can readily switch to another mode of travel or adjust their travel schedules, others depend on transit and would suffer disproportionate harm if transit services are dramatically scaled back. Transit-dependent riders lack access to other choices because of cost, age, disability, or other factors, and reduction in transit services can cost them time and access to employment, education, healthy food, and other important services. This lack of access is particularly prevalent among riders who have low incomes and/or are from communities of color. Almost 15 percent of US households containing people of color did not have access to a car in 2015, compared with only 6.5 percent of white households (PolicyLink and PERE 2018). Households that do not own a vehicle are more likely to live in a city, have a low income, and be dependent on public transportation (Tomer 2011).

Ben Schumin/Creative Commons (Wikimedia Commons)

Thousands of people use public transit to get around the DC area every day; for many of them, transit is their only available transportation option. If AVs draw a lot of riders away from transit and governments scale back transit services, it would leave transit-dependent communities in the lurch.

BOX 4.

First Mile/Last Mile Gap

What is the first-mile/last-mile gap? It begins with a quarter mile. Most people are comfortable walking up to a quarter mile to or from a public transit stop. The gap is the distance between the point where the walk starts to be uncomfortable and the destination. The gap's length depends on a person's physical health, the time of day, and the weather, among other factors. New technologies and smart planning—including neighborhood AVs, scooters, better sidewalks, and bike lanes—can extend the distance potential transit riders are willing and able to travel, making transit an attractive option for more people.

Recently, there has been much discussion about how ride-hailing services such as Uber and Lyft are affecting transit ridership, how AVs could accelerate or alter these changes, and what it all means for the mobility of transit riders. One possibility is that inexpensive and ubiquitous AV services will provide the first- and last-mile connections between households and transit stations (see Box 4). This would make high-capacity mass-transit lines accessible and convenient to people whose origins or destinations are too far for walking and could increase mass transit ridership. There is some evidence that ride-hailing companies are playing this complementary role today, and AVs could make these last-mile services less expensive and thus more attractive (Hall, Palsson, and Price 2018). Another possibility is that AVs compete with transit, allowing potential transit riders to travel directly from origin to destination in an AV ride-hailing service, thus decreasing transit ridership to the detriment of transit agency finances and traffic congestion. Again, evidence from the growth of ride-hailing services suggests this is already happening (Schaller 2018). Finally, AV technology can also be applied to transit vehicles, allowing transit agencies to innovate, improve service, and reduce costs. For example, a study of the application of AV technology to a bus rapid transit (BRT) system suggested that this technology could cut delays by 50 percent and reduce travel times by 35 percent compared with standard BRT or cars, while maintaining the same high throughput of traditional BRT systems, which have more than five times the capacity of standard car-dominated lanes (Calthorpe and Walters 2016). Whether AVs help or hurt transit ridership, transit agency finances, congestion, and urban mobility will depend on technology, consumer preferences, and public policy, and many cities are starting to pay close attention (Bloomberg Philanthropies and the Aspen Institute 2017).

Transit Investment Reduces Congestion and Preserves Mode Choice

Our study finds that better transit helps preserve mode choice and reduces congestion. As discussed above, pooled AVs dramatically increase access to jobs and other opportunities, but most of these jobs are accessible only by car. In our projected 2040 baseline, 23 percent of jobs accessible by car are also accessible by mass transit, but since pooled AVs double job accessibility by car without changing job accessibility by transit, the percentage of jobs available to both mass transit and car falls by half to 11 percent. In order to take advantage of the additional accessible jobs, people will have to travel by car. Yet, while AV rides may be less expensive than car ownership today, car travel is still likely to remain a more expensive mode of travel than transit, so the switch will be a burden for low-income communities. The Pooling scenario also sees transit mode share fall by a third, which will threaten the financial stability of the transit system or require greater government support.

By contrast, our Pooling, Better Transit and No Pooling, Better Transit scenarios show more of the region located within reach of high-quality mass transit. The scenarios model improvements in speed and frequency along existing lines

Katherine Catalano/UCS

As a single parent living in a Maryland suburb, William Cox has to think about his own commute in addition to getting his son where he needs to go, all using public transportation. His biggest challenge is that pediatricians accepting Medicaid seem to be moving farther and farther away, and now it's almost an hour bus ride to get his son to the doctor, longer if during the peak congestion of rush hour. If AVs aren't cost-competitive with transit, they'll do nothing to make parenthood easier for William, but increased investment in transit will directly benefit him with or without AVs.

plus the build-out of high-capacity transit along key corridors consistent with proposals made by a 2017 long-range planning task force for the DC metro area. In the Pooling, Better Transit scenario, 21 percent of jobs are accessible by transit, giving people more choices for both employment and mode of travel. In both these scenarios, transit trip duration dropped by 10 minutes compared with the 2040 baseline. Transit mode share is almost 20 percent higher in the Pooling, Better Transit scenario than in the Pooling scenario, which reduces the financial burden on transit systems, although transit mode share remains well below the 2040 baseline.

Transit Accessibility Is Most Important for Members of Low-Income Communities

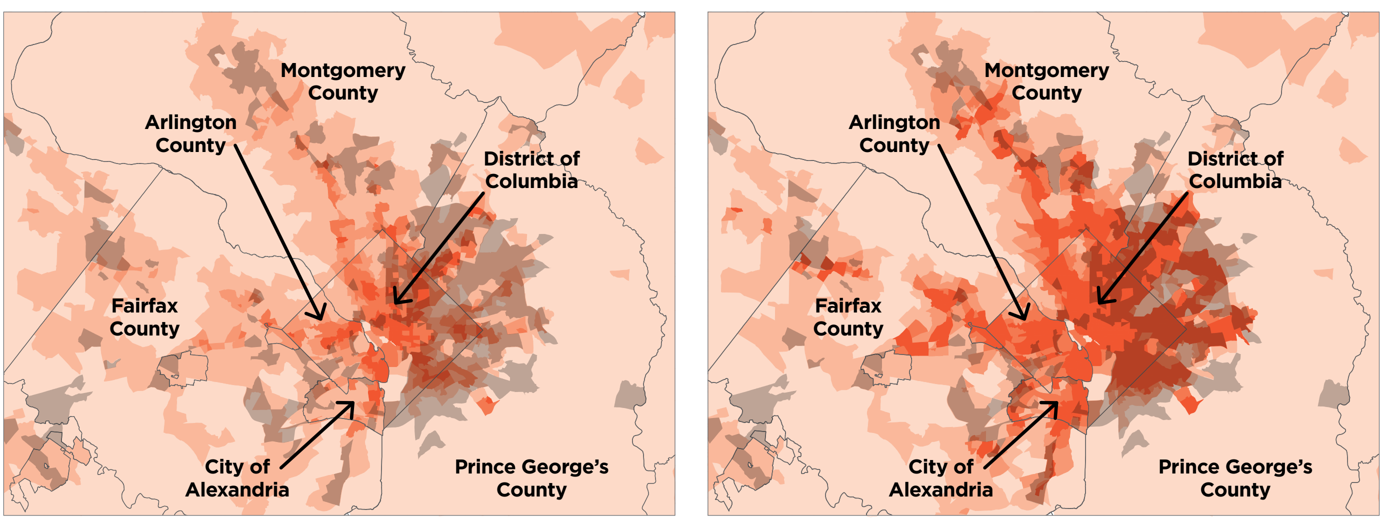
Access to transit is especially important to communities with limited or no access to cars, but transit is useful only for those who live and work close enough to the network to access it. The map in Figure 5 shows the ratio of jobs accessible by transit to jobs accessible by car across the region for both the Pooling and Pooling, Better Transit scenarios; this ratio provides a

> ***Having many job options available by the most affordable travel mode is valuable to lower-income communities.***

measure of whether driving is required to access opportunity. Note the much larger share of EEAs on the eastern side of the region that now have greater access to jobs via transit in the Pooling, Better Transit scenario, which helps bridge the East–West divide. For EEAs in the eastern side, pooling and better transit might provide access to 35 percent as many jobs by transit as by car, versus just 18 percent with pooling alone. While our study does not project specific future costs for any mode, we expect mass transit to remain the least expensive option. Having many job options available by the most affordable travel mode is especially valuable to lower-income communities.

FIGURE 5. Job Accessibility by Car and Job Accessibility by Transit: Two Scenarios

AV Pooling | **AV Pooling, Better Transit**



Percentage of Jobs Available by Both Car and Transit

< 1% | 1–10% | 10–20% | 20–30% | > 30% | County Boundary | Equity Emphasis Areas

Investments in high-capacity mass transit will ensure that people have significant job opportunities that do not require driving to work. This will help everyone by reducing traffic and pollution, and especially low-income populations that benefit from the lower cost of travel by transit.

CASE STUDY 2.

Historic Anacostia and Cleveland Park

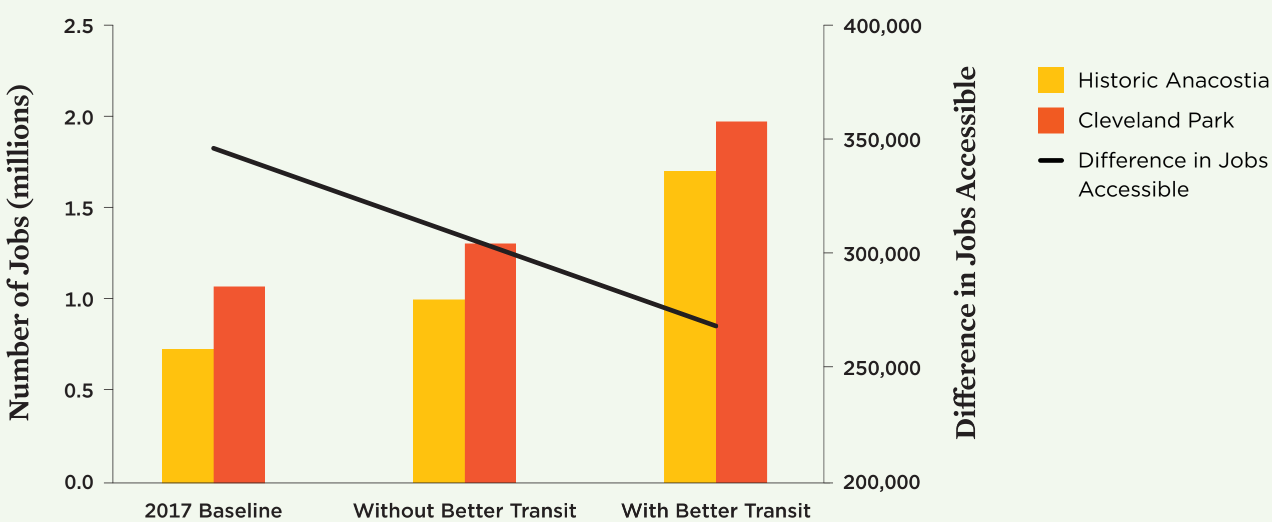
Two neighborhoods in Washington, DC, that exemplify the potential positive effect of better transit are Historic Anacostia and Cleveland Park. Both neighborhoods are similarly close to downtown DC and currently have good access to transit. Historic Anacostia is 98 percent people of color and has an average household income of $23,700, while Cleveland Park is 87 percent white and has an average household income of $89,700. Figure 6 depicts the differences in job accessibility between Historic Anacostia—an EEA—and Cleveland Park—a non-EEA. In all our scenarios, Historic Anacostia has lower job accessibility by transit. But enhancing transit accessibility narrows that gap by 25 percent. Enhancing transit as high-occupancy AVs become prevalent would narrow the inequitable job accessibility between this EEA and non-EEA.

Tim Evanson/Creative Commons (Flickr)

Many residents in Historic Anacostia are dependent on public transit.

Overall, enhancements to the transit system could increase job accessibility by transit by 126 percent and reduce the disparity in accessibility between these neighborhoods. Because transit is likely to remain the least expensive transportation option, it is especially important to enhance accessibility for low-income and other transit-dependent communities. Moreover, improving transportation infrastructure in Historic Anacostia and other communities in the eastern side of the region could help address some of the longstanding disparities that have marked the region's history (CUMP 1999).

FIGURE 6. Disparities in Jobs Accessible by Transit, Historic Anacostia vs. Cleveland Park



Improving the transit system in the DC metro area would reduce inequities in job accessibility by transit between Historic Anacostia, an EEA, and Cleveland Park, a non-EEA.

Note: Pooling and No Pooling variables are not shown because they have no impact on job accessibility in these scenarios.

Pollution and Climate Change

AVs increased driving in all scenarios that we studied. Pooling and better transit limit the increase somewhat, but all scenarios show total VMT growth was well beyond projections that do not account for AVs (such as the 2040 baseline). Without commensurate reductions in pollution per vehicle mile, this growth will increase global warming and local air pollution compared with the status quo. A rapid transition to EVs will be required to mitigate these negative effects.

Transportation Is a Major Source of Air Pollution and Creates Inequitable Health Outcomes

Transportation is the largest source of carbon dioxide emissions in the United States, surpassing the power sector in 2016 (EIA 2017). A recent report describes the changes needed to reduce regional transportation emissions to meet climate goals set in the Paris Agreement of 2015. The report concludes that more efficient vehicles, a rapid transition to EVs, and a gradual transition to low-carbon fuels could lead the Northeast and Mid-Atlantic regions (including Maryland, Virginia, and the District of Columbia) to cut global warming pollution from transportation by 37 percent by 2030 and 78 percent by 2050 (Lowell, Saha, and Van Atten 2018).

The United Nations Intergovernmental Panel on Climate Change has already warned that the world is witnessing a higher incidence of heat waves, floods, droughts, and other extreme weather events (IPCC 2018). Extreme weather events disproportionately affect low-income communities and communities of color; this disproportionality is known as the "climate gap." For example, African Americans in the Los Angeles metropolitan area had a projected heat wave mortality rate that is nearly twice that of other city residents (Shonkoff, Pastor, and Sadd 2011). One explanation is that members of low-income communities and communities of color are often segregated and concentrated in inner cities and lack access to air conditioning. The heat island effect—in which lighter-colored materials such as grass and trees are replaced in urban areas by darker-colored materials such as roads and buildings, leading to increased absorption of sunlight and reduced dissipation of heat, thus warming the local area—will likely result in a widening of this climate gap (Shonkoff, Pastor, and Sadd 2011).

[Transportation is the largest source of carbon dioxide emissions in the United States, surpassing the power sector in 2016.]

The transportation sector is also a major source of so-called criteria pollutants, such as nitrogen oxides and fine particulate matter. Low-income communities and communities of color suffer disproportionately from criteria pollutants' negative health effects. For example, in the United States in 2010, people of color were exposed to air containing a nitrogen dioxide (NO_2) concentration that was 37 percent higher than whites were exposed to, and people of color were 2.5 times more likely than whites to live in a census block group where the air's average NO_2 concentration was above the World Health Organization annual guideline (Clark, Millet, and Marshall 2017). A study by the Environmental Protection Agency's National Center for Environmental Assessment showed that, compared with the general population, African Americans and low-income residents, respectively, were exposed to 54 and 35 percent more particulate matter small enough to lodge in lung tissue (Mikati et al. 2018). Furthermore, an analysis of national census and traffic data showed that in 2010, 27 percent of communities of color, compared with 19 percent of the total population, lived near major roads, where transportation-generated air pollutants were at their highest concentrations (Rowangould 2013). Living near major roadways is linked to a higher incidence of respiratory illnesses such as asthma; people of color and low-income families are also less likely to be able to treat these ailments because they are less likely to carry health insurance (Cordova et al. 2006).

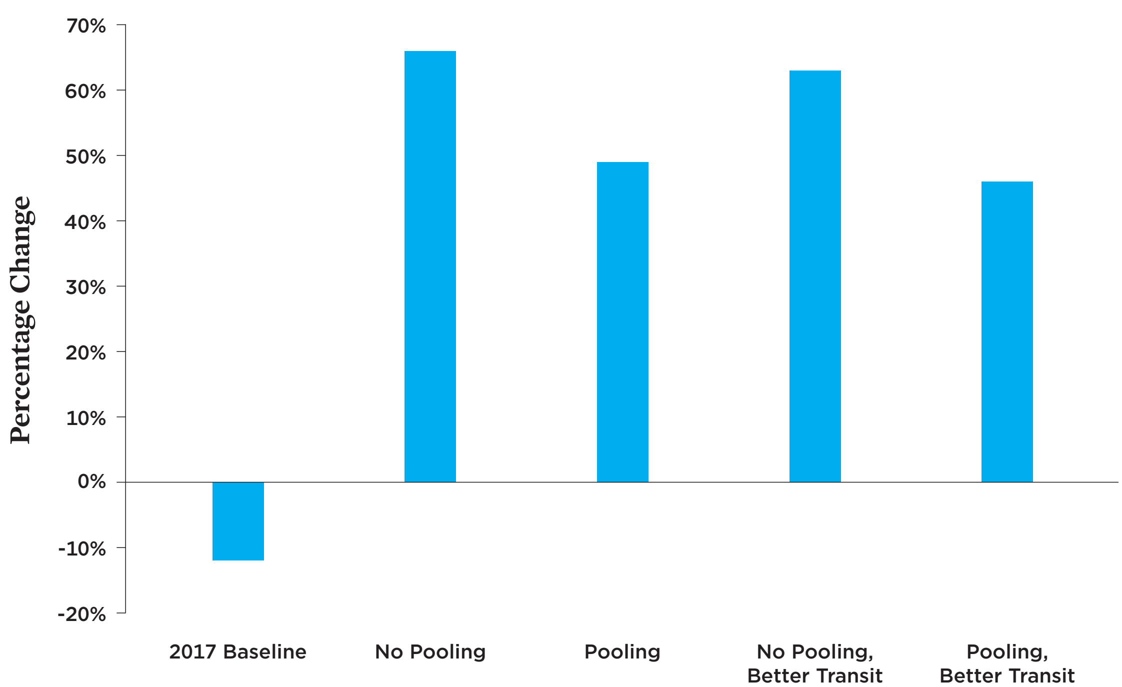
AVs Increase Total Driving

We found that AVs increase total driving in all scenarios, with a maximum increase of 66 percent in the No Pooling scenario compared with the 2040 Baseline scenario (Figure 7). The increases were somewhat mitigated by pooling, with the increase falling to 49 percent in the Pooling scenario and 46 percent in the Pooling, Better Transit scenario.

Our analysis finds that AVs increase total driving in all scenarios, from 46 percent to as much as 66 percent.

VMT increases of this magnitude make reducing transportation-related global warming emissions substantially harder. A recent transportation emissions study found that 60 percent of the in-use passenger car fleet in the Northeast and Mid-Atlantic region would have to be electric by 2040 to cut transportation global warming pollution by 37 percent by 2030 and 78 percent by 2050, and this finding is based on status quo assumptions for overall travel demand (Lowell, Saha, and Van Atten 2018). To meet the same targets with 46 to 66 percent more VMT will require a much more rapid transition to EVs. Moving to EVs at the same time as AVs and pooling can introduce synergies that make all the technologies more successful than if introduced separately (see Box 5).

FIGURE 7. VMT Percentage Change from 2040 Baseline



AVs increase total driving in all scenarios. Pooling mitigates the increases somewhat.

BOX 5.

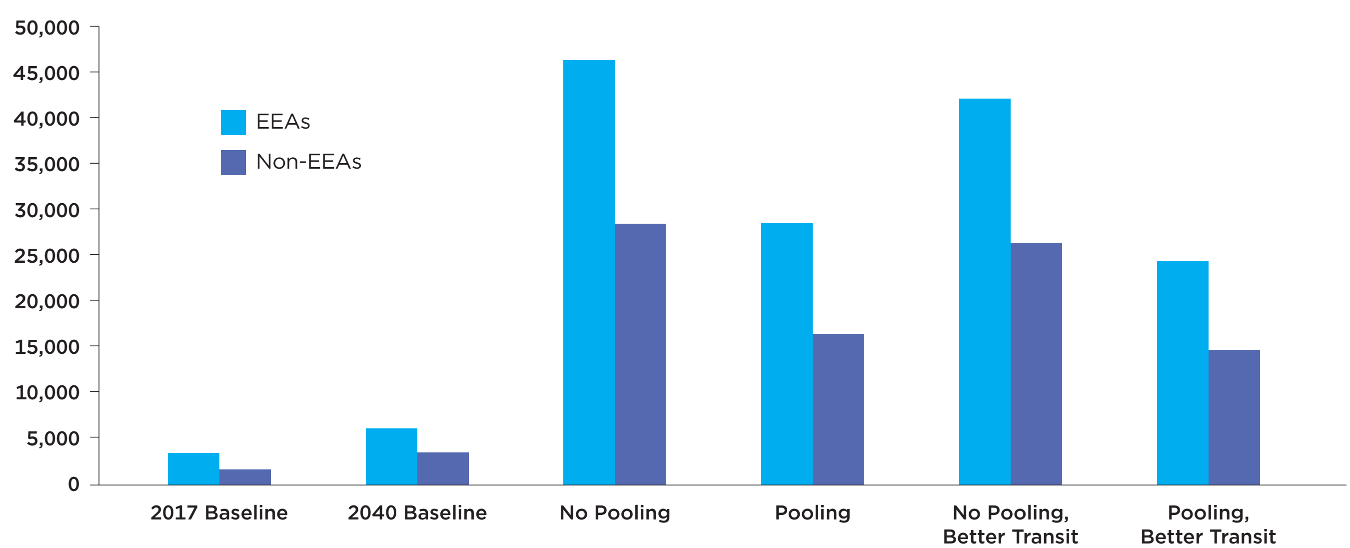
Electrifying Pooled AV Ride-Hailing Fleets: Three Revolutions

AV technology is sometimes presented as just one of three major shifts in transportation, the other two being a conversion from gasoline to electric-powered vehicles and from private vehicle ownership to pooled rides and other shared modes. Together, these "three revolutions"—automation, electrification, and sharing—may provide benefits that each alone would not (Sperling 2018). For example, a transition to EVs might happen faster in a three revolutions scenario. Fewer cars would be required and each shared car would drive more miles, so total fleet turnover would happen much faster than it does now, when privately owned cars stay on the road for an average of 15 years (ORNL 2018). Moreover, because each car would drive so many more miles per year, cost savings associated with electric drive would outweigh higher battery cost sooner than in privately owned cars. AV technology could thus accelerate the transition to EVs, particularly if they are in high-occupancy shared fleets.

AVs Could Increase Local Air Pollution, Especially in Disadvantaged Neighborhoods

We also analyzed the effects of AVs on total VMT during afternoon rush hour congestion (Figure 8). The addition of AVs to the road results in marked increases in congested VMT in all our scenarios compared with the 2040 Baseline scenario, leading to increased population exposure to air pollution, noise, crash risk, and other negative effects associated with proximity to congested roadways. For EEAs, the increases are especially dramatic, with the No Pooling scenario increasing congested VMT by more than seven times compared with the 2040 Baseline scenario. In the Pooling scenario, congested VMT was 38 percent lower than in No Pooling, and in Pooling, Better Transit it was 47 percent lower. However, this is still almost four times higher congested VMT than in 2040 Baseline, so

FIGURE 8. Congested Vehicle Miles Traveled



Congested VMT increases in all cases when AVs are introduced to the transportation system, especially in EEAs. Pooling and better transit mitigate the increase somewhat.

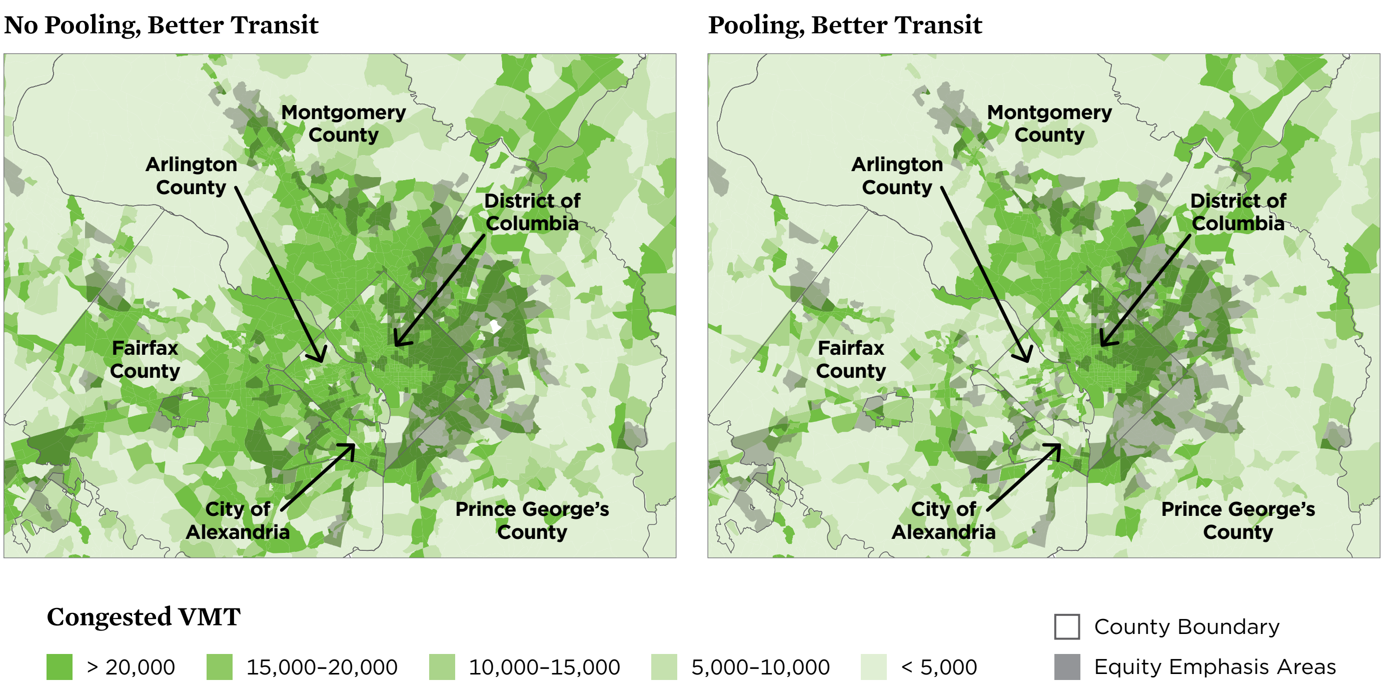
Automated vehicle technology could revolutionize how people get around—with especially high stakes for low-income neighborhoods and communities of color.

additional measures are required to mitigate the increased exposure to the resulting damage. Non-EEAs experience similar large percentage increases in congested VMT, but in absolute values that are much less than EEAs experience.

Direct prediction of air pollution levels was beyond the scope of our model, but congested VMT provides an indicative proxy. The discrepancies we found in congested VMT highlight the increased exposure of EEA residents to air pollution because they are more likely to live near major roadways. In every scenario, residents living in EEAs are exposed to 60 to 75 percent more congested VMT than those living in non-EEAs. The accelerated phase-out of more-polluting vehicles and a more rapid transition to EVs could mitigate exposure to air pollution; however, exposure to other negative effects of living near major roadways will require additional measures that specifically address disparate effects on individual communities.

Figure 9 depicts congested VMT in the No Pooling, Better Transit and Pooling, Better Transit scenarios. Although congestion is widespread in both scenarios, fewer areas are exposed to congested VMT, and thus to more pollutants, in Pooling, Better Transit.

FIGURE 9. Congested Vehicle Miles Traveled with Better Transit



Even with better transit, AVs will increase the number of vehicle miles driven in traffic congestion, in turn increasing nearby residents' exposure to pollution. Pooling rides in AVs will somewhat reduce this problem, and the electrification of AVs will help as well.

CASE STUDY 3.

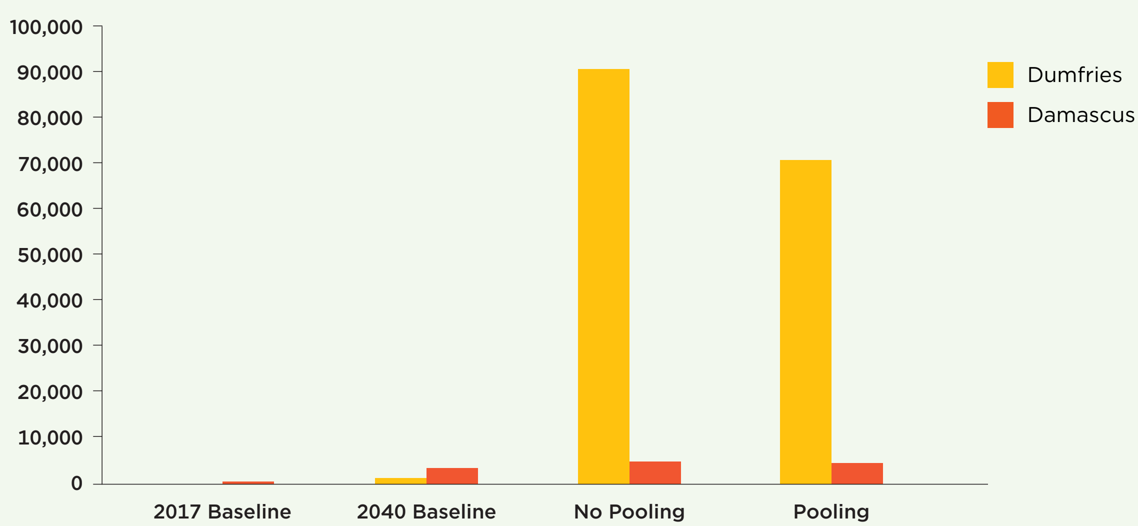
Dumfries and Damascus

Dumfries and Damascus, Virginia, are two communities on the DC metro area's outer edge. Neither has good access to transit, so cars are the dominant transportation mode in both. Dumfries is racially mixed, with 56 percent people of color, and has a median household income of $76,700, well below the regional average. Damascus is 78 percent white and has a median household income of $123,700, slightly above the regional average. Moreover, while Dumfries is located on a major interstate highway, Damascus is not. Neither community currently has significant congested VMT, and both remain below the regional average in the 2040 Baseline scenario. However, the AV scenarios show a significant increase in congested VMT for Dumfries—almost 25 times the 2040 regional average—because of its location on a major regional highway (see Figure 10). Because Damascus is farther from major highways, AVs cause much less local congestion. Pooling AVs mitigates the congestion by about 20 percent, but additional measures will need to be taken to protect people living near highways from air pollution. Rapid electrification may help, but other measures (such as implementing street design to prioritize non-drivers) may also be required to address the other negative effects of increased VMT and congestion.

famartin/Creative Commons (Wikimedia Commons)

Cars are the dominant mode of transit in Dumfries, and congestion in that community could skyrocket in 2040.

FIGURE 10. Congested Vehicle Miles Traveled, Dumfries vs. Damascus



AVs increase congested driving in all scenarios, especially for communities in close proximity to highways.

[CHAPTER 5]

Conclusions and Policy Recommendations

What's at Stake

The scenarios we analyzed present clear choices. AVs operated as single-occupancy vehicles will increase congestion and pollution. They will also reduce transit use. A pooled AV system that increases average vehicle occupancy and complements a better public transit network will increase job accessibility while creating less pollution and greater mode choice. These outcomes as summarized in the table below.

Within the framework of our analysis, AVs offer some improvement in accessibility over the current system with or without pooling or transit enhancements, but only with pooling and better transit are the best outcomes realized. For example, because AVs, even without pooling, increase the effective capacity of highways, our study projects that nonpooled AVs will reduce travel times and increase job accessibility but will also lead to dramatic increases in congestion and pollution. Pooling and transit investment will enhance AVs' benefits and mitigate their downsides, but additional changes in land use, vehicle electrification, and other policies that are beyond the scope of our analysis will also be needed to deliver AVs' potential benefits. We describe the implications of these additional changes, together with our findings, in the recommendations that follow.

Best and Worst Case Scenarios for AV Deployment, Compared with 2040 Baseline

	2040 Baseline	No Pooling	Pooling, Better Transit
Jobs Accessible by a 45-Minute Car Commute	1,201,095	1,463,995	2,772,072
Jobs Accessible by a 45-Minute Transit Commute	278,748	278,748	569,536
Average Car Trip Duration (minutes)	45	38	32
Average Transit Trip Duration (minutes)	53	51	43
Average Car Trip Distance (miles)	9.9	11.4	12.8
Transit Mode Share (percentage)	10.8	8	8.7
Daily VMT	158,535	263,322	231,964
Congested VMT	3,660	30,668	15,645

A comparison of key indicators shows that a pooled AV system and improved public transit network will increase job accessibility while creating less pollution and greater mode choice.

Katherine Catalano/UCS

Nina-Sophia Pacheco is a professional singer and actress living in a non-metro-accessible Virginia suburb. Her ability to make a living is dependent on her driving across the region day or night for auditions and jobs, but she tries to avoid traveling during rush hour because the congestion and tolls are so prohibitive. If AVs reduce congestion and travel times she can get around more easily, but this will only happen if they are implemented in a high-occupancy scenario.

BEST CASE SCENARIO

In the best case, electric-drive AVs are used as high-occupancy pooled vehicles. Rides affordable to all are available without discrimination in vehicles that provide universal access for the disabled. With affordable mobility readily available, car ownership is no longer necessary to access opportunity. And because AVs are electric and the electricity comes from renewable sources, transportation pollution is dramatically reduced. AV neighborhood shuttles provide convenient first- and last-mile access to a robust and growing high-capacity, affordable mass-transit system, allowing people more choices of how to get around. Space no longer used for parking is repurposed for other functions such as parks, bike lanes, and sidewalks. Streets with protected lanes for bicycles and walking enhance the livability of dense, transit-accessible communities.

WORST CASE SCENARIO

In the worst case, AV technology is added to cars without changing the way people access mobility or moving away from petroleum-based fuels. By eliminating the need to have a person physically drive, AVs lead to big increases in vehicle miles traveled and associated increases in congestion. AVs also draw passengers away from transit. Declining ridership leads to decreased transit service and higher costs. AV technology increases the cost of owning and operating cars, and, because there are few transportation alternatives, these costs increase low-income communities' burdens associated with limited mobility, forcing individuals either to spend a larger share of their income on transportation or to miss out on many opportunities accessible only to car owners. Increased driving and congestion increase global warming emissions and local air pollution, and large increases in congested VMT create barriers to walking and bicycling. People being able to work or sleep during AV travel allows for longer commutes, and housing development focuses on far-flung car-dependent suburbs on the region's outer periphery. Increased investment on the region's far western edge creates jobs that are inaccessible to those living in the region's eastern side, exacerbating the East–West divide and perpetuating or even amplifying historical inequities.

Policy Recommendations

As AVs are introduced, policymakers will face unfamiliar challenges and opportunities affecting the transportation system and the equitable treatment of communities historically lacking access to high-quality transportation options. This study examined multiple scenarios of AV deployment in the DC metro area and found that pooled, electric AVs combined with a robust mass-transit system provide the best societal outcomes for all communities.

Based on our findings, we make three general recommendations and suggest several specific policy approaches to steer the region toward a more equitable, efficient, and clean transportation future. Some of these policies can be implemented today to guide the early deployment of AVs, while others can be implemented as AVs are more widely deployed.

RECOMMENDATION 1: TO AVOID CONGESTION, AV DEPLOYMENT MUST PRIORITIZE THE MOVEMENT OF PEOPLE OVER VEHICLES BY ENCOURAGING POOLING

If AVs fulfill their promise of providing more convenient, affordable transportation to a larger share of the population, they could dramatically increase demand for single-occupancy travel, leading to increases in congestion. AVs deployed predominantly as part of shared transportation services that pool riders going to similar destinations can move more people in fewer vehicle trips than would AVs following today's

> ***AV pooling can move more people in fewer trips, reducing pollution and congestion.***

Ben Schumin/Creative Commons (Wikimedia Commons)

Public transit moves many more people in fewer trips than single-occupancy vehicles, reducing congestion and air pollution.

prevailing single-occupancy usage patterns; they could thus reduce congestion that would otherwise compromise AVs' potential benefits. For more information, see "AV Technology Can Dramatically Increase Jobs Accessible by Car If Rides Are Pooled" (p. 6).

Specific Policy Recommendations:

1. **Expand high-occupancy vehicle lanes, high-occupancy toll lanes, and other congestion pricing strategies** that manage congestion by prioritizing the movement of high-occupancy vehicles. Although these strategies are already in use around the metro area, connecting and expanding these road sections to create a more comprehensive express travel network could ensure that pooled rides are more affordable and convenient than riding alone. Because AVs, especially when coupled with pooling, will increase the existing infrastructure's capacity to move people, the express travel network should be expanded primarily by converting general-purpose lanes to express lanes that give priority to pooled rides rather than by widening roadways.
2. **Adapt street design to accommodate shared modes.** Today's street infrastructure is designed to accommodate private cars, but pooled transportation services will need a different street design, with less parking and more curb space dedicated to safe passenger pick up and drop off that does not interrupt traffic. To encourage the use of pooled vehicles, policymakers should ensure that street design and the allocation of street space supports their safe and efficient use.
3. **Ensure pooled rides benefit all communities.** Different communities have different needs, preferences, and ways of doing business, and robust community engagement is needed to ensure that all communities can benefit from AVs and associated services. Residents of all neighborhoods and communities, companies, and local officials must all have a voice in pilot programs and experimentation to see what works and to address problems that arise. Ultimately, new regulations will be needed to ensure that residents in EEAs and other populations poorly served by today's transportation system are able to access and benefit from the expanded mobility pooled AV services can provide and are also able to play an active role in these regulations' development.

RECOMMENDATION 2: TO MAINTAIN MULTIMODAL ACCESS AND IMPROVE EQUITY, MASS TRANSIT MUST BE MODERNIZED AND IMPROVED

Although AVs combined with pooling could make car trips more convenient, accessible, and affordable, high-capacity mass transit provides a complementary service, particularly because it would connect dense, urban job and housing centers while facilitating a healthier and affordable multimodal transportation system. Continued investment in and enhancement of high-capacity mass transit can ensure that AVs and mass transit complement one another and support smart growth goals. For more information, see "Transit Investment Reduces Congestion and Preserves Mode Choice" (p. 15).

Specific Policy Recommendations:

1. **Enhance and expand high-capacity mass transit.** Mass transit can utilize AV technology to increase ridership, improve service, and reduce fares to remain a robust part of a future transportation system. The DC Metro system is a core connection between many of the region's urban centers; it must be properly maintained, modernized, and improved to support the vitality and growth of these neighborhoods. Regional rail and BRT systems should expand the reach of high-quality mass transit to more of the region and to prioritize improved accessibility for areas with the greatest needs, such as EEAs.
2. **Enhance first- and last-mile connections and smart growth.** Transit agencies and ride-hailing companies should develop partnerships to facilitate first-mile/last-mile connections that make high-quality mass transit systems accessible to more of the region. Compact development in transit-accessible communities can reduce demand for car trips, support better transit, and provide many additional health and economic benefits. Affordable housing within these transit-oriented communities is essential to ensure these benefits are provided equitably.

Kevin H./Creative Commons (Flickr)

Increased vehicle traffic can deter people from walking and biking. Transportation planning policies must ensure that all road users—not just cars—can get around safely.

3. **Ensure AVs are accessible to persons with disabilities.** As AVs make rides more convenient and affordable, private transportation service providers may take over some services currently offered by public transit agencies. Policymakers must ensure that the new services are ADA compliant, and AV manufacturers should design vehicles with universal access so that people with disabilities maintain their current access to the transit system and share in the benefits new mobility options offer.

RECOMMENDATION 3: TO REDUCE POLLUTION ASSOCIATED WITH INCREASED DRIVING, AVS MUST BE POWERED PRIMARILY BY ELECTRICITY

In all our scenarios, AVs increase total VMT and the increase is especially severe in EEAs. These increases can be limited by AV pooling and enhancing mass transit, but a rapid transition to EVs is also required to ensure AV technology does not undermine efforts to reduce global warming pollution or increase other air pollution. For more information, see "AVs Increase Total Driving" (p. 18).

Specific Policy Recommendations:

1. **Require that AVs be EVs.** State and local policymakers should encourage and eventually require that AV deployment occurs in tandem with a transition to EVs by instituting incentives, per-passenger-mile emissions standards, and other approaches.
2. **Deploy EV charging infrastructure equitably.** Policymakers, AV companies, and state utility commissions should ensure that plug-in charging infrastructure is available to facilitate the deployment of electric AVs in disadvantaged communities.
3. **Mitigate pollution hot spots.** Engage communities living near transportation corridors who are disproportionately affected by air pollution, noise, and increased risk to vehicle collisions. The hope is to understand their needs and provide resources that will address these inequities they face.

AVs are already here—companies such as Waymo, Uber, Lyft, and Ford are actively testing them on streets today—and they may be common within the next few years. Now is the time for citizens and policymakers to start planning the cities and regions that will meet their needs, not just benefit the AV companies. We hope that our findings and recommendations can help inform important decisions at a key period of evolution in transportation.

[REFERENCES]

All URLs accessed on January 13, 2019.

AAA. 2018. *Your driving costs: How much are you really paying to drive?* Heathrow, FL. Online at *https://exchange.aaa.com/wp-content/uploads/2018/09/18-0090_2018-Your-Driving-Costs-Brochure_FNL-Lo-5-2.pdf.*

American Association of People with Disabilities (AAPD). 2012. *Equity in transportation for people with disabilities*. Washington, DC. Online at *www.civilrightsdocs.info/pdf/transportation/final-transportation-equity-disability.pdf.*

Bloomberg Philanthropies and the Aspen Institute. 2017. *Taming the autonomous vehicle: A primer for cities*. Washington, DC. Online at *www.bbhub.io/dotorg/sites/2/2017/05/TamingtheAutonomousVehicleSpreadsPDF.pdf.*

Blumenberg, E., and M. Waller. 2003. *The long journey to work: A federal transportation policy for working families*. Washington, DC: The Brookings Institution. Online at *www.brookings.edu/wp-content/uploads/2016/06/20030801_Waller.pdf.*

Bullard, R.D. 2003. Addressing urban transportation equity in the United States. *Fordham Urban Law Journal* 31:1183. Online at *https://ir.lawnet.fordham.edu/ulj/vol31/iss5/2*.

Bureau of Labor Statistics (BLS). 2018. *Consumer expenditures survey tables*. Washington DC. Online at *www.bls.gov/cex/tables.htm*.

Calthorpe, P., and J. Walters. 2016. Autonomous vehicles: Hype and potential. *Public Square*, September 6. Washington, DC: Congress of New Urbanism. Online at *www.cnu.org/publicsquare/2016/09/06/autonomous-vehicles-hype-and-potential*.

Center for Neighborhood Technology (CNT). 2018. Housing and transportation affordability index. Chicago, IL. Online at *https://htaindex.cnt.org/fact-sheets/?focus=cbsa&gid=220#*.

Center on Urban and Metropolitan Policy (CUMP). 1999. *A region divided: The state of growth in greater Washington, DC*. Washington, DC: Brookings Institution. Online at *www.brookings.edu/wp-content/uploads/2016/06/DCRegion.pdf.*

Clark, L.P., D.B. Millet, and J.D. Marshall. 2017. Changes in transportation-related air pollution exposures by race-ethnicity and socioeconomic status: Outdoor nitrogen dioxide in the United States in 2000 and 2010. *Environmental Health Perspectives* 125:097012.

Cohn, J., R. Ezike, J. Martin, K. Donkor, M. Ridgeway, and M. Balding. 2019. Examining the equity impacts of autonomous vehicles: A travel demand model approach. Transportation Research Record (forthcoming). Online at *http://amonline.trb.org/68387trb-1.4353651/t0015-1.4368127/1513-1.4368346/19-04696-1.4361730*.

Cordova, R., M. Gelobter, A. Hoerner, J.R. Love, A. Miller, C. Saenger, and D. Zaidi. 2006. *Climate change in California: Health, economic and equity impacts*. Oakland, CA: Redefining Progress.

Corwin, S.J., E. Vitale, E. Kelly, and E. Cathles. 2015. *The future of mobility: How transportation technology and social trends are creating a new business ecosystem*. Westlake, TX: Deloitte University Press. Online at *www2.deloitte.com/insights/us/en/focus/future-of-mobility/transportation-technology.html.*

Danks, D., and A.J. London. 2017. Algorithmic bias in autonomous systems. In *Proceedings of the twenty-sixth international joint conference on artificial intelligence: AI and autonomy track*. International Joint Conferences on Artificial Intelligence Organization, 4691–4697. Online at *https://doi.org/10.24963/ijcai.2017/654*.

DC Fiscal Policy Institute (DCFPI). 2014. *DC poverty demographics*. Washington, DC. Online at *www.dcfpi.org/wp-content/uploads/2009/03/DC-Poverty-Demographics.pdf.*

Energy Information Administration (EIA). 2017. Power sector carbon dioxide emissions fall below transportation sector emissions. *Today in Energy*, January 19. Washington, DC: US Department of Energy. Online at *www.eia.gov/todayinenergy/detail.php?id=29612*.

Ezike, R. 2016. *Transportation, sustainability, and equity, and the effect on the African-American community*. Washington, DC: Congressional Black Caucus Foundation. Online at *www.cbcfinc.org/wp-content/uploads/2016/10/CBCFTransportationBriefing.pdf.*

Greater Washington 2050 Coalition (GWC). 2010. *Region forward: A comprehensive guide for regional planning and measuring progress in the 21st century*. Washington, DC. Online at *www.mwcog.org/documents/2010/01/28/region-forward-vision*.

Green, J. 2015. Access to public transit is a matter of racial equity. New York, NY: Center for Social Inclusion. Blog, April 9. Online at *www.centerforsocialinclusion.org/access-to-public-transit-is-a-matter-of-racial-equity*.

Guzman, G.G. 2017. Household income: 2016. American community survey briefs. Washington, DC: US Census Bureau. Online at *www.census.gov/content/dam/Census/library/publications/2017/acs/acsbr16-02.pdf.*

Hall, J.D., C. Palsson, and J. Price. 2018. Is Uber a substitute or complement for public transit? *Journal of Urban Economics* 108:36. Online at *https://doi.org/10.1016/j.jue.2018.09.003*.

Intergovernmental Panel on Climate Change (IPCC). 2018. *Global warming of 1.5°C: An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. New York, NY.

Johnson, B.A. 2015. *Disruptive mobility: AV deployment risks and possibilities*. Chicago: Barclays Capital, Research Department. Online at *https://orfe.princeton.edu/~alaink/SmartDrivingCars/PDFs/Brian_Johnson_DisruptiveMobility.072015.pdf.*

Johnson, C., and J. Walker. 2016. *Peak car ownership: The market opportunity for electric automated mobility services*. Boulder, CO: Rocky Mountain Institute. Online at *https://rmi.org/wp-content/uploads/2017/03/Mobility_PeakCarOwnership_Report2017.pdf*.

Kravitz-Wirtz, N., K. Crowder, A. Hajat, and V. Sass. 2016. The long-term dynamics of racial/ethnic inequality in neighborhood air pollution exposure, 1990–2009. *Du Bois Review* 13(2):237–259. Online at *https://doi.org/10.1017/S1742058X16000205*.

Lazere, E. 2018. DC's growing prosperity is not reaching black residents, census data show. Washington, DC: DC Fiscal Policy Institute. Blog, September 26. Online at *www.dcfpi.org/all/dcs-growing-prosperity-is-not-reaching-black-residents-census-data-show*.

Litman, T. 2018. *Autonomous vehicle implementation predictions: Implications for transport planning*. Victoria, BC, Canada: Victoria Transport Institute. Online at *www.vtpi.org/avip.pdf*.

Lowell, D., A. Saha, and C. Van Atten. 2018. *Decarbonizing transportation: The benefits and costs of a clean transportation system in the Northeast and Mid-Atlantic region*. Concord, MA: M.J. Bradley and Associates. Online at *www.ucsusa.org/sites/default/files/attach/2018/10/UCS_Final_Report_FINAL_11Oct18.pdf*.

Marcantonio, R.A., A. Golub, A. Karner, and L. Nelson. 2017. Confronting inequality in metropolitan regions: Realizing the promise of civil rights and environmental justice in metropolitan transportation planning. *Fordham Urban Law Journal* 44:1017. Online at *https://ir.lawnet.fordham.edu/ulj/vol44/iss4*.

Mikati, I., A.F. Benson, T.J. Luben, J.D. Sacks, and J. Richmond-Bryant. 2018. Disparities in distribution of particulate matter emission sources by race and poverty status. *American Journal of Public Health* 108(4):480–485.

Morgan Stanley. 2016. Shared mobility on the road to the future. New York, NY. Online at *www.morganstanley.com/ideas/car-of-future-is-autonomous-electric-shared-mobility*.

National Capital Region Transportation Planning Board (TPB). 2017. Methodology for equity emphasis areas. Washington, DC. Online at *www.mwcog.org/assets/1/6/methodology.pdf*.

National Capital Region Transportation Planning Board (TPB). 2014. *Regional transportation priorities plan*. Washington, DC. Online at *www.mwcog.org/rtpp*.

National Capital Region Transportation Planning Board (TPB). 2006. *Regional mobility and accessibility study: Alternative land use and transportation scenarios: Phase I technical report*. Washington, DC.

National Capital Region Transportation Planning Board (TPB). 1998. *TPB vision*. Washington, DC. Online at *www.mwcog.org/documents/tpbvision*.

National Center for Smart Growth (NCSG). 2018. *Engaging the future: Baltimore-Washington 2040*. College Park, MD: University of Maryland. Online at *www.umdsmartgrowth.org/wp-content/uploads/2018/04/39317-UMD-Printing-Presto-Long-report-FINAL-1.pdf*.

New York Lawyers for the Public Interest (NYLPI). 2018. *Left behind: New York's for-hire vehicle industry continues to exclude people with disabilities*. New York, NY. Online at *www.nylpi.org/wp-content/uploads/2018/05/Left-Behind-Report.pdf*.

Oak Ridge National Laboratory (ORNL). 2018. *Transportation energy data book edition 36*. Oak Ridge, TN. Online at *https://cta.ornl.gov/data/tedbfiles/Edition36_Full_Doc.pdf*.

Office of Policy Research and Development (OPRD). 2018. *Displacement of lower income families in urban areas*. Washington, DC: US Department of Housing and Urban Development. Online at *www.huduser.gov/portal/publications/DisplacementReport.html*.

PolicyLink. 2018. *The equity manifesto*. Washington, DC. Online at *www.policylink.org/sites/default/files/pl_sum15_manifesto_FINAL_2018.pdf*.

PolicyLink and Program for Environmental and Regional Equity (PERE). 2018. National equity atlas. Washington, DC, and Los Angeles, CA. Online at *https://nationalequityatlas.org/indicators/Car_access*.

Rowangould, G.M. 2013. A census of the US near-roadway population: Public health and environmental justice considerations. *Transportation Research Part D: Transport and Environment* 25:59–67.

Schaller, B. 2018. *The new automobility: Lyft, Uber, and the future of American cities*. Brooklyn, NY: Schaller Consulting. Online at *www.schallerconsult.com/rideservices/automobility.pdf*.

Schrank, D., B. Eisele, T. Lomax, and J. Bak. 2015. *2015 urban mobility scorecard*. College Station, TX: Texas A&M Transportation Institute and INREX. Online at *https://mobility.tamu.edu/ums/report*.

Shonkoff, S., M. Pastor, and J. Sadd. 2011. The climate gap: Environmental health and equity implications of climate change and mitigation policies in California—A review of the literature. *Climate Change* 109:S485–S493.

Sperling, D. 2018. *Three revolutions: Steering automated, shared, and electric vehicles to a better future*. Washington, DC: Island Press.

Tomer, A. 2011. *Transit access and zero-vehicle households*. Washington, DC: Brookings Institution. Online at *www.brookings.edu/wp-content/uploads/2016/06/0818_transportation_tomer.pdf*.

Union of Concerned Scientists (UCS). 2017. *Maximizing the benefits of self-driving vehicles*. Cambridge, MA. Online at *www.ucsusa.org/clean-vehicles/principles-self-driving-cars*.

US Census Bureau. 2018. American community survey data. Washington, DC. Online at *www.census.gov/programs-surveys/acs/data.html*.

Washington Metropolitan Area Transit Authority (WMATA). 2016. *Connect Greater Washington*. Washington, DC. Online at *https://planitmetro.com/wp-content/uploads/2016/07/ConnectGreaterWashington-ExSum-Land-Use-As-Transport-Strategy-2016-02-29-Final-for-Posting.pdf*

Where Are Self-Driving Cars Taking Us?

Pivotal Choices That Will Shape DC's Transportation Future

We must make the right choices today to ensure that automated vehicles do not increase traffic and pollution, undermine public transit, and exacerbate inequities in our transportation system.

Automated vehicles (AVs) have the potential for transformational change in how we get around. But how will AVs affect our cities and communities—especially the most underserved populations? Will they help or hinder our ability to access jobs, health care, and education? If we do not make the right choices now, these vehicles could increase traffic and pollution, undermine public transit, and exacerbate inequities in our transportation system, leaving low-income neighborhoods and communities of color with less than their share of potential benefits and bearing a disproportionate share of the burdens.

This report examines future scenarios of AV and transit deployment in the Washington, DC, metro region, and recommends smart policies to guide the deployment of AVs, so they can be a tool to help everyone get access to the reliable, affordable, and efficient transportation they need, while cutting pollution. We can build a better transportation future if AVs are pooled, powered by electricity, and integrated with an effective mass transit system. Governments at every level need to start now to craft policies that will steer AV technology toward a more equitable and sustainable future.

Union of Concerned Scientists

FIND THIS DOCUMENT ONLINE: www.ucsusa.org/AV-equity

NATIONAL HEADQUARTERS
Two Brattle Square
Cambridge, MA 02138-3780
Phone: (617) 547-5552
Fax: (617) 864-9405

WASHINGTON, DC, OFFICE
1825 K St. NW, Suite 800
Washington, DC 20006-1232
Phone: (202) 223-6133
Fax: (202) 223-6162

WEST COAST OFFICE
500 12th St., Suite 340
Oakland, CA 94607-4087
Phone: (510) 843-1872
Fax: (510) 451-3785

MIDWEST OFFICE
One N. LaSalle St., Suite 1904
Chicago, IL 60602-4064
Phone: (312) 578-1750
Fax: (312) 578-1751

WEB: www.ucsusa.org

PRINTED ON RECYCLED PAPER USING VEGETABLE-BASED INKS