transfers

FROM KNOWLEDGE TO ACTION

Improving Pedestrian Access

Alleviating Urban Heat

Rewording Crash Coverage

Environmentally Friendly Highway Construction

Issue 5
Spring 2020

Issue 5 - Spring 2020

Table of Contents

Photo Credit: Pexels

Editor's Note

Michael Manville, Editor-in-Chief

It is more than a little odd to release a magazine about transportation at a time when few people are going anywhere. Travel is largely a derived demand. We move around not for its own sake but because there are things we want or need to do: go to work, gather with friends, get a meal or see a movie.

COVID-19 has dramatically restricted these activities, so travel, the subject matter of Transfers, has declined as well. The articles in this issue describe situations — walking to a train platform, hopping in a shared Uber — that mere months ago were commonplace, but that today seem distant and even dangerous.

Eventually, however, the pandemic will end. When it does, the world will need wise transportation policy. Transportation agencies will need to salvage their tattered budgets. Transit operators will need to make their vehicles safe for passengers and operators. And we all, hopefully, will need to rethink the transportation system we had before the virus put it on pause.

Many of us, during our stay-at-home orders, have marveled at our uncongested streets and clean air, and found solace in neighborhood walks or bike rides. COVID-19 has, in this way, exposed profound disparities and inefficiencies in our transportation system, which we came to accept because their sheer normalcy made them less visible. Our roads were congested, our skies hazy with pollution. Walking and cycling were difficult and dangerous. Our communities were hostile and inaccessible to people who couldn't drive.

The crisis has not just exposed but deepened these inequities. Low-paid essential workers are less likely than others to own automobiles. They ride to work on public transit systems we have neglected, and when they become sick we refer them to drive-thru testing sites. Our protocols for protection and treatment assume both the ability to stay home and access to a car. But our comfort and survival rely on people who often have neither.

We can do better. We can price our roads to minimize congestion and pollution, design our cities to protect and encourage walking and biking, treat our public transportation like something other than an afterthought to which we consign the unfortunate. And we can give cars to people who lack them. A fairer transportation system will involve most of us driving less, and some of us driving more. COVID-19 is new, and our progress against it is slowed because we don't understand it. That isn't the case with surface transportation. The fundamental problems of our system — congestion, pollution, unequal access — are not mysteries. We have long known what to do, and long been able to do it. The obstacle we face is smaller, and sadder. Too many of us, for too long, have just not cared.

It's hard to know if this will change. But the mission of *Transfers* is to make transportation research more accessible — to arm those who want a different world with the knowledge they need to get it. In that spirit, we give you this issue.

The 30-Minute City

David Levinson

In my home city of Sydney, Australia, the average speed of travel by car is about 20 mph after considering traffic signals and congestion. On highways in rural areas outside the city, the average speed is three times that (60 mph). Yet despite Sydney's congestion, rational people pay a pretty dear price to live in it, compared to what it would cost to live in rural Australia. Sydney, like many cities, is valuable for reasons other than ease of driving. What it offers is *access*.

Cities are organized so that many people can reach one another, and important destinations, in a short amount of time, whether on foot, or by bike, bus, train, ferry, or car. The most accessible cities maximize the destinations people can reach in a reasonable amount of time, even at modest speeds. Outside cities, travel speed, particularly by automobile, tends to be higher, but people and places are also farther apart.

Planners and urban designers recognize that automobiles have a number of negative effects (wasting scarce space, causing pollution and crashes), and they encourage people to walk more and drive less. Yet cities continue to create and maintain traffic systems that favor people in cars over people on foot. There are many ways to improve this situation, short of eliminating private car traffic from busy urban districts — although that should also be considered.
No one will be surprised to hear that cities seeking to increase access must make wise choices about long-term investments in major transport infrastructure, such as subways or highways. But cities must also make intelligent *smaller* decisions — about streets, intersections, and transit stops. This article is about those latter decisions: modest, local-level steps that are often overlooked by politicians, planners, and engineers who focus on major infrastructure policies and programs. These small decisions could easily improve accessibility by helping people minimize their travel time while walking or taking public transit. Actions like these could help achieve the "30-minute city."

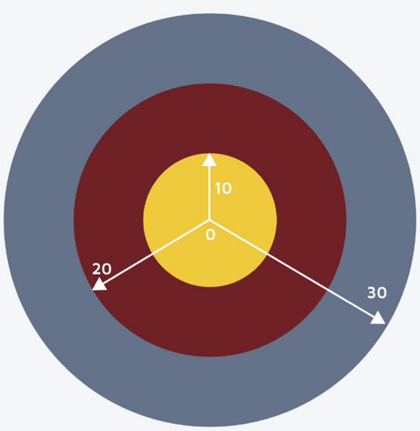
Access and Time

I borrow the phrase "30-minute city" from the Greater Sydney Commission, the planning agency for the Sydney region. The commission developed a 30-minute city concept as a centerpiece of its 40-year plan. The aim is for all residents of Sydney to be able to reach one of three important regional centers in less than a half-hour by walking, biking, or public transit (for context, right now the average transit-riding Sydneysider commutes for 62-minutes each way).

The 30-minute city is an example of the *cumulative opportunities* concept of accessibility, which focuses on how many potential destinations (jobs, schools, stores, doctors, etc.) someone can reach from a particular point in a given travel time (say 30 minutes), by a particular mode, at a certain time of day. The cumulative opportunities approach is a simple and useful way to compare accessibility across

While 30 minutes is a good measure for the journey to work, other metrics have been proposed for different activities, like shopping or daily living. For instance, the "pint-of-milk test" asks whether you can purchase a pint of milk within a 10-minute walk of your home whereas the "20-minute neighborhood" concept is all about living locally by giving residents the opportunity to access all the services they need within a 20-minute walk, bike ride, or transit trip.

Figure 1. Accessibility rings



different places and times. For instance, we can calculate how many jobs a person boarding transit at 8:00 a.m. in downtown Los Angeles could reach in 30 minutes, and compare that with the number of jobs a transit rider can reach in the same time if they start in downtown Santa Monica instead. Planners can use these standards and others like them (see **text box**) to develop strategies for creating walkable and transit-friendly cities and neighborhoods.

A key point is that minutes, and even seconds, can matter. When the goal is to maximize the opportunities available in a short window of time, shaving off a few seconds here and there adds up to minutes, and saving those minutes can have an outsized impact on overall accessibility. To illustrate, consider **Figure 1**, which shows the potential area a person could access from a central point if they travel for 10, 20 or 30 minutes. Note that each additional 10 minutes of travel opens up a much larger area and provides access to many more locations. The area of the accessibility ring from 20 to 30 minutes (grey) is much larger than from 10 to 20 minutes (cardinal) and even larger than 0 to 10 minutes (gold).

Now imagine that a traveler routinely experiences a 10-minute delay in what would otherwise be a 30-minute trip. That delay costs them more than half of their accessibility, meaning it deprives them not only of time but also of significant opportunities. **Figure 2** extends this point and shows that the relationship between travel delay and lost accessibility is non-linear, which means that the first few minutes of delay count more, and the impact diminishes as the delay gets longer. A five-minute delay reduces trip accessibility by 30 percent, but a 10-minute delay costs travelers 50, not 60, percent. The initial minutes of delay cost more. This point brings us back to the importance of seemingly-small decisions.

Improving Access to Train Platforms

A simple example of how small decisions can improve overall regional accessibility can be found on the boarding platforms of Sydney

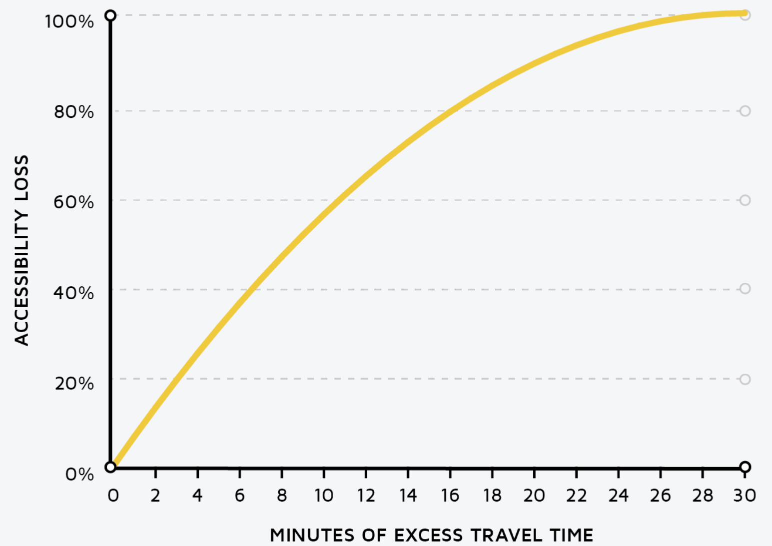


Figure 2. The estimate of percent accessibility loss

Trains, the Sydney region's 813 km (505-mile) commuter rail system.

Sydney Trains is one of the best commuter rail systems in the English-speaking world, providing high-frequency service from many suburbs to central Sydney. However, 44 of its 175 stations have entrances at only one end of the platform. A traveler approaching from the other end of the platform must walk alongside the station for the full length of the platform, which — given the length of trains — usually takes two minutes. Some unfortunate passengers travel between two stations with gates on only one end of each platform, and a quarter of them face situations where the gates are on the "wrong" end of both platforms. Because minutes matter, this design exacts a heavy toll in accessibility, and probably a heavy toll in ridership. A long history of research, along with a simple dose of common sense, tells us that people who live closer to transit are more likely to use it than those living farther away. People who can see the platform but not get to it (because it has no entrance near them) for all intents and purposes live further away. They have less access and ride less, and this results from nothing but the mismatch of entry and exit locations at the train stations.

Figure 3a provides a real-world example of this problem, by mapping access to Erskineville station, one of the most extreme cases of accessibility loss in the Sydney Trains system. The figure shows five-, 10-, and 15-minute bands of walking time around the station. In 2016, about 1,400 people lived within a five-minute walk (about a quarter-mile) of the station platform.

This number would be larger, but many people live or work on the south end of the platform, which is near a number of large apartment blocks. Unfortunately, the station's only entrance is on the north end. If a southern entrance were added, the number of residents who live five minutes away would increase by 89 percent (**Figure 3b**). This increase in accessibility should translate into more riders, as well as increased land value and higher real estate tax revenue. Indeed, the second entrance could add enough ridership, and new revenue, to pay for itself.

Erskineville is just one example. Similar interventions could be made for most stations, in Sydney or beyond, that have comparable configurations. Misaligned station entrances are low-hanging fruit that cities can easily pick. The costs are low, the gains are large, and the improvements can be made immediately.

Accessibility comparisons at Erskineville Station before and after potential new station entrance

Figure 3a. Map

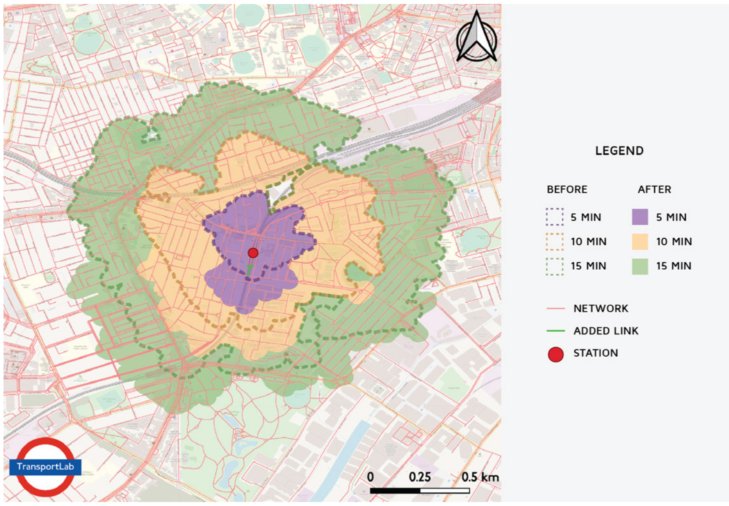
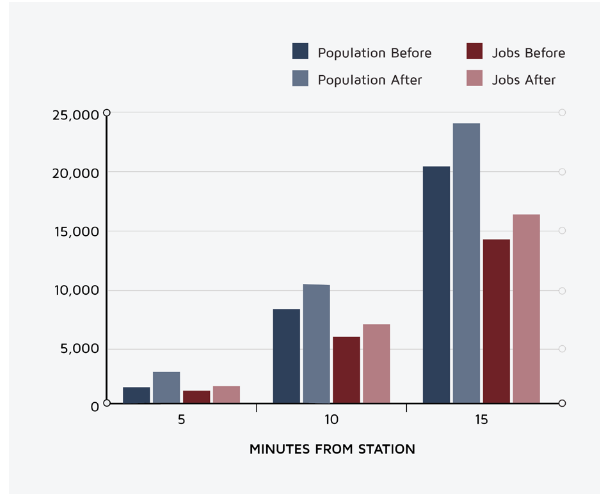


Figure 3b. Changes in population and jobs



Encouraging Bus Rapid Transit

A second example of gaining lots of regional accessibility by saving just a few minutes comes from the Minneapolis-St. Paul A Line, a rapid bus service that opened in 2016. The first rapid bus line of the region's transit network, the A Line operates from the suburban Rosedale area and connects to both lines of the region's light rail system. The line is effective, in part, because several seemingly small features allow it to save a few seconds of time for each passenger at each stop, compared to a conventional bus line:

- **Prepaid fares**: Passengers tap a fare card on the platform before boarding the bus, rather than line up at the front of the bus to tap-in or pay in cash. This saves 1.5–6.0 seconds per passenger.

- **All-door boarding**: Since they have already paid their fare, passengers can board at any door, not just the front. This cuts the overall boarding time in half.

- **Fewer stops**: Conventional buses stop roughly every eighth of a mile. The A Line stops every half-mile. Fewer stops result in less time spent slowing down, waiting, and then picking up speed.

A few seconds per passenger, when there are many passengers, adds up to a lot of time saved. Combined, these interventions result in more and quicker trips, even with the same number of buses and hours of driver time. Bus service thus becomes more productive. But does access increase? For the most part, yes. **Figure 4** maps neighborhoods near the A Line, and shows whether they gain access to jobs (green) or lose it – because people there now need to walk farther to reach stations (yellow). Most people in the area come out ahead. They have longer walks to stations, but the faster and more frequent buses compensate for that and let people reach more locations in the same overall travel time. Overall, the rapid bus configuration increased job accessibility by 5 percent for local residents. As was the case with Sydney Trains, nothing is particularly unique about this situation. Bus networks in many cities could apply these lessons and make small changes that yield large returns.

Rethinking Traffic Signals

Here is a final example: traffic signals. Everyone, from a young age, is familiar with traffic signals. But cities installed traffic signals to help drivers, not pedestrians (pedestrians, after all, even in crowds, can navigate around each other without collisions). As traffic proliferated over the last century, signals gave increasing priority to cars, and pedestrian conditions worsened.

Pedestrian travel quality has deteriorated because traffic signal engineers have focused more on limiting vehicle delay rather than improving pedestrian accessibility.

Imagine that a car arrives at an intersection when the light is red. It waits for the light to become green, and then moves on. That period of waiting is vehicle delay. The extent of delay will depend on whether a driver arrives when a signal is red, and how far along the signal is in its red cycle (i.e., did it just turn red, or is it about to turn green?). Engineers consider this delay when they adjust the timing of the signals, and try to maximize the number of cars crossing the intersection while minimizing wait time.

Traffic engineers apply the same treatment to pedestrian crossings, but because it takes longer to walk across the street than to drive, engineers assign pedestrians a longer "yellow" period. For pedestrians, though, these periods are not yellow lights, as they are for cars, but the flashing "don't walk" signals deter people from starting to cross. As a result of this longer "yellow," pedestrians get systematically less "green" time than cars. At a typical greater Sydney traffic signal, the light indicates "walk" for as few as six seconds of a two-minute cycle. Any pedestrian who arrives outside that six-second window must wait an average of 57 seconds, and could wait as long as one minute, 54 seconds — much longer than the typical car. (And all this assumes, for some intersections, that the pedestrians pushed a walk light button immediately on arrival, and the traffic signal controller responded promptly to the button being pushed.)

I have estimated that in a typical urban environment, traffic signals impose enough delay on pedestrians to amount to 27 percent of their total trip time. A pedestrian losing 27 percent of their time on a 30-minute walk loses eight minutes. They will now need 30 minutes to reach what they could otherwise reach in 22 minutes. And remember **Figures 1 and 2**: Even small delays translate to large accessibility losses. In this case, pedestrians losing eight minutes can reach 45 percent fewer opportunities.

Cities could improve traffic-signal timing, and pedestrian accessibility, in some simple ways:

- In a number of cities, including much of Greater Sydney, pedestrian phases aren't automatic. But they *could* be. Rather than force pedestrians to push a button to get a signal, cities could have pedestrian phases arrive as a matter of course. The pedestrian could still push a button, but the button would just bring the walk signal sooner, and extend its duration.

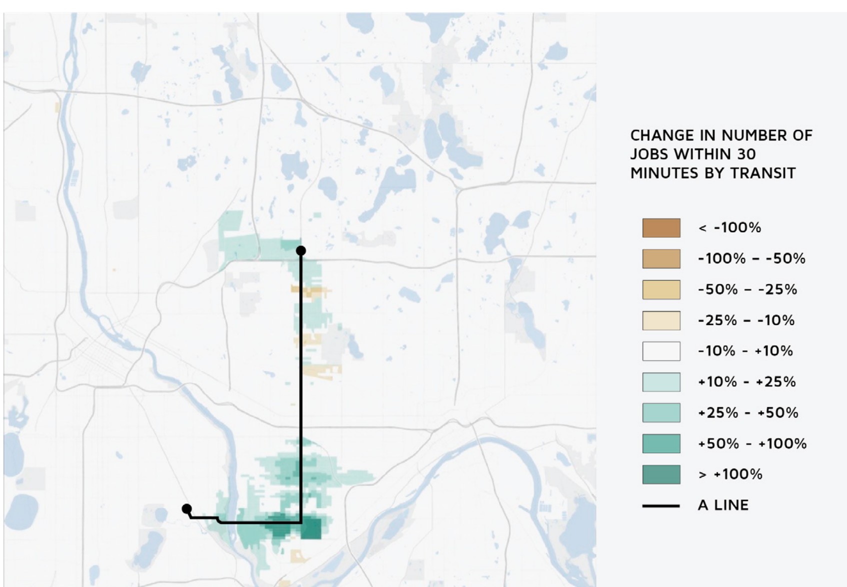


Figure 4. Change in number of jobs within 30 minutes by transit

- Smart intersections *could* use existing technology to automatically sense and count pedestrians (not just cars).

- Traffic signals *could* prioritize pedestrians to give them the maximum rather than the minimum green time.

- Signals *could* be designed to give pedestrians a leading interval: the walk signal would light up before turning cars get a green light to cross their path. This would increase the visibility of pedestrians because they would already be in the road before cars begin to move.

- Cities *could* provide more "all pedestrian" phases. These phases are sometimes referred to as a "pedestrian scramble." Indeed, cities could set some traffic signals to "walk" by default, and only change them to "don't walk" when enough cars arrive.

These are all things that we *could* do. If we did them, pedestrians would on average gain accessibility. And since most transit trips start and end with walking, transit accessibility would rise as well. Thus as walking rose, transit use would probably follow. Usually, however, we don't make these changes, in part because planners and engineers worry about the accessibility losses for automobile travelers, who would have to wait a bit longer. So we systematically design traffic signals to be hostile to people on foot, even as we urge people to walk more and drive less.

Cities are Made of Places, Not Points

Transportation planners and engineers often represent intersections, transit stops, and even entire communities as dots on a map. They then draw lines between these dots, to connect them with new roads, buses, or trains. While such large-scale plans are important, simply connecting points can also miss crucial details. The small things hidden inside each dot also matter.

Up close, a train station or bus stop is not a point. It's a place, and we can design it to prioritize efficiency and equity for the passengers, not just the operator. An intersection, similarly, is not a point — it is a space of flows, where people going in different directions, using different modes, come together. How they come together, and who gets priority when they do, should be a focus of policy.

When we blindly focus on big regional plans, we mistake places, small and large alike, as points, and we exacerbate the deep professional chasms that already exist within the transportation community. Engineers and planners have similar objectives when it comes to safety and equity, but often fail to communicate effectively with one another. Maps abstract away details, but the map is not the territory. We have "big thinkers" who focus on the region and fail to consider how small places interact with it, and "bounded thinkers" who focus on small places and neglect the wider community. Understanding that points are also places can let both types of thinkers contribute.

The bias today is toward points, and to thinking about big interventions over small ones. Planners, engineers, and — especially — politicians like to focus on building shiny new things rather than repairing, restoring, and (as I have discussed here) *reshaping* existing systems. The kind of reshaping I have advocated, which yields incremental time savings, can easily seem trivial, or pointless. But small amounts of time saved do matter at train stations, bus stops, traffic signals, and everywhere else. Small savings add up to large savings, and increase the number of opportunities people can reach in a reasonable amount of time. And accessing opportunities is neither trivial nor pointless. Access to opportunity is why so many people live in cities in the first place.

This article is based on the 12th Annual Martin Wachs Distinguished Lecture in Transportation, given by the author at UCLA in May 2019.

About the Author

David Levinson is a professor of transport in the School of Civil Engineering at the University of Sydney.

Further Reading

Levinson, D. M. (2019). *The Thirty-Minute City: Designing for Access*. Network Design Lab. Sydney. https://transportist.org/books/the-30-minute-city-designing-for-access/

Levinson, D. M., & Lahoorpoor, B. (2019). *Catchment if you can: The effect of station entrance and exit locations on accessibility*. TransportLab http://hdl.handle.net/2123/20286

Levinson, D. M., Marshall, W., & Axhausen, K. W. (2017). *Elements of Access: Transport Planning for Engineers, Transport Engineering for Planners*. Network Design Lab.

Noland, R. B. (1996). Pedestrian travel times and motor vehicle traffic signals. *Transportation Research Record*, *1553* (1), 28-33.

Norton, P. D. (2011). *Fighting traffic: The dawn of the motor age in the American city*. MIT Press.

Wachs, M., & Kumagai, T. G. (1973). Physical accessibility as a social indicator. *Socio-Economic Planning Sciences*, *7*(5), 437-456.

Valley of the Sun-Drenched Parking Space

Christopher G. Hoehne, Mikhail V. Chester, and David A. King

Most cities have little to no idea how many parking spaces they have. Nevertheless, we know that most cities have a lot of parking, and that most of it is free. This free parking comes with significant economic, environmental, and social costs. A city full of parking is a city designed for cars. When cities are designed for cars, car use becomes necessary, which makes drivers call for more car-oriented design, even though such design leads to more driving and pollution, and creates landscapes that hinder walking, biking and transit use.

For all these reasons, academics tend to think most cities have too much parking. Officials, however, often worry that they don't have enough. Cities as a result enforce minimum parking requirements: zoning laws that require ample parking for nearly all buildings and land uses. The end result is automobile dependence masquerading as mobility freedom.

So, do cities have too much parking or too little? Answering that question requires good data. How much parking do cities actually have? Unfortunately, cities do not systematically inventory their spaces, and parking requirements are often inconsistent even across local municipalities. This makes it difficult to measure parking and evaluate related policy issues. Cities and researchers sometimes resort to manually counting spaces — a process that works for small areas like downtowns or business districts — and the results have been consistent: urban parking is oversupplied. Land use planning and policy are blindly expanding the supply of parking without any evidence that more parking is actually needed or how much parking even exists.

The importance of measuring the parking supply takes on new urgency when we consider climate change. Despite ample research on many impacts of abundant parking — on sustainable travel, urban design, and affordable housing, to name a few — researchers have to date paid little heed to its potentially significant consequences for urban heat.

Parking lots heat up in the sun and store solar energy, warming the local environment. Phoenix, where we work, regularly records asphalt surface temperatures in excess of 170 degrees Fahrenheit on summer afternoons. But this is not just a problem for desert cities. Continued global urbanization will intensify what are known as *urban heat islands*; situations where urban areas are warmer than rural areas due to built infrastructure (such as parking) and human activity (like driving).

Urban heat islands, which are exacerbated by climate change, have increased both the severity and frequency of urban heat waves. Human health, urban productivity, and critical infrastructure systems are all threatened by extreme heat. Urban heat-related injuries and deaths are a growing concern around the globe. Extreme heat is dangerous to work in, and it discourages desirable outdoor activities like exercise, tourism, and travel. When heat rises, paved roads rut, water pumps are more likely to fail, and water quality declines as water pipes degrade. Energy use rises as demand for air conditioning increases, and water use rises as more water is lost to evaporation.

Heat islands are caused by human activity, especially activity that covers the natural landscape with paved surfaces such as asphalt and concrete. This fact suggests that parking requirements could be an engine of urban heat islands: the requirements force developers to make the city hotter. To date, however, researchers have not meaningfully investigated the connection between parking requirements, automobile dependence, and urban heat, in part because the parking supply is so hard to measure.

We tackled this problem by studying the metropolitan region of Phoenix, also known as the *Valley of the Sun*. Metro Phoenix is ideal for investigating the relationship between urban heat and urban parking. The region is saddled with many issues resulting from severe urban heat, including a rising number of heat-associated deaths over the last two decades. In each year from 2016 to 2018 metro Phoenix reported a record number of heat deaths, rising from 154 in 2016 to 182 in 2018. The metro is rapidly growing, sprawling, and car-dependent. In 2017, the region had more than 4 million residents, 2.9 million cars and 1.8 million jobs. Lastly, minimum parking requirements have the greatest impact on land use and car dependence in cities that have predominantly grown in the latter half of the 20th century, and this describes the Phoenix region well.

Metro Phoenix's Current Parking Supply

We created a parking inventory for metro Phoenix by first combining, for 33 cities and towns in the Phoenix region, records of how property is used (e.g., office, retail, residence) with an inventory of minimum parking requirements for those uses (e.g., one space per unit for apartments). This allowed us to estimate how much off-street parking is required for each of the 1.6 million parcels of land in our sample. We then estimated the on-street parking supply by mapping the street network, adjusting for areas where parking would be prohibited (e.g., in front of driveways, in front of fire hydrants, within or near intersections, within tunnels, on bridges, and so on) and then dividing the remaining road length by the dimensions of a typical street space. We validated these results by manually counting more than 22,000 spaces.

Our results suggest that as of 2017, metro Phoenix had about 12.2 million parking spaces. There are 3.7 million off-street residential spaces, 3.6 million off-street non-residential spaces, and 4.9 million on-street spaces. This equates to approximately 4.3 spaces per vehicle, 3.0 spaces per person, and 6.6 spaces per job. The entire metropolitan region of Phoenix has a parking density of approximately 39 spaces per hectare (16 per acre). Put another way, approximately 10 percent of the region's land area is dedicated to parking.

Residential parking (on- and off-street) accounts for 69 percent of total spaces, and off-street parking (residential and non-residential) accounts for 60 percent of total spaces. **Figure 1** compares the on- and off-street parking density in metro Phoenix, while **Figure 2** compares residential and non-residential parking density. Parking supply in residential areas is high: all municipalities in metro Phoenix require at least two off-street parking spaces for every single-family home — even when on-street space nearby is plentiful — and over two-thirds of urban properties are single-family homes. Parking density is highest around high-density travel corridors and within downtown districts; Downtown Scottsdale has the highest density of parking, with 127 spaces per hectare, compared to downtown Tempe (113) and downtown Phoenix (112).

Historical Metro Phoenix Parking Growth

Metro Phoenix added most of its parking supply between the end of World War II and the Great Recession of 2008. Starting in the mid-20th

Figure 1. On and off-street parking density in metro Phoenix

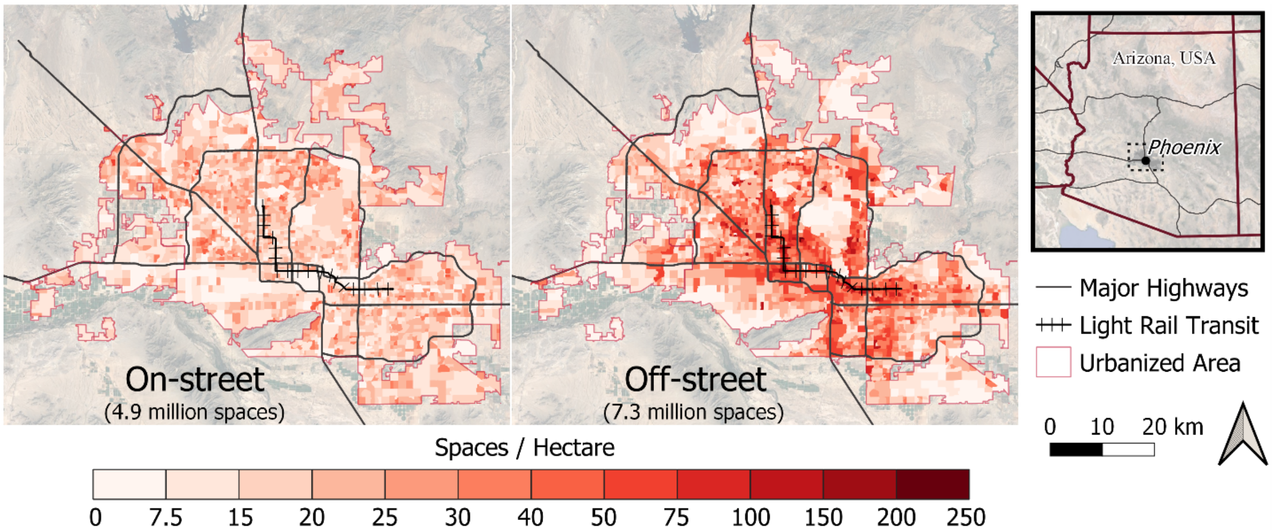
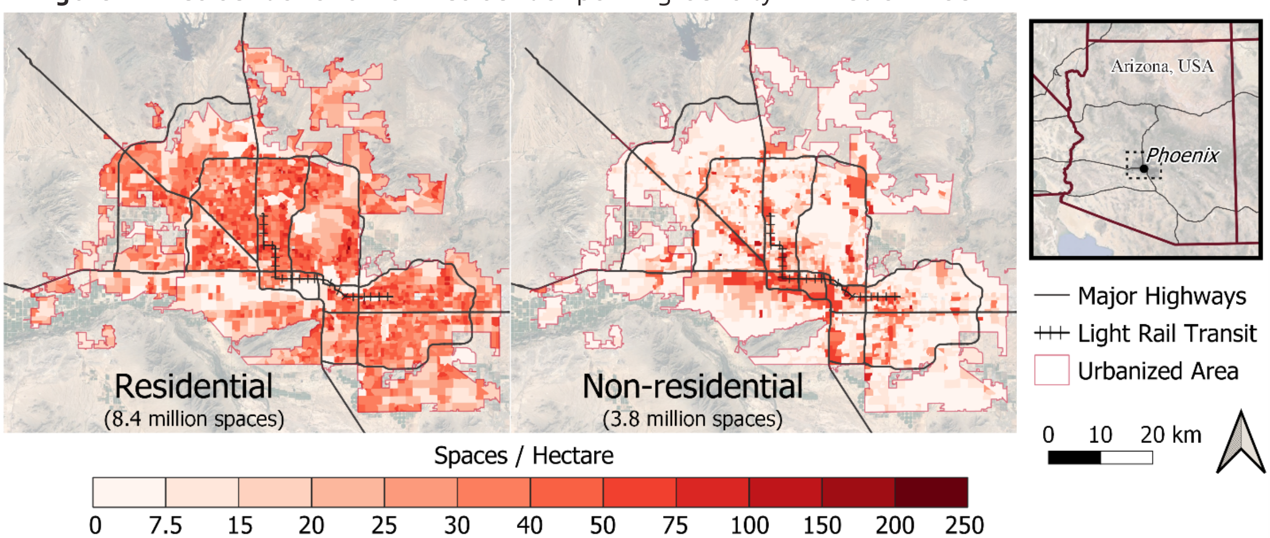


Figure 2. Residential and non-residential parking density in metro Phoenix



century, parking supply grew rapidly, but after the 2008 recession, the growth significantly slowed. Before 1960, metro Phoenix had less than one off-street parking space per resident, and the majority of available parking was on-street. Since 1960, metro Phoenix has seen an increase of nearly 11 million parking spaces, 3.4 million residents, 2.6 million vehicles, and 1.6 million jobs. From 1960 until 2000, parking availability in metro Phoenix grew by 5.2 percent per year compared to population growth of 4.1 percent per year (**Figure 3**). In recent years, parking growth has significantly slowed down to less than 1 percent per year. This recent decline is directly linked to the 2008 recession's slowing of new property development. When parking is provided primarily through mandates on new development, less development means less new parking.

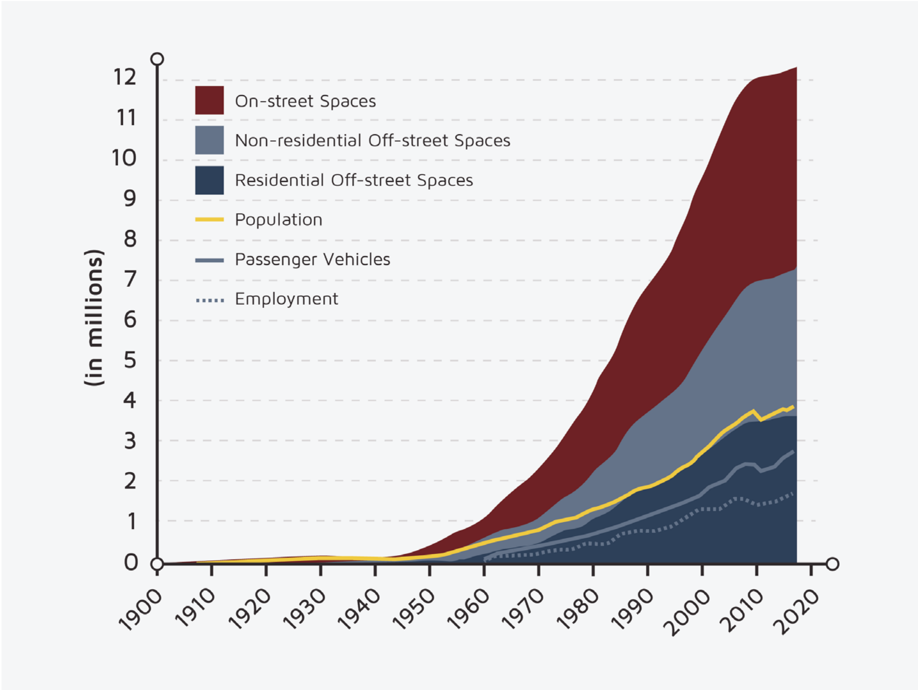


Figure 3. The historical growth of parking in metro Phoenix

A Tale of Two Cities

Phoenix is often compared to Los Angeles. Both regions are products of postwar development booms, with the main differences being Phoenix's lack of land constraints (it has neither oceans nor mountains) and its boom beginning several decades after Los Angeles. As a result, Los Angeles is further along in dealing with issues related to parking and car dependence. When comparing parking in Phoenix to Los Angeles, some interesting differences arise (note: we compare Los Angeles in 2010 to metro Phoenix in 2017).

Los Angeles County had more parking spaces (18.6 million vs. 12.2 million) and a higher density of land dedicated to parking (14% vs. 10%), but metro Phoenix had more parking spaces per car (4.3 vs. 3.3 spaces). Metro Phoenix also has more spaces per job (6.6 vs. 4.7) (**Figure 4**).

Despite the greater overall parking supply and density in Los Angeles County, metro Phoenix has 36 percent more on-street parking spaces, largely driven by increased residential street parking. To explore the cause, we compared the two regions in metrics of density (and zoomed into *urbanized* Los Angeles County here), finding Los Angeles denser by nearly all metrics. The two regions have nearly identical roadway densities but in Los Angeles there is a more connected road network and a higher density of buildings. As a result, we conclude there is less street space available for parking per mile of road in Los Angeles (basically, there are more obstructions to curb space from intersections and driveways). Despite the higher availability of curbside parking in metro Phoenix, Los Angeles likely has much higher utilization of and cruising for on-street parking due to higher demand and lower supply.

Urban Heat Consequences of Parking and Auto-Dependence

Using the newly generated parking inventory data in combination with vehicle travel data and road network data, we evaluated the heat emitted from parking, roadways, and cars in metro Phoenix. A large body of research has previously examined urban heat effects from buildings, vehicles, and humans (we give off

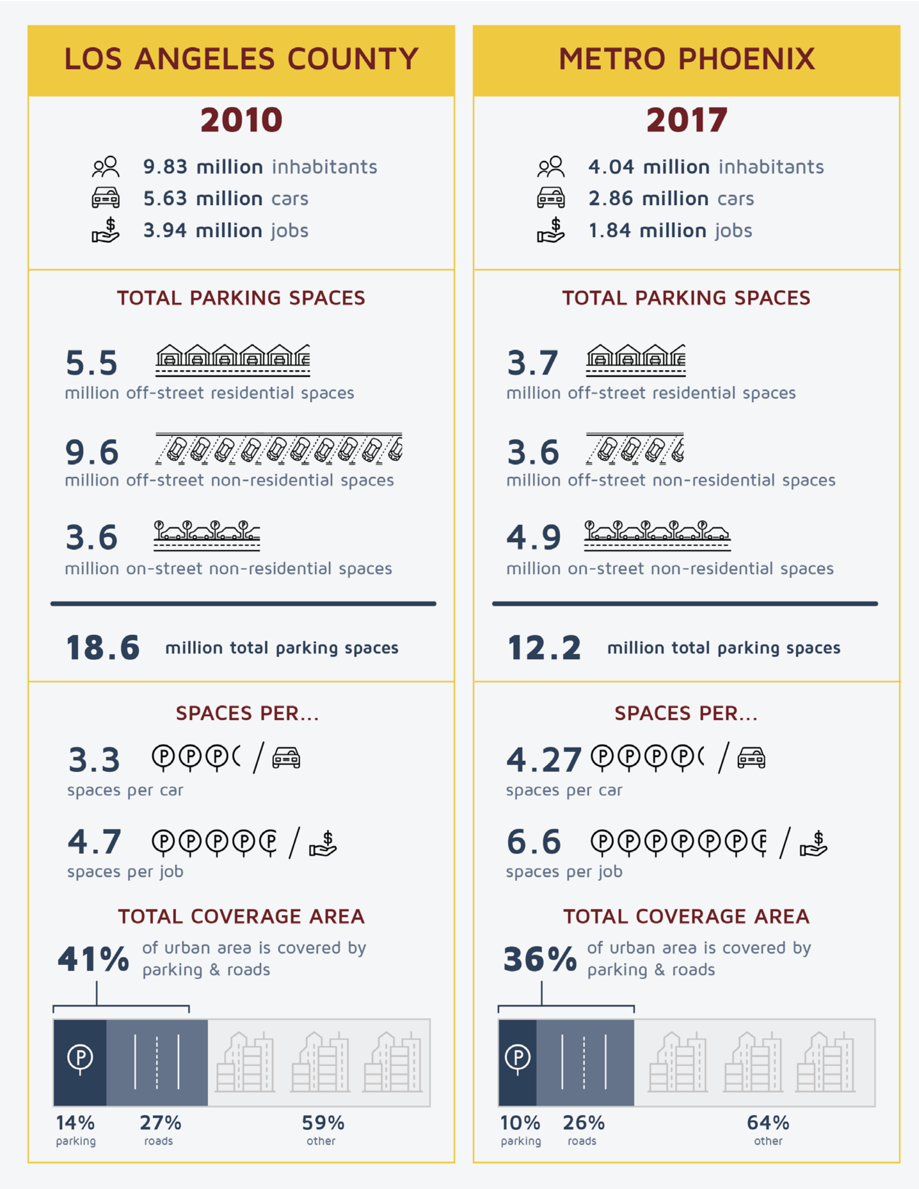


Figure 4. Parking, jobs, people and vehicles in Los Angeles County and metro Phoenix

heat too!). In these studies, buildings are the primary culprit, vehicles are marginal contributors overall (but can be significant in some contexts, especially near highways), and human metabolic heat is usually inconsequential. However, almost no research had quantified the citywide impacts from pavement.

We find that, in hot, sprawling, and car-dependent metro Phoenix, all the paved parking lots, abundant roads, and 2.6 million vehicles combine to contribute significant amounts of heat to their surroundings (**Figure 5**). By our estimate, Phoenix's parking infrastructure accounts for roughly 29 percent of the region's total heat emitted from pavements and vehicles on a typical day (roads contribute to 67 percent of the total, vehicles 4 percent). Heat emitted from pavement is most intense during summer afternoons; at these times, pavement radiates 46 percent more heat than the natural landscape. We know from other research that while buildings, cars, and people also contribute substantially to urban heat, the heat from these sources often peaks outside the summer months. As a result, the high coverage of parking and roadway pavement may be the most significant urban design contributor exacerbating extreme summer heat. Therefore, reducing the urban parking oversupply (and pavement overall) may help reduce severe urban heat.

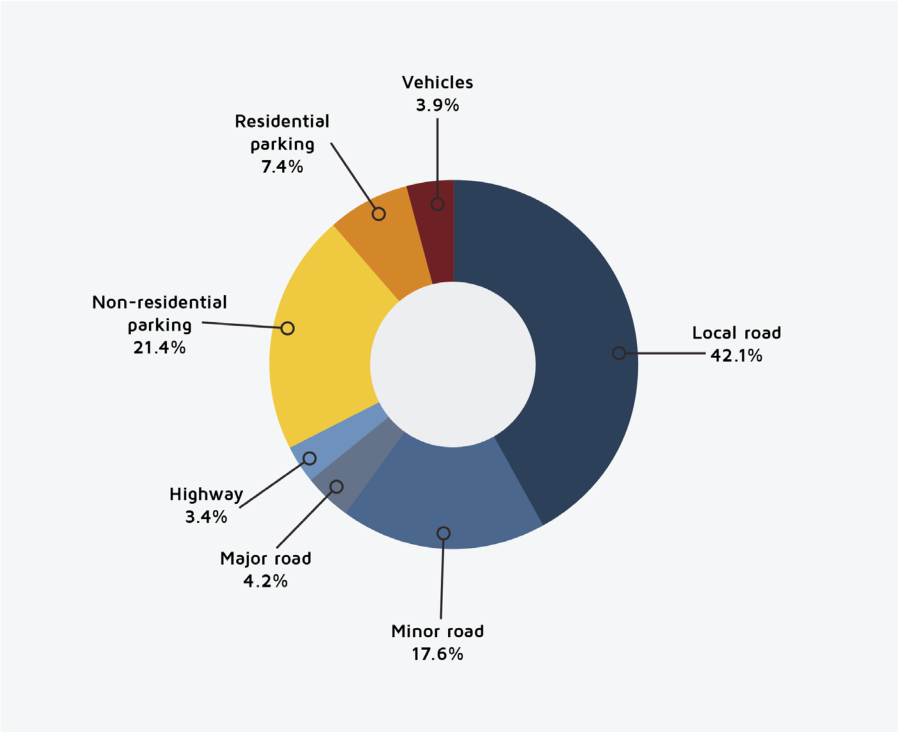


Figure 5. Percent of urban heat emitted from pavement and vehicles

Towards Auto-Independence and Cooler Cities

What can cities do to reduce the heat impacts of so much parking? Parking lots are often paved with asphalt, so one way to reduce their heat effect is to increase the albedo, or reflectivity, of the pavement. Doing so makes the pavement reflect more solar radiation and absorb less of it, which results in cooler pavements and cooler nearby air temperatures. Albedo can be increased through methods like whitetopping (covering an existing asphalt pavement with a layer of highly reflective concrete). Whitetopping has one major drawback, however: even though the surroundings will ultimately be cooler, during the day, pedestrians traversing a more reflective pavement will often *feel* hotter because they are exposed to additional radiation being reflected off the pavement beneath their feet (without whitetopping, that radiation would have been stored in the pavement, warming its surroundings over time). This heat effect is particularly acute during summertime afternoons when incoming solar radiation is at its peak, and when improving thermal comfort for pedestrians is most crucial.

Another common strategy to reduce heat through design is to increase the amount of shade, with more structures or trees. Yet this strategy is less viable than it might first seem. Parking lot pavement makes the temperature of surrounding soil rise, and accelerates evaporation. Any nearby trees thus need more water than usual, making it more difficult to keep them healthy. This challenge is especially problematic in hot climates, both because pavement's impact on soil temperature increases as air temperatures rise, and because many hot places, like Phoenix, already face constraints on their water use.
A similar suggestion is to cover parking lots with solar panels, which can provide shade in addition to their primary purpose of providing electricity. But solar panels absorb heat, and also have low reflectivity. Adding panels thus means adding an additional surface that partially absorbs and slowly radiates heat, leading to a greater amount of heat that can become trapped. A recent study of solar installations over asphalt parking lots in Phoenix found that, for precisely this reason, they might actually *warm* the local environment. Other research, however, has found the opposite, so this question warrants more scrutiny. And none of this is to suggest that shading is useless; pedestrians are shielded from direct sunlight while in the shade. It does suggest, however,

that the best approach for cities might be to reduce urban pavement coverage — have less paved area to begin with — rather than mitigating pavement once it is there, with steps like whitetopping or tree planting.

Reducing paved area means reducing surface parking. Given the abundance of parking in metro Phoenix, planners and policymakers should reform minimum requirements, and provide opportunities for both improved parking management and parking space repurposing. Doing so would not make it meaningfully more difficult to park, and could pay substantial environmental and social dividends. At a minimum, parking requirements should reflect the large number of current parking spaces, and should more aggressively promote opportunities to share existing spaces. Phoenix could reform or remove residential parking requirements. Buffalo, Minneapolis, and San Francisco have already removed all off-street parking requirements. Identifying current and future areas where excess parking could be repurposed into greenspace, affordable housing, or other beneficial urban land uses will become an increasingly valuable strategy, especially since changing standards for new development will not immediately affect the oversupply of parking that already exists.

The high urban pavement coverage needed to serve automobiles is likely the most significant urban driver of increased urban heat. Therefore, reducing car dependence — through not just reformed parking standards but also planning for increased urban density — could be an effective way to alleviate urban heat. Increasing urban density can reduce the frequency and distance of car trips. It can also make parking and road infrastructure less necessary, by putting destinations closer to each other and making public and active transit more effective, meaning fewer trips need to be by car. Zoning for increased building density can also improve what designers call street canyon shading — more buildings that are closer together and closer to the street can provide more shade on streets and sidewalks. Greater shade also makes walking more comfortable during hot periods. Sprawling urban design has been linked to more extreme heat events, likely driven by sprawling pavement coverage, and is yet another reason for planners and policymakers to focus on compact urban design over sprawl.

The amount of infrastructure devoted to automobiles is large and has devastating effects on cities. We have long known that parking requirements encourage and subsidize driving. This research is part of a growing body of literature that documents the problems caused by reserving so much space for driving and parking. Now we can add local climate effects to that list of problems. Phoenix's 12 million parking spaces capture the sun's energy and cook the city even more than the desert climate already does.

This article is adapted from two studies: "Valley of the sun-drenched parking space: The growth, extent, and implication of parking infrastructure in Phoenix" and "Urban heat implications from parking, roads, and cars: A case study of metro Phoenix."

About the Authors

Christopher G. Hoehne was a PhD student and graduate research associate at Arizona State University when this research was conducted. He is currently a postdoctoral researcher at the National Renewable Energy Laboratory.

Mikhail V. Chester is director of Arizona State University's Metis Center for Infrastructure and Sustainable Engineering and associate professor in ASU's School of Sustainable Engineering and the Built Environment.

David A. King is an assistant professor at Arizona State University's School of Geographical Sciences & Urban Planning.

Further Reading

Chester, M., Fraser, A., Matute, J., Flower, C., & Pendyala, R. (2015). Parking infrastructure: A constraint on or opportunity for urban redevelopment? A study of Los Angeles County parking supply and growth. *Journal of the American Planning Association, 81*(4): 268–286. https://doi.org/10.1080/01944363.2015.1092879

Hoehne, C., Chester, M., Fraser, A., & King, D. (2019). Valley of the sun-drenched parking space: The growth, extent, and implications of parking infrastructure in Phoenix. Cities, *89*(December 2018), 186–198. https://doi.org/10.1016/j.cities.2019.02.007

Hoehne, C., Chester, M., Sailor, D., & King, D. (in press). Urban heat implications from parking, roads, and cars: A case study of metro Phoenix. *Sustainable and Resilient Infrastructure.* https://doi.org/10.1080/23789689.2020.1773013

Matute, J., Chester, M., Fraser, A. M., & Pendyala, A. (2016). Do cities have too much parking? *ACCESS Magazine*. https://www.accessmagazine.org/fall-2016/do-cities-have-too-much-parking/

Pham, J., Baniassadi, A., Brown, K., Heusinger, J., & Sailor, D. (2019). Comparing photovoltaic and reflective shade surfaces in the urban environment: Effects on surface sensible heat flux and pedestrian thermal comfort. *Urban Climate, 29*(100500). https://doi.org/10.1016/j.uclim.2019.100500

Stone, B., Hess, J., & Frumkin, H. (2010). Urban form and extreme heat events: Are sprawling cities more vulnerable to climate change than compact cities? *Environmental Health Perspectives, 118*(10), 1425–1428. https://doi.org/10.1289/ehp.0901879

Taleghani, M., Sailor, D., & Ban-Weiss, G. (2016). Micrometeorological simulations to predict the impacts of heat mitigation strategies on pedestrian thermal comfort in a Los Angeles neighborhood.” *Environmental Research Letters, 11*(2). https://doi.org/10.1088/1748-9326/11/2/024003

Building Highways and Preserving the Environment

Martin Wachs

Transportation agencies have been trying for generations to improve mobility while harming the environment as little as possible. But the goals of enhancing mobility and preserving species and natural lands unavoidably conflict.

Cars, trucks, trains, and buses kill countless animals by colliding with them, but those conflicts are a small part of the story. A bigger issue is that transportation projects directly harm endangered species by damaging their habitats, and then indirectly harm them further by inducing urban growth, which also damages habitats. The huge scale of harbors and airports, and the linear nature of highways and rail lines, means that building them will fragment multiple habitats, and hinder seasonal migration and reproduction. Water pollution from runoff poisons animals and plants, and noise pollution disrupts feeding and mating patterns.

For all these reasons, activists and environmental protection agencies for decades aggressively opposed transportation facilities that threatened to intrude into pristine habitats, whether on land or in water. Epic legal battles lasted for years, with people on both sides claiming to speak for the public interest, and seeing no option but to keep fighting. The two sides have combined to spend millions of dollars on legal fees and advocacy — money they could otherwise have spent on transportation projects and environmental protection.

In recent years, however, we have seen a sea change. Transportation agencies have started to consider money spent on mitigation — actions taken to offset environmental impacts — as an investment, rather than just an added cost. They have begun incorporating funds for environmental stewardship into transportation programs, using an approach called "advance mitigation." Environmentalists have responded by gradually starting to see transportation agencies as potential allies rather than enemies.

Conflicts between environmental advocates and transportation agencies often arise when proposed highway, runway, or rail construction threatens to destroy or fragment critical habitat, such as a wetland, and when the damage cannot be avoided or mitigated at that site. It is often possible, however, to preserve some land away from the project to compensate for its environmental damage. This mitigation might involve protecting part of another existing wetland or patch of forest from future development, restoring a wetland that has become degraded, or even creating a new wetland or meadow.

Environmental mitigation is not new, but transportation agencies often addressed it late in the design and planning stages of a project, after already making critical decisions and commitments. Mitigation was piecemeal, and often resulted in transportation agencies setting aside individual and frequently isolated parcels of land to protect particular plants or animals. Preserving land here and there was useful but not ideal. Neither agencies nor environmentalists were happy with the result. Agencies did not like challenges and costs that arose late in a project's development when they had to pay a premium to buy or restore land. Advocates worried that piecemeal mitigation did not address the larger problem of habitat loss affecting many species across wider areas. Animals often need large expanses of land to migrate, feed and reproduce, so complex ecologies require large protected spaces. Mitigation, to use a familiar metaphor, was preserving a few trees while ignoring the forest.

Advance Mitigation Proves its Worth

As a solution to these concerns, transportation agencies now employ advanced mitigation to address environmental damage even before they've begun the project proposal process. Like many good ideas, this one was started by a single insightful and creative act. Decades ago, the California Department of Transportation (Caltrans) acquired a large tract of environmentally sensitive land near Beach Lake, in the Sacramento River Valley. Caltrans bought the land intending to build on it, but by the 1990s plans had changed and the agency decided the land was no longer needed. Caltrans intended to sell the land as surplus, but a staff member urged the agency to consider a different use: keep the land and use it for environmental mitigation. A large piece of sensitive land, after all, could offset damage from multiple future transportation projects at other locations. The agency agreed to what was an unusual move at the time. The gamble paid off handsomely, as over time the land fulfilled the mitigation requirements for 49 separate road projects in 14 counties, saving Caltrans more than $25 million. Since then Caltrans and many local transportation agencies have accepted advance mitigation having discovered that it improves their road and transit programs while promoting preservation of the natural environment. It also converts many environmental interest groups from opponents to project partners.

Advance mitigation preserves larger and thus more environmentally valuable tracts of land, and does so at a lower cost. It saves project sponsors the money and time spent fighting environmental opposition, and the money and time spent redesigning projects in response to challenges. Consequently, advance mitigation has become an increasingly attractive strategy for both transportation planners and environmental advocates, and has built trust between the two groups. Advance mitigation has allowed transportation agencies to strategically use their revenue to achieve environmental ends.

The Conservation-Transportation Finance Conundrum

The legal basis for collaboration between agencies that build infrastructure and those that protect fragile environments is Section 10 of the federal Endangered Species Act. The act prohibits the "taking" (killing or endangering) of listed endangered plant and animal species through direct harm or habitat destruction, but authorizes the Secretary of the Interior to issue permits for the "incidental take" of endangered and threatened species if the damage is mitigated through a Habitat Conservation Plan, or HCP. Incidental take permits thus allow otherwise lawful activity, like building infrastructure, to proceed as long as there is a plan in place to mitigate the damage done to affected species and their habitats. The Endangered Species Act requires, among other things, that infrastructure projects conserve more acres of land than they develop or take.

Quite a bit of money is needed to support this process: agencies must plan ahead, and then buy and manage habitat. Management is expensive: the agency must maintain the land into the future, and continue the conservation program. Because funding is so important, the Endangered Species Act requires an HCP to demonstrate a "reasonably secure" funding source, and show that projected revenues can cover projected costs over decades to come. If an agency cannot demonstrate this financial stability, its take permit may be denied.

Many local governments raise revenue through exactions on land development. These are fees charged as a condition for issuing permits to build new homes and businesses. New development destroys habitat so some communities devote a portion of the revenue from their exactions to the funding of local habitat conservation plans. For many HCPs, exactions are a major source of revenue, providing money to buy land and restore it to pristine condition. Unfortunately, money produced by exactions typically does not arrive until well into a project's life. Relying on exactions to fund an HCP means waiting for the transportation project to be completed and development to begin, typically years and sometimes more than a decade after initial project planning. But mitigation is best started much earlier. Thus, HCPs face a persistent "catch 22" when they rely on revenue from exactions. Land costs are usually lowest *before* development occurs. By the time exactions arrive, development has already driven up land prices, making mitigation more expensive. During economic downturns, land prices fall but, because development also slows down, revenue from exactions falls just when it would be most valuable. Revenue for land acquisition is necessarily lowest when the cost of land is lowest, and revenue is always highest when land is most expensive.

New development often directly follows the building of new highways so local habitat conservation agencies long sought additional funding from state and local highway agencies. Fuel taxes and transportation sales taxes provide stable revenue streams compared to more volatile development revenues. More importantly, their revenue is available well before any particular project has begun. An HCP cannot buy a large swath of land years in advance using fees exacted from development on that land that has not started or even been proposed. But the agency *can* purchase land using fuel tax or sales tax revenue if a transportation agency makes that money available. These revenue streams can thus get the mitigation started. Once the development begins, exactions can be used to help finance its continuation. Transportation agencies at first refused to contribute to habitat conservation but gradually learned that doing so meant that they could claim they had already mitigated the environmental damage caused by their new projects. This reduced their costs and sped up transportation project approvals.

A good example of this approach is the Western Riverside County Multiple Species Habitat Conservation Plan. This plan is a comprehensive, multi-jurisdictional, long-term effort to conserve 146 endangered and threatened plant and animal species and their habitats, on more than 1.2 million acres, while accommodating some major new transportation projects. The agency that implements the plan receives revenue from exactions on new land development, but also receives some county sales tax revenue, which it uses to buy land and preserve habitat. The preserved land fulfills the mitigation requirements for the new road and freeway projects. The Conservation Plan was an adjustment, and highway authorities came to the table reluctantly. Over time, however, they participated with increasing commitment, having seen that it streamlines the process of permitting their projects.

Sales Taxes Bring Opponents to the Table

Since the 1970s, many counties and cities across the United States have responded to stagnating federal transportation funding by adopting voter-approved local option sales tax (LOST) measures. These measures raise the sales tax slightly, and dedicate the resulting revenue to transportation spending. The Riverside County case above shows that the rise of these local taxes can help the cause of advance mitigation. The benefits actually flow both ways: advance mitigation can also help enact local transportation sales taxes.

Getting voter approval for new taxes is always difficult, especially in California where state law requires new taxes to win a two-thirds supermajority. Approval is even more challenging if the tax revenue is going to build highways that many environmentally-minded voters might oppose. In these circumstances, sales tax proponents need to broaden their base of support, and bring environmentalists on board. One way to win over "green voters," is for transportation agencies to promise that some of the tax revenue will be used for advance environmental mitigation. Including dedicated funding for environmental mitigation of transportation projects in Orange and San Diego counties led to vital support from environmental advocacy groups for voter approval of the tax measures.

Sales tax revenue has dramatically supported habitat conservation in California. In the first 25 years of the Western Riverside County agency, $12 billion worth of transportation projects were supported by $371 million of mitigation funding. Of that, almost a third ($121 million) came from Riverside County's voter-approved sales tax measure.

In Orange County, the transportation authority developed an HCP to mitigate transportation projects, and helped fund land purchases and habitat restoration by dedicating 5 percent of the revenue from the county's proposed transportation sales tax. This commitment earned the support of environmental groups, which in turn helped deliver the votes needed to pass the measure. Likewise, in 2004, San Diego County residents voted to extend the county's TransNet half-cent sales tax for transportation infrastructure by 40 years. Included in the measure was a commitment to spend $650 million to purchase mitigation land through several HCPs. That commitment led environmentalists to endorse the extension.

Advance Mitigation Goes Statewide

In 2017, California's state legislature approved a controversial law called the Road Repair and Accountability Act (SB1). The bill was controversial because it substantially increased the state's gasoline and diesel fuel taxes, which had not been raised in 25 years, and also raised annual vehicle registration and use fees. The bill's proponents said the state desperately needed revenue to manage and maintain its infrastructure. Opponents called it a money grab.

Almost unnoticed among these arguments was that SB1 also created a statewide Advance Mitigation Program. To address the mitigation needs of multiple future transportation projects, the law allocated $120 million, to fund a revolving advance mitigation bank account. Caltrans will be able to withdraw money from this account and use it to buy and preserve sensitive land. When the agency completes transportation projects, and has received federal and state funding to construct them, it will reimburse the revolving account, and by replenishing it will ensure that later projects can also draw on it.

Conclusion

Transportation planners should be sensitive to environmental concerns. Some proposed transportation projects would so severely damage the environment that they should probably be cancelled. Other projects, however, deliver substantial transportation benefits with environmental impacts that can probably be managed. Environmentalists should not just routinely oppose all transportation projects. Decades of conflict and distrust between transportation agencies and environmental advocates, however, made compromise difficult. Advance mitigation has increased dialog among these different groups, and made finding a middle ground feasible. Transportation officials have come to realize that meeting environmental requirements in piecemeal fashion after the planning and design of projects was inefficient and intensified disagreement. Environmentalists who opposed virtually all transportation investments, similarly, have gradually realized that collaboration and mutual accommodation, if it involves preserving large swaths of land, can be a more fruitful path to improved environmental protection. Proactive cooperation has led to more positive outcomes for travelers and for surrounding ecosystems and the environment in general. Money is always a good lubricant that smooths rough edges among competing public policies. The small steps taken thus far show that spending transportation project money wisely on advance mitigation can, in the long run, preserve sensitive land, enhance species' habitats, and deliver transportation projects more quickly and at lower cost.

This article is derived from a chapter by M. Wachs, J. Lederman, and G. C. Sciara entitled "Building Environmental Collaborations While Funding Highways in California," which will appear in a forthcoming book, The Future of Habitat Conservation Planning, to be published by the Environmental Law Institute in Washington, D.C.

About the Author

Martin Wachs is Distinguished Professor Emeritus of City and Regional Planning and Civil and Environmental Engineering at the University of California.

Further Reading

Lederman, J., & Wachs, M. (2016). The Growing Role of Transportation Funding in Regional Habitat Conservation Planning. *Journal of the American Planning Association, 82*:4, 350-362. http://doi.org/10.1080/01944363.2016.1214079

Sciara, G. C., & Stryjewski, E. (2015). Saving Money When Safeguarding Species and Habitats: Conventional vs. Advance Land Acquisition for Transportation Mitigation. *Research in Transportation Economics, 52,* 100–110.

Thorne, J. H., Huber, P. R., Girvetz, E. H., Quinn, J., & McCoy, M. C. (2009). Integration of regional mitigation assessment and conservation planning. *Ecology and Society, 14*(1), 47–73. http://www.ecologyandsociety.org/vol14/iss1/art47/

Venner, M. (2005). *Early Mitigation for Net Environmental Benefit: Meaningful Off-Setting Measures for Unavoidable Impacts*. Washington, DC: National Cooperative Highway Research Program, Transportation Research Board. http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/25-25(10)_FR.pdf

Going My Way? The Evolution of Shared Ride and Pooling Services

Susan Shaheen

Sharing rides is a longstanding tradition that predates even horse-and-buggy travel. Recent innovations, however, make sharing a ride easier, more convenient, and more efficient. Innovative mobility services premised on pooling — getting multiple riders into the same vehicle — can lower travel costs, mitigate congestion, and reduce greenhouse gas emissions. They also offer travelers more mobility choices between the traditional bookends of auto ownership and public transit.

The motivations for pooling are simple. There are economic incentives. Cars are among the most underused capital assets in our economy, sitting empty 95 percent of the time and usually carrying only one person the rest of the time. If cars were used more often, and if they carried two, three, or four passengers, their cost per rider, and per hour, would drop dramatically. But the benefits of pooling go well beyond cheaper mobility. If the car is carrying many people who might otherwise drive themselves, sharing can result in fewer vehicles on the road, which means less air pollution and energy use and fewer greenhouse gas (GHG) emissions and parking spaces. With more than 1 billion cars and light trucks in the world, the potential for major reductions in pollution and GHGs is huge — in the United States and most other countries.

We know that technologically, a future with many shared rides is now possible. What we don't know is whether and under what conditions people will be willing to make that transition. Thinking about this possibility requires that we understand the history of shared mobility, and how it interacts with modes we already know.

Historic Trends, About to Be Disrupted

Shared mobility is a radical departure from the culture of auto ownership that has long dominated the industrialized world. This culture became entrenched after World War II, when interstates, suburbs, and auto-oriented industries (such as drive-thru restaurants) grew. Almost everywhere, car ownership increased and public transit use often declined — despite efforts to boost its ridership. The affluent world, to a greater extent, was defined, by driving alone.

Efforts to change this situation have for decades met little success. Since the late 1960s, public agencies, particularly in the United States and Canada, have tried to increase the use of carpooling and vanpooling. They have enacted trip-reduction ordinances to discourage solo driving, built carpool lanes and park-and-ride lots to make sharing easier, and used telephone and computerized ridematching to help people interested in carpooling find each other.

In the United States, these efforts saw modest success during the energy crisis of the 1970s — with carpooling's commute share peaking in 1980 at 20.4 percent. From there, carpooling's commute share dropped steadily and was only 9.4 percent by 2013 (see **Figure 1**). Over the

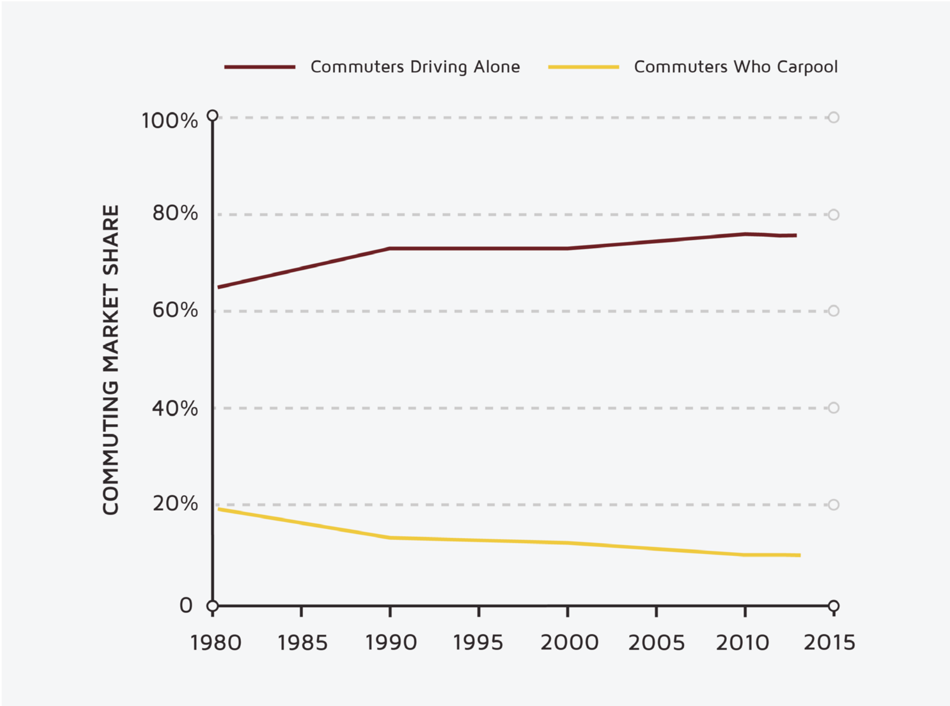


Figure 1. The decline in carpooling and the growth in commuters driving alone in the United States

past decade, advancements in technology, such as smartphone apps, enable people to arrange shared rides in a variety of ways.

The Rise and Repercussions of TNCs

For-hire ride services, such as transportation network companies (TNCs), differ from traditional ridesharing, as they provide travelers with pre-arranged and on-demand access to transportation services and do so for a fee. The service runs via digital applications by connecting customers with drivers — who either use their privately owned vehicles or one from a maintained vehicle fleet. Common service providers include Lyft, Uber, Ola Cabs in India, Grab in Southeast Asia, Chauffeur Privé in France, and Didi-Chuxing in China (which bought Uber's China subsidiary in 2016 and soon became the largest on-demand company in the world).

What all these companies share is an asset-light, peer-to-peer model of using individually owned cars. Uber, Lyft, and other TNCs are large companies that don't own the vehicles they use to provide rides. Most of their product maintenance is around their apps and, as such, they don't need or have large inventories of vehicles, equipment, or facilities. (They also technically have few employees, because their drivers are contractors — an issue that has now landed their labor practices in controversy.) Their principal innovation was thus not in transportation per se, but in devising computer algorithms that more efficiently matched riders and drivers. The apps removed the exchange of money from the rider-driver relationship — they automatically calculated and billed the fares — and applied some basic economic principles of supply and demand. By raising prices when demand exceeded supply, they resolved the problem of shortages and long wait times that had long plagued conventional taxis. Both Uber and Lyft are now publicly owned companies, but neither business is profitable.

The Fate of Taxis

The TNCs brought both opportunities and threats to other shared modes. TNCs may well be an existential threat to the traditional taxi industry. As just one example: Uber launched its UberX product in San Francisco in 2012, the same year Lyft began operating in the city. Between March 2012 and July 2014, the number of taxi rides in San Francisco fell 65 percent and in January 2016, the city's largest taxi company, Yellow Cab, filed for bankruptcy. From New York to Paris,

Figure 2. The impact of Uber on taxi ridership in San Francisco

taxis have been fighting to block Uber and Lyft, sometimes successfully but generally not.

Can taxis adopt some TNC technology to help them compete? Electronic hailing (e-hailing) services, such as Arro, Bandwagon, Curb, Flywheel, Hailo, and iTaxi in the United States, are a step in that direction. Travelers can use these mobile apps — maintained by either the taxi company or a third-party provider — to digitally dispatch a taxi. Although in the works for many years, e-hailing finally emerged largely in response to the success of Uber and Lyft. When taxi companies have adopted it, they have brought their wait times down, closer to those of TNCs. E-hailing alone may not be enough, however. In many jurisdictions, regulations still limit the number of taxis that can operate on the roads and still require taxis to charge locally regulated prices, which means they cannot vary their prices to help balance supply and demand, as TNCs often do.

The Fate of Public Transit

Public transit, like the taxi industry, has struggled in the last decade. Transit's difficulties are probably linked to a number of factors including low fuel prices (which encourage the use of personal vehicles), poor public transit service in some markets, and competition with shared mobility services like TNCs. The TNC relationship with public transit, however, differs from their relationship with taxis. TNCs are, to taxis, direct competition. While TNCs compete with public transit, they may be able to help it as well.

Public transit operators are under tremendous pressure to improve the quality and quantity of their service, as more cities become focused on improving social equity, urban livability, and air quality, and they want to tackle problems like climate change and traffic congestion. Partnering with shared mobility operators may be one way to help achieve these goals. Public transit often struggles to make first/last-mile connections, provide service in low-density areas or at off-peak times, and provide paratransit service. TNCs, and other shared operators, can help fill these service gaps.

Shared demand-responsive services, in general, can help round out public transportation. Microtransit, for example, provides shuttle-based services that can include fixed or flexible routes, as well as fixed schedule or on-demand services. For riders, these services tend to be less expensive than Lyft, Uber, and taxis, but they are more expensive than public transportation. Typically, riders use mobile apps to pay for trips electronically and track the vehicles as they approach, although a few microtransit services use telephone dispatch and cash payment mechanisms. Microtransit is very similar to another privately operated service called jitneys. The main difference is that jitneys do not use a smartphone for dispatch or payment, and they instead operate in a manner that more closely resembles public transportation. Jitneys can take many forms, and they are common in many cities around the world. In the United States, however, regulators have perceived these services as a threat to public transit, and they have largely disappeared as a result.

One exception is the "dollar vans" of New York City. These vans got their start in 1980, during an 11-day public transit strike. They are a shadow transportation service that follows popular bus routes (thus competing with public transit), but they also serve communities neglected by subways and buses (thus complementing public transit). While jitneys require a license, many unlicensed dollar van vehicles also give rides. These unlicensed operators are technically illegal, but because they are now an integral part of the community, regulators frequently condone them and enforcement has been intermittent. In 2016, dollar vans carried about 120,000 riders per day. In March 2017, 325 official (licensed) dollar vans were in operation, down from more than a thousand just a few years prior. However, this decline probably reflects a lack of license enforcement rather than an actual decline in the number of vehicles.

In recent years, new microtransit services have emerged (e.g., Via). Microtransit could be particularly well-suited to complement, enhance, or replace existing paratransit or dial-a-ride services, which are legislatively required to provide service to passengers with mobility limitations. Paratransit services deploy specially outfitted small buses and vans on request and operate door-to-door. Paratransit became common in the United States in the 1970s as regulators imposed requirements and provided subsidies to serve people with disabilities. Paratransit providers take numerous forms. Some are part of larger transit bus operators; others are small companies that contract with public transit operators and often outsource to taxis. The takeaway is that these services are ripe for integration into a larger shared mobility system and can complement public transit (filling gaps, providing first/last-mile connections, and replacing low-ridership routes).

The Promise of Pooling

As the TNC model has grown, it has also developed specialized niches. Lift Hero provides rides for older adults and those with disabilities, while HopSkipDrive and Kango provide rides for children to and from school.

Among the most transformative services could be those that involve pooling — finding unacquainted riders who have similar origins and destinations and bringing them together in the same vehicle. With pooling services, computer algorithms add riders to vehicles in real-time. In return for the possibility of a slight delay in reaching their destinations, riders typically get a lower fare, even if the driver never picks up another rider.

Pooling is usually associated with Uber and Lyft, but taxis have also experimented with sharing. The idea is the same: multiple passengers with different destinations use the same taxi. Cities like Los Angeles, Burbank (California), and Boston have permitted sharing of taxi rides, although only in downtown districts and at airports. New York City technically allows taxi sharing, but in practice, it has been successful only at airports, some in-city taxi stands, and along one East Side corridor.

Pooling can also be successful for longer intercity trips, as demonstrated by BlaBlaCar, the world's largest long-distance ridesharing service. BlaBlaCar was founded in France in 2006 as a free platform for carpooling but transitioned in 2011 to a fee-based service. In its current model, it charges users a percentage of trip fees (between 7.9 and 12.5 percent), as well as a fixed amount (about $1) for each trip. It connects drivers and passengers willing to travel together between cities and share the cost of the journey.

By 2017, BlaBlaCar had more than 40 million members across 22 countries.

While there are different forms of pooling — carpooling/ridesharing and paid trips (i.e., taxi splitting and TNC pools), the economic sustainability of these business models is important to mention. Traditional carpooling and ridesharing involve incidental trips that would have happened anyway in the driver's personal vehicle, and the rider may or may not reimburse the driver. A pooled TNC ride, in contrast, involves a commercial transaction with a paid driver. The driver is only making the trip because the riders want to. It is still unclear whether this model can be economically sustainable, particularly without government subsidies.

What makes pooling so important? A study by the Paris-based International Transport Forum in 2016 offers a glimpse into how shared mobility could change urban living. This study, which was a simulation, modeled the impact of replacing all car and bus trips in Lisbon, Portugal, a mid-sized European city, with fleets of shared automated taxis and shuttle buses. Among the key findings: 97 percent fewer vehicles (cars, shuttle buses, and full-size buses) would be needed to serve all trips, 95 percent less space would be required for public parking, and the vehicles would travel 37 percent fewer kilometers. All this would occur because drivers and riders would use each vehicle more intensively: the study estimated that each vehicle would travel 10 times the total distance that current vehicles do. The benefits of pooled fleets include: 1) more efficient use of vehicles (e.g., using a smaller fleet more often rather than a larger fleet of privately owned vehicles, many of which spend most of the day parked); 2) lower cost per passenger (since depreciation and operating costs are spread over many more occupants); and 3) greater vehicle use will result in more rapid vehicle replacement, which could accelerate the adoption of low- and zero-emission fleets (e.g., the California Clean Miles Standard incentivizes the deployment of electric vehicles in TNC fleets).

A second study, also a simulation, by researchers at the Lawrence Berkeley National Laboratory, found that a fleet of shared, automated, electric vehicles, when combined with a low-carbon electricity grid (forecasted for 2030), could reduce per-mile GHG emissions by 63 to 82 percent by 2030 compared to privately owned hybrid vehicles.

These studies suggest that pooling, especially when combined with other interventions, may offer numerous transportation, infrastructure, environmental, and social benefits. Pooled rides have a far smaller carbon footprint, consume much less road space and parking space, and have the potential to serve far more trips.
In short, pooling is critical to maximizing the benefits of shared mobility. Innovative one-way and peer-to-peer carsharing represents a critical first step toward creating more choice for travelers and making it easier for drivers to give up personal car ownership.

When Do People Choose Shared Rides?

App-based pooling has promise, but its future is unclear. The technology is largely in place: Advancements in technology and mobile computing, along with widespread use of smartphone apps and tracking technologies, provide new opportunities for pooling. Some big questions are behavioral: when, and under what conditions, are people willing to give up personal car space and at what price are people willing to share rides with strangers? This question is particularly salient now, given the COVID-19 pandemic and heightened sensitivity about social distancing, but will be highly relevant even when the health emergency ends.

Other questions are financial: Uber and Lyft still haven't reached profitability. What is the path to firms making money selling shared rides? Pooling can help, since it lowers costs for firms while adding more riders, but whether firms can attract enough shared rides to be profitable remains to be seen.

Public policy will play an influential role in accelerating pooling in conventional, electric, and eventually automated vehicles. Cities will need to make pooling more attractive, perhaps by giving priority to pooled vehicles at curbs and on roadways.

People and cities are on the cusp of rapid change as advancements in technology and services converge in the marketplace. The need to reduce congestion and emissions globally, coupled with the overarching trends of population growth and urbanization, is contributing to a fundamental reimagining of transportation across the world. The convergence of shared mobility services, with other technologies, including fleet electrification and vehicle automation, could lead to fundamental changes and disruption in how people live, work, shop, and travel every day. Cities will need to experiment to find the right mix of policies. What is certain is that we are entering a new era of mobility unlike anything we have seen since the introduction of the automobile more than a century ago.

This article is adapted from Shaheen, S. (2018). Shared Mobility: The Potential of Ridehailing and Pooling. In Three Revolutions: Steering Automated, Shared, and Electric Vehicles to A Better Future (pp. 55–76). Island Press.

About the Author

Susan Shaheen is a professor in the Department of Civil Engineering and co-director of the Transportation Sustainability Research Center at UC Berkeley. She is also the director of the Resilient and Innovative Mobility Initiative of the University of California Institute of Transportation Studies.

Further Reading

Chan, N., & Shaheen, S. (2012). Ridesharing in North America: Past, Present, and Future, *Transport Reviews, 32* (January 2012): 93–112.
Greenblatt, J. B., & Saxena, S. (2015). Autonomous Taxis Could Greatly Reduce Greenhouse Gas Emissions of U.S. Light-Duty Vehicles. *Nature Climate Change, 5* (2015): 860–863.

Sankin, A. (2016, May 9). Can a Smartphone App Save the Taxi Industry from Uber? *The Daily Dot*. https://www.dailydot.com/debug/flywheel-taxi-uber-san-francisco/

Shaheen, S., & Cohen, A. (2018). Shared Ride Services in North America: Definitions, Impacts, and the Future of Pooling. *Transport Reviews*, pp. 1-17. https://doi.org/10.1080/01441647.2018.1497728

Shaheen, S., Stocker, A., & Mundler, M. (2017). Online and App-Based Carpooling in France: Analyzing Users and Practices—A Study of BlaBlaCar. In G. Meyer and S. Shaheen, *Disrupting Mobility: Impacts of Sharing Economy and Innovative Transportation on Cities* (pp. 181–196). Springer.

Sperling, D., & Brown, A. (2019, May). How Lyft and Uber Can Fix — Not Cause — Congestion. *Transfers Magazine*. https://transfersmagazine.org/how-lyft-uber-can-fix-congestion/

Viegas, J., Martinez, L., & Crist, P. (2016). Shared Mobility: Innovation for Liveable Cities, International Transport Forum Corporate Partnership Board.

Opinion: To Save Lives, Let's Cover Crashes Better

Kelcie Ralph

On a typical day, 100 Americans lose their lives in car crashes. That is like a commercial airplane falling out of the sky every other day. Yet crashes have not generated sustained outrage and society doesn't treat them as a public health crisis. The way the media covers crashes is partly to blame for this muted response. Fortunately, simple changes to newsroom editorial practices could increase public support for road safety and help save lives.

My evidence comes from two studies: one examined how journalists report and write about crashes, while the other examined if, and to what extent, coverage mattered — if it influenced the way people thought. The first study reviewed 200 local news stories from across the United States that described a car crash involving a person walking or biking. The second study was an experiment. We took a group of people and randomly assigned them to read one of three slightly different descriptions of the same crash. Some people read typical coverage, while others read a revised text where the driver — not the pedestrian or the vehicle — was the focus. The third group read coverage that provided more context about the crash location, and also provided broader statistics about traffic safety in the area. We then asked each person questions about the crash, to see if these minor editorial changes affected their perceptions of it.

First, the news coverage. We found that it had two key shortcomings: It tended to blame the victim through subtle grammatical choices, and it treated crashes as isolated incidents, rather than a recurring, systematic problem.

With regard to victim-blaming: It turns out that by far the most common way for the press to describe a crash is to write, "A pedestrian was hit" or "A pedestrian was hit by a car." These sentences shift blame onto pedestrians in three ways.

First, they focus on the pedestrian, making them the star of the show. This feels like a nice gesture toward the victim, but linguistics scholars have documented that the sentence's focus tends to garner more blame. Because pedestrians are the focus in three-quarters of crash coverage, they shoulder considerable responsibility in readers' eyes.

Second, both sentences use the passive voice to play tricks with agency. Writing "A pedestrian was hit" omits an agent altogether. The crash just *happened* to the pedestrian. No one caused it. And if no one caused it, no one is accountable. There's a reason people sometimes call this type of passive voice the *exonerative* tense — it's how people talk when they need to acknowledge something bad happened, but would rather not dive too far into why. Fully one-third of the crash coverage we examined omitted an agent.

Third, the coverage blames the victim by using object-based language. Journalists were four times more likely to grant agency to vehicles than to drivers, despite the fact that autonomous technology is exceedingly rare. Journalists should report that a driver, not a car, hit a pedestrian. Some people may cringe at this formation, but it really isn't unusual. No one says "a gun shot a person." We say "someone shot a person with a gun." If they are really worried about being misunderstood, journalists could write "a driver hit a pedestrian with their car."

In addition to victim-blaming, coverage of collisions usually lacks context. Most articles treat crashes as isolated incidents, and in doing so they obscure common factors that make crashes more likely. Reporters rarely tell readers, for example, about vehicle speeds, the availability of crosswalks, or whether crashes are typical at that location or locations like it.

Now to the question of whether coverage matters. Our review showed the coverage was biased. But can we say this bias actually affects the way news consumers think? Yes — as a result of the experiment mentioned above, where one group read typical coverage, a second read a driver-focused text, and a third read coverage that contextualized the crash.
The big result is that readers of the driver-focused text were 30 percent less likely to blame the pedestrian and 30 percent more likely to blame the driver. That is extraordinary. Simple changes to sentence-level grammar dramatically shifted readers' perceptions.

Article-level framing matters too. Readers who were provided with more context were less likely to blame the driver or pedestrian, and were more likely to blame "other factors," like unsafe road design. These readers were also less likely to support a *Walk Smart!* campaign to "train pedestrians to cross the street more safely" (a classic pedestrian-blaming intervention) and more likely to support new pedestrian infrastructure and lower speed limits.

Given these results, I implore journalists to alter their editorial practices. An easy-to-implement — albeit incomplete — fix is to shift focus away from the pedestrian and focus instead on the driver. A more complete overhaul would require journalists to connect the dots between seemingly isolated crashes. In particular, journalists should describe crash settings, include local and national data on crashes, and mention safety measures that the city or state has implemented or is considering. Time permitting, journalists should consider contacting local transportation, planning, or public health experts to provide further context.

I recognize that these recommendations constitute just one more demand on already overstretched journalists. But they are also straightforward. Practitioners can help by proactively contacting journalists and making themselves available for quotes whenever a crash occurs. Advocates can bring these suggestions to the attention of local journalists and hold them accountable. Revising crash coverage can shift perceptions, and shifting perceptions can save lives.

About the Author

Kelcie Ralph is an assistant professor at the Bloustein School of Planning and Public Policy at Rutgers University.

Further Reading

Goddard, T., Ralph, K., Thigpen, C., & Iacobucci, E. (2019). Does News Coverage Affect Perceived Blame and Preferred Solutions? Evidence from an Experiment" *Transportation Research Interdisciplinary Perspectives.* https://doi.org/10.1016/j.trip.2019.100073

Ralph, K., Iacobucci, E., Goddard, T., & Thigpen, C. (2019). "Editorial patterns in Bicyclist and Pedestrian Crash Reporting" *Transportation Research Record.* https://doi.org/10.1177/0361198119825637