Pima Long-Range Regional Transit Plan

Transit Choices Report

Pima Association of Governments

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1 Summary: Why a Long-Range Transit Plan?

The Tucson region needs better alternatives to automobile travel.

A landscape made for cars

Since 1950, Tucson has transformed from a small town of 50,000 in the Sonoran Desert to the center of a metropolitan region home to over 1 million people. This transformation was enabled by - and planned around - the widespread use of the automobile.

This is clear from the shape of the region's buildings, streets and neighborhoods. Wide and fast thoroughfares like the Miracle Mile and East Broadway were built with driving in mind, even when most of the city was still on gridded streets close to Downtown. More recent development in suburban areas has reinforced this further, with large arterial roads connecting subdivisions to malls.

The design and planning for cars is reflected in how people behave. From 2012 to 2016, American Community Survey (ACS) data suggest that over 86 percent of commuters in the Tucson metro area reported driving to work in a private vehicle. Local data from the Pima Association of Governments (PAG) suggest that transit rides account for only 1.5 percent of all trips in the region.

...that doesn't serve everyone

Despite the very low share of public transit in existing trips, there are good reasons to think that many people could use alternatives to driving, if they were more viable.

Many people have limited access (or no access) to a car. ACS data suggest that nearly one in ten people in the Tucson region live in zero-vehicle households. Meanwhile, 24 % of all households own at least two fewer vehicles than people. As a result, many people rely on friends, neighbors and family for transportation when they cannot use public transit.

Household transportation costs are high. The average household in Pima County drives nearly 20,000 miles per year, and spends over $12,000 doing so. That amounts to 27% of the average household income. The cost of owning, maintaining and driving a vehicle is in many cases higher than the cost of housing.

Household incomes are low. The median household income in the Tucson area stood at about $45,000 in 2016, nearly 20% below the national average. In the City of Tucson, median household income was only $38,000 dollars. Over 18% of Tucson households live in poverty, compared to 12% nationally. High transportation costs impact low-income populations disproportionately.

Figure 1: Miracle Mile in 1958 (top) and Tangerine Road in 2018 (bottom). The development of Tucson from a small desert town to a major metropolitan area has always revolved around increasing the number of places that can be reached by driving in a car. But many people have limited access to a personal vehicle or no vehicle at all, and households throughout the region face high transportation costs.

Photo Credits:
Miracle Mile: Tucson Historic Preservation Fund
Tangerine Road: RTA

1 IN 10 PEOPLE LIVE IN HOUSEHOLDS WITH NO VEHICLES

1 IN 4 HOUSEHOLDS HAVE 2 MORE PEOPLE THAN VEHICLES

$12,000 ANNUAL TRANSPORTATION COST PER HOUSEHOLD

$38,000 AVERAGE HOUSEHOLD INCOME IN THE CITY OF TUCSON

$45,000 AVERAGE HOUSEHOLD INCOME IN THE TUCSON REGION

27% OF HOUSEHOLD INCOME IS SPENT ON TRANSPORTATION

Public transit is the most viable alternative to the car for large numbers of trips.

Why focus on transit?

Because of the long distances between homes, schools, shops and jobs in the Tucson region, the vast majority of people can not meet their transportation needs on foot, scooter or bicycle alone.

Transit on buses and trains isn't the only alternative to owning and driving a car. Ridehailing (like Uber and Lyft) and taxis are available in some areas, but are more expensive than driving a private car per mile travelled, so very few people can afford to use them on a daily basis. Other alternatives like carpooling and vanpooling only work when several people who know each other come from or go to the same places at the same times.

Another alternative could be on-demand dial-a-ride service, similar to the paratransit service that is required for eligible disabled users by the Americans with Disabilities Act (ADA), or subsidized ridehailing. But this is extremely expensive to extend to the general public, because each trip costs at least as much as the equivalent taxi ride.

Public transit on fixed routes can help bridge the gap. In the right conditions, fixed-route transit can do two things:

- Extend how far people can go on foot, or on a bicycle, providing some of the benefits of access to a private vehicle but at a much lower cost and without relying on friends or family.
- Replace driving trips in times and places where driving a car is inconvenient or too expensive.

Benefits of Transit

Transit can't serve every trip, but it has many personal and community benefits, such as:

- **Transit is inexpensive to ride.** Sun Tran fare is less than $2 on most routes, and includes transfers with a SunGO card. The cost of owning and driving a car is about $20 a day in Pima County.
- **Transit can move many people.** The average Sun Tran bus carries 25 passengers per hour, and operates 16 hours per day. Most cars carry one or two people, and sit parked most hours of the day.
- **Transit requires very little space.** A typical sedan requires 70 square feet of road space for a single person. A typical bus carries ten to 60 people on 400 square feet of road space. That's up to ten times less road space per person!
- **Transit requires less fuel, and produces fewer emissions than driving alone.** A diesel bus gets 4 to 8 miles per gallon. That means it only takes 5 passengers on board to make a bus more fuel efficient than most cars.
- **Transit is available to everyone near it.** Not everyone can drive or bicycle, and not everyone wants to. Transit allows all individuals the freedom not to rely on a personal vehicle, and not to depend on friends and family for transportation.

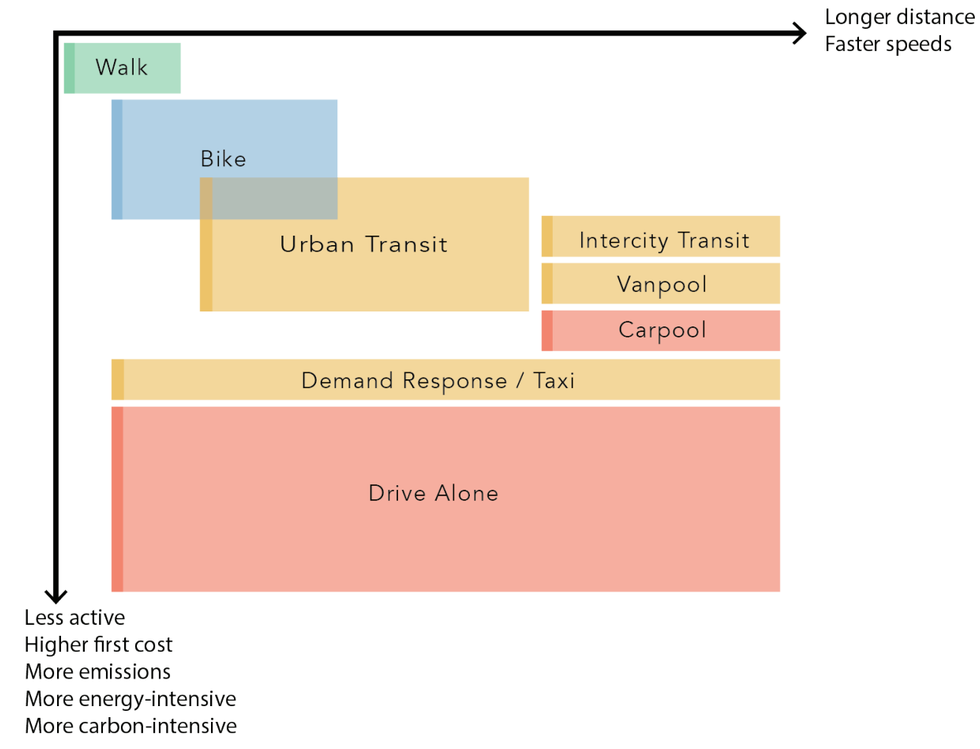


Figure 2: Different transportation modes are useful for different types of trips. When conditions are right, transit can extend the reach of biking or walking trips, or replace driving.

Significant investments in transit have had mixed results.

Public Transit in the Tucson Region

The largest provider of public transportation in the region is the City of Tucson, including:

- **Sun Tran** provides all-day bus service on 29 routes serving Tucson, South Tucson, Flowing Wells, Casas Adobes, Drexel Heights and Valencia. Sun Tran also provides 12 peak-hour express routes connecting suburban locations to Downtown Tucson, the University of Arizona and the Aero Park.
- **Sun Link** is the streetcar line, with frequent all-day service between Downtown Tucson and the University of Arizona.
- **Sun Van** is a paratransit service, providing rides to passengers who live within Sun Tran's service area but are unable to use transit due to a disability.

In addition, the Regional Transportation Authority (RTA) funds limited regional service through a county-wide sales tax and funding from Pima County, Town of Oro Valley, and Town of Marana. These include:

- **Sun Shuttle**, which provides all-day routes connecting outlying communities such as Marana, Oro Valley, Sahuarita/Green Valley and others to places on the Sun Tran network.
- **Sun Shuttle Dial-A-Ride** provides a reservation-based demand-responsive service to the general public in Oro Valley and Sahuarita/Green Valley, as well as a paratransit service for eligible disabled passengers that serves outlying areas not covered by Sun Van.

Sun Tran and Sun Link together account for 66% of total service provided in the region and 96% of ridership. Sun Shuttle accounts for 5% of total service and under 1% of ridership.

The Frequent Transit Network (FTN)

In recent years, Sun Tran has focused service improvements on expanding the Frequent Transit Network (FTN). **These routes operate every 15 minutes or better from 6 AM to 6 PM on weekdays.** There are currently eleven FTN routes; they cover much of the City of Tucson but do not extend to suburban areas.

The FTN routes replicate Tucson's grid of east-west and north-south arterial streets. Because these routes operate frequently, it is relatively simple to transfer from one bus to another to travel between any two points. As a result, expanding the FTN has significantly improved travel times for trips that start and end outside of Downtown Tucson.

Nonetheless, Sun Tran ridership has declined since 2014. A significant cause for this decline is the 42-day work stoppage in 2015, which forced many Sun Tran riders to find alternatives. Other factors likely to have had a significant effect include fare changes, lower gasoline prices and low automobile lending rates. Gas prices and lending rates in particular appear to have contributed to a nationwide drop in transit ridership over the same period.

However, comparing productivity (riders per hour) between different routes shows that **the most successful frequent routes also operate frequently on weekends, and always maintain evening service at every 30 minutes or better.** FTN routes where buses only come every 60 minutes on evenings and weekends haven't attracted significantly more ridership than similar routes that operate only every 30 minutes during the daytime.

Sun Link Streetcar

The Sun Link streetcar was first included in the Regional Transportation Plan in 2006, and has been in service since July 2014, attracting nearly 1 million riders per year.

The streetcar links several high intensity areas in central Tucson, including Downtown, the Fourth Avenue Business District, and the University of Arizona. It operates very frequently, with service every 10 to 15 minutes on weekdays and Saturdays (even into the evenings), and every 20 minutes on Sundays.

As a result, this streetcar line is among the most successful transit routes in the region. Sun Link attracts nearly 40 boardings per hour on weekdays, placing it on a similar to footing to some of the most successful Sun Tran lines, like the 8-Broadway and 16-Oracle.

In addition, the streetcar is believed to play a significant role in the ongoing economic revitalization of central Tucson. Some accounts credit the streetcar with helping catalyze up to $2 billion in redevelopment in the last five years.

Because the streetcar is located in such a prime and dense central market, its success is a good example of some of what is possible in the best conditions in the Tucson region. However, this model may not scale to many other locations.

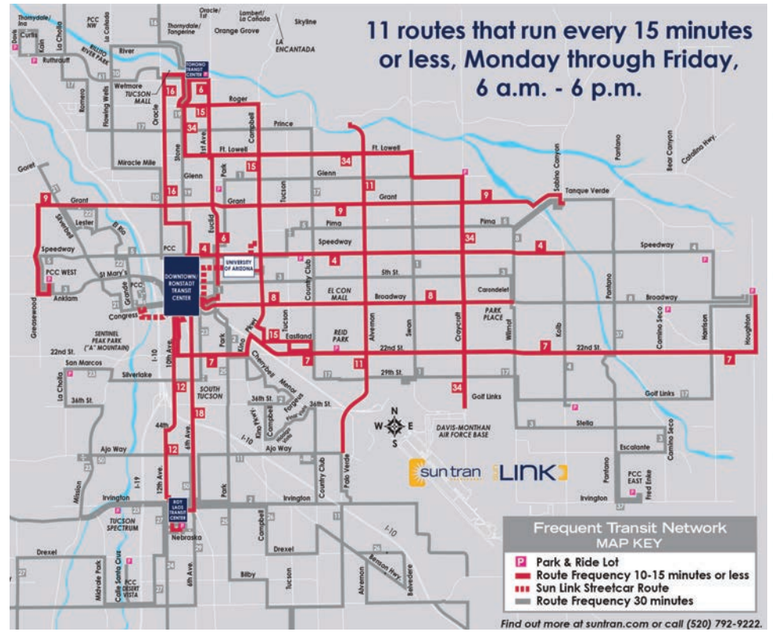


Figure 3: Sun Tran Frequent Transit Network (FTN) map. The FTN now covers most of the City of Tucson, but frequent service rarely extends to weekends and evenings.

Figure 4: Sun Link streetcar. The streetcar has been very successful in connecting and revitalizing parts of central Tucson, but few other areas have as much potential. Photo by David Wilson.

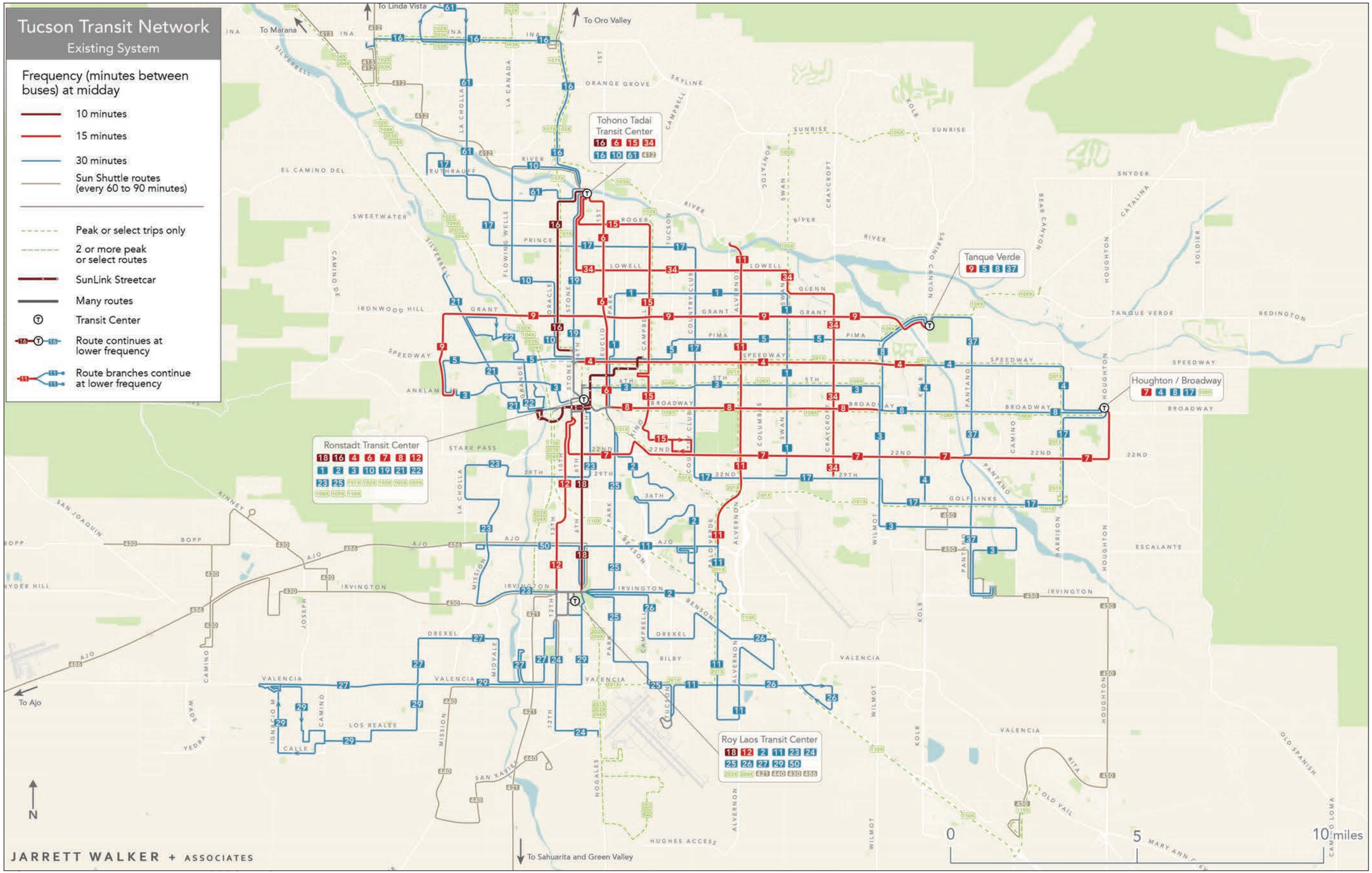


Figure 5: The public transit network in and around Tucson. The vast majority of service is provided by Sun Tran and Sun Link. Sun Shuttle provides occasional services that connect far suburban and outlying communities to the edges of the Sun Tran network. This map colors routes according to their weekday midday frequency. Sun Link, and routes in Sun Tran's Frequent Transit Network (FTN), are in shades of red.

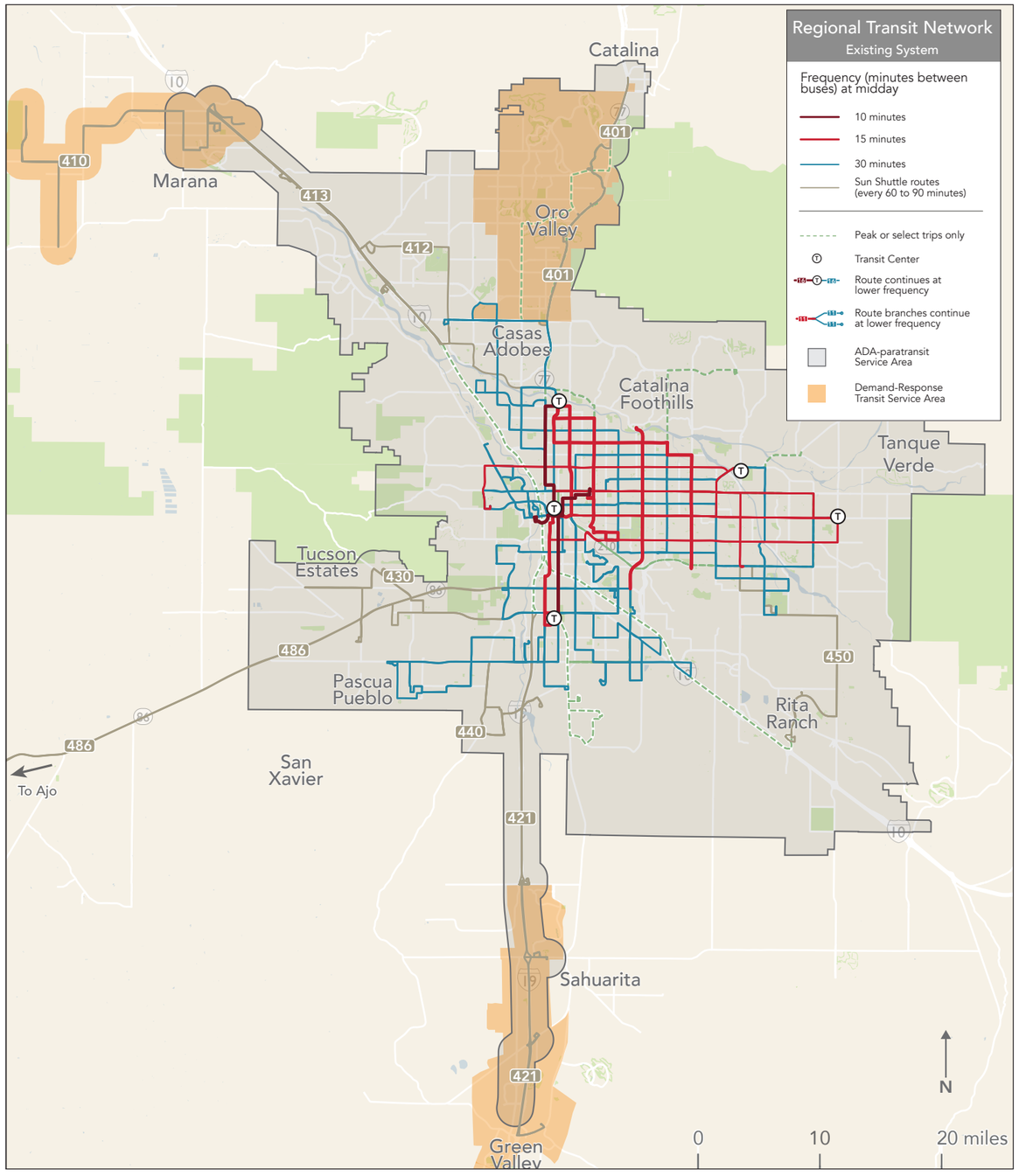


Figure 6: Regional transit network. Transit service is much more sparse in outlying parts of the Tucson region. Sun Shuttle and Sun Tran Express routes extend north, east, and south far beyond the limits of the City of Tucson, to serve places like Marana, Oro Valley, the Catalina Foothills, Sahuarita/Green Valley, and territories of the Pascua Yaqui and Tohono O'odham nations. However, Sun Express routes operate at rush hours only; most provide three trips per direction. Sun Shuttle routes within the urbanized area operate every 60 to 90 minutes. Sun Shuttle to Ajo in east Pima County operates once per day in each direction.

For transit to be a viable alternative, it needs to become more useful and liberating.

People will ride transit when it offers a satisfactory answer to the following concerns:

- **Access (or Freedom).** Where can you get to on public transit in a reasonable amount of time, compared to your alternatives?
- **Pricing.** What does transit cost, compared to your alternatives?
- **Individual Preference.** This includes subjective factors and other aspects of the transit experience. What are you doing later? Do you feel safe? How much stuff are you carrying home?

A long-range plan can't change what how individuals feel about riding a bus or a streetcar on a given day, and it can't set fares and fuel prices ten years into the future. But it can have a significant impact on how much access the transit network provides.

Ridership and Access (or Freedom)

Wherever you are, there is a limited number of places you can reach in a given amount of time. These places can be viewed on a map as a blob around your location. Figure 7 shows an example.

Think of this blob as "the wall around your life." Beyond this limit are jobs you can't hold, places you can't shop, and things you can't do because it takes too long to get there. So the extent of this area determines your options in life for employment, school, shopping, or whatever you want to reach. If you have a bigger blob, you have more choices, so in an important sense you are more free.

How Transit Creates Access

On transit, the extent of access is determined by:

- **The network**, including transit lines with their frequency and speed. These determine how long it takes to get from A to B.
- **The layout of the city**. How many destinations are near each transit stop? Access to places where there are more destinations to reach (jobs, services etc.) is valuable to more people.

The way the network and a city's layout determine access from any point is simple math, but it's very important:

- **Access to jobs** is key for keeping people employed. If you are deciding where to live based on how you'll reach your job, school, or relatives, you are asking a question about access.
- **Access from any location** gives that location value. Real estate firms routinely study where you can get to by car from a property, and this is the same analysis for transit.

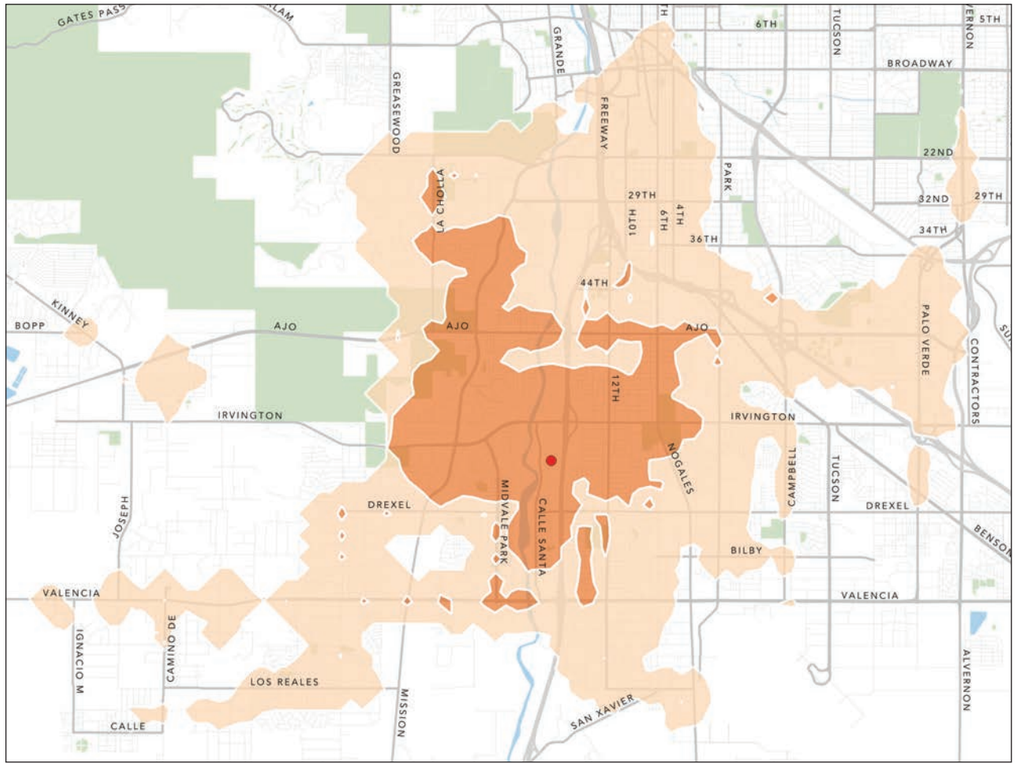


Figure 7: Map of how far one can travel in 60 minutes by transit from Tucson Spectrum, on a typical weekday. The size of the area you can travel in, and the places within that area, are a good indication of how much access the transit network provides. Like in most parts of Southern Tucson, the nearest bus line to Tucson Spectrum (Route 23) comes every 30 minutes. If you were to leave the mall at exactly the right time, you might be able to reach anywhere in the light orange area in an hour. But you can only *dependably* reach the area in dark orange. If the bus came more frequently, you could dependably reach many more places, which would make the service more useful.

From Better Access to Higher Ridership

At the individual level, transit service becomes more useful when it provides you with better access. So planning for useful transit means planning for better access.

At the level of the city and region, transit ridership arises in large part from providing useful access to many people. So while access is not in itself a prediction of ridership, it is a necessary foundation. It is the source of ridership that we can most influence by planning.

Room for improvement

The high number of people with limited or no access to a vehicle - and the significant expense involved in driving - suggest that many people would use transit if it were more convenient.

For transit to be viable for more people, the service needs to become more convenient and more useful. At the moment:

- **Trips on transit typically take more than twice as long on average as driving alone.** When walking and waiting times are included, it takes over 30 minutes longer to reach Downtown or the University of Arizona from most of Tucson.
- **Trips on transit take much longer (and sometimes aren't possible) in the evenings and on weekends.** Most Sun Tran bus routes operate only once an hour after 7 PM and on weekends. This means passengers wait extremely long times.
- **Most people in the Tucson region don't have access to frequent transit, and many don't have access to any transit.** Less than 30% of Pima County residents and less than 60% of City of Tucson residents live within a half-mile of the Frequent Transit Network. 41% of Pima County residents don't live near any transit service. Because suburban and outlying development is very dispersed, it is difficult to reach most of these residents.

What choices do we have to improve transit in the Tucson region?

How much investment in service?

Transit vs. Other Local Services

Different regions invest different amounts in transit service. That level of investment is the most important factor in how useful a transit system can become.

Figure 8 shows how the amount of service available relates to the relevance of the transit system (how often people ride) in a range of mid-sized US cities. **Transit networks that offer more service generate higher ridership.**

For example:

- Salt Lake City invests twice as much in transit service per person as Tucson; the transit system is used twice as much.
- Albuquerque invests about 30% less in service per person as Tucson; transit is used almost 25% less.

Any increase in funding for transit service is likely to require a local funding source. So any decision to increase transit service is also a decision to either pay more local taxes, or to invest less in other local public services.

This trade-off doesn't necessarily affect everyone. A new funding source for transit could be regional, or could be specific to the City of Tucson, which holds the vast majority of neighborhoods likely to generate significant ridership.

Regions and cities that invest more in transit service have more useful networks that generate higher ridership. But any new service would require new local funds. What kind of transit city and region should Tucson be?

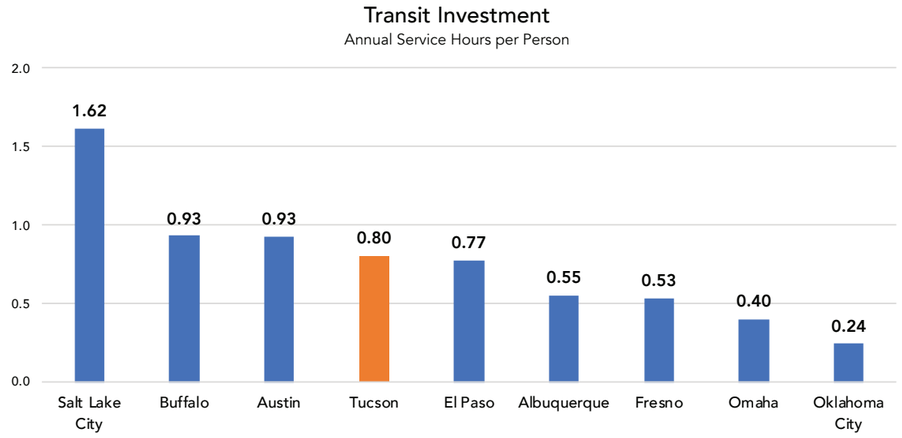


Figure 8: Transit service investment and ridership in Tucson and peer regions. Tucson invests more than many cities in the US, and gets higher ridership as a result. To generate significant further increases in ridership, the city or region would need to allocate more resources.

How do we make service more useful?

Frequency vs. Coverage

As shown in Figure 9, 98% of people living in the City of Tucson live within a half-mile of transit service, but this is true for less than 60% of all Pima County residents. Extending service to more suburban areas would improve this statistic. But it might not result in very useful service, because most suburban areas have low residential and job densities and could not support high frequency service.

Extending transit service into new areas would provide a lifeline to people who have no service now. But improvements to the Frequent Transit Network (FTN) would make existing service useful to more people. Which is valuable?

Frequency in More Places vs. Frequency at More Times

All routes in Sun Tran's Frequent Transit Network (FTN) feature service every 15 minutes or better on weekdays, from 6 AM to 6 PM. But the highest ridership routes in the FTN (8-Broadway, 16-Oracle and 18-South 6th) also provide frequent service on weekends, and run every 30 minutes or better in the evening.

These routes are more useful because they feel more reliable: if you take the bus somewhere, you know it'll still be running at a reasonable frequency when you come back. If you work on weekends, the service is almost the same as on weekdays, so you can count on it. Improving evening and weekend frequency on all FTN routes would make them more useful, and would likely attract more riders.

At the same time, there are still big gaps in the frequent network. East of Downtown, there's a frequent east-west route every mile (22nd, Broadway, Speedway, Grant, Lowell) but a north-south route only every two miles (Campbell, Alvernon, Craycroft). And the only frequent service on the south side is on 6th and 12th Avenues north of Irvington. Expanding the number of frequent routes would improve weekday access to many areas.

The more we invest in new frequent routes, the less is available to improve weekend and evening frequency on existing routes. Which is more important?

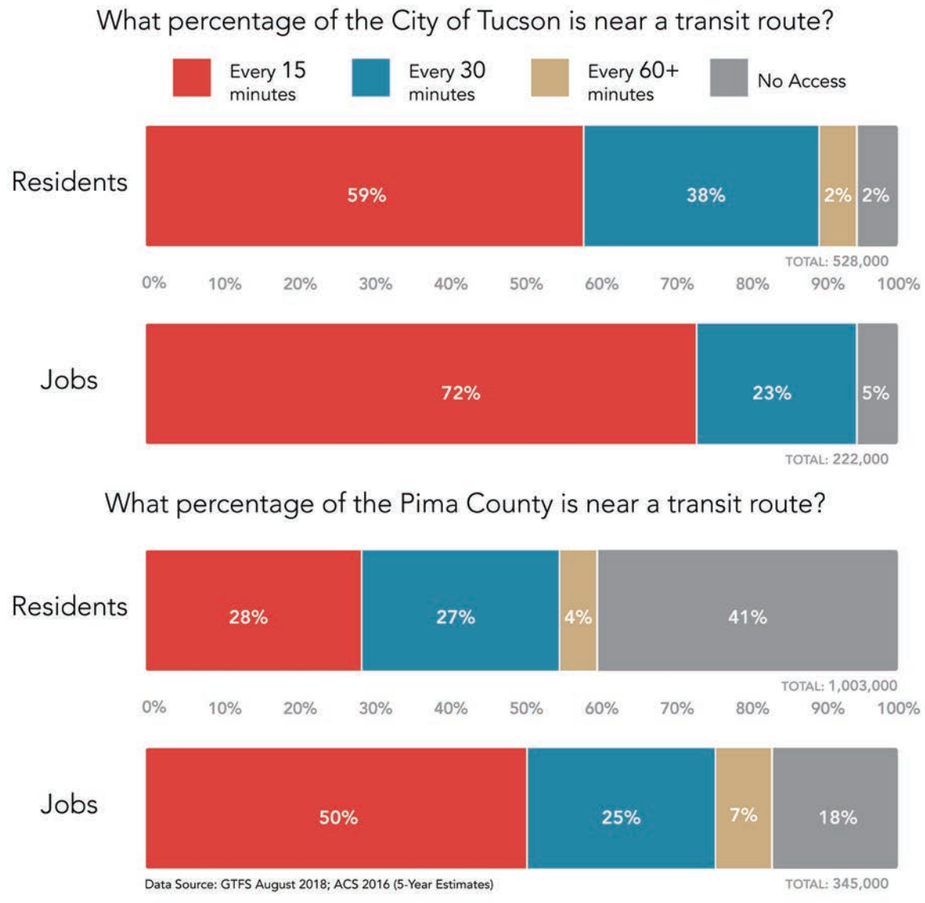


Figure 9: Percentage of the population within a 1/2-mile of transit service in the City of Tucson, and in Pima County as a whole. Most people in the Tucson region don't live near a frequent transit route, and most jobs aren't near any transit service at all. This severely limits the usefulness of the transit system. Expanding service to more areas could help, but the greatest improvements in access would come from expanding the population and jobs specifically near frequent service.

How do we improve infrastructure?

Concentrated vs. Diffuse investments

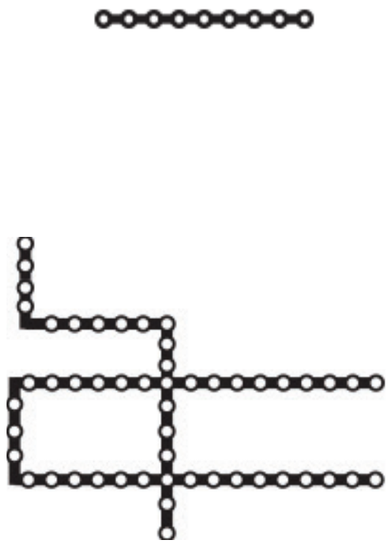
Transit service works best when combined with good infrastructure, like sidewalks and bus stop shelters. Frequent transit routes benefit significantly from improvements to speed and reliability, like bus priority at traffic signals, and dedicated lanes in areas with significant congestion.

Through efforts like the High Capacity Transit Implementation Plan, the Pima Association of Governments (PAG) and City of Tucson have invested time in studying options for streetcar or Bus Rapid Transit (BRT) improvements on some of the most successful corridors, such as Oracle Road, Broadway and South 6th Avenue.

Focusing on streetcar and BRT options both imply concentrating investment in certain corridors. As a result, travel time reductions and other improvements to the user experience would only be available in those corridors.

An alternative possibility would be to plan for many spot improvements like added crosswalks, better bus stops, and bus priority measures for existing routes. This type of investment wouldn't change the face of Tucson, but it could be acheivable over a much wider area and improve many people's experience on transit.

Smaller infrastructure improvements benefitting many places can be made at similar costs as transformational improvements that benefit a small area. Which is more valuable?



MOST CONCENTRATED

STREETCAR EXTENSION

Transformational improvement in a small area.

Light rail operating in mixed traffic or a dedicated lane, with highly improved stations, level boarding, and priority at some lights.

INTERMEDIATE

BUS RAPID TRANSIT

Significant improvement to a slightly wider area.

Special bus routes that may feature stations, level boarding, and bus priority on some segments.

LEAST CONCENTRATED

Small improvements in many places.

These could include more crosswalks, better stops and shelters, and bus priority measures in congested areas. These improvements could be spread throughout the network.

Figure 10: For a similar amount of capital investment, Tucson could build an extension to the Sun Link streetcar, two or three longer Bus Rapid Transit lines, or make small improvements spread throughout the existing transit network. Which is more valuable?

2 What Makes Transit Useful?

Transit can serve many purposes; which purposes it should serve depends on your values.

Public transit can serve many different goals. Different people and communities value these goals differently.

Possible Goals of Transit

Understanding which goals matter most in the Tucson region matters in planning and designing future service.

Possible goals for transit include:

- **Economic.** Transit can give businesses access to more workers, and give workers access to more jobs. Transit can also help attract certain industries, new residents, tourists, or other economic contributors.
- **Environmental.** Increased transit use can reduce air pollution and greenhouse gas emissions. Transit can also support more compact development and help conserve land.
- **Social.** Transit can help meet the needs of people who are in situations of disadvantage, providing lifeline access to services and jobs.
- **Health.** Transit can be a tool to support physical activity by walking. This is partly because most riders walk to their bus stop, but also because regular transit riders will tend to walk more in between their transit trips.
- **Personal Liberty.** By providing people the ability to reach more places than they otherwise would, a transit system can be a tool for personal liberty, empowering people to make choices and fulfill their individual goals.

Some of these purposes are served only when transit has high ridership. We call these ridership goals. For example, the environmental benefits of transit only arise from many people riding the bus rather than driving, taking a taxi, or getting a ride in a private vehicle. And subsidy per rider is lower when ridership is maximized.

Other purposes are served by the mere presence of transit. We call these coverage goals. A bus route through a neighborhood provides residents insurance against isolation, even if the route is infrequent and few people ride it. That same route may also fulfill a political or equity need, such as the desire to provide some service to all wards in a city, or all towns and cities in a region.

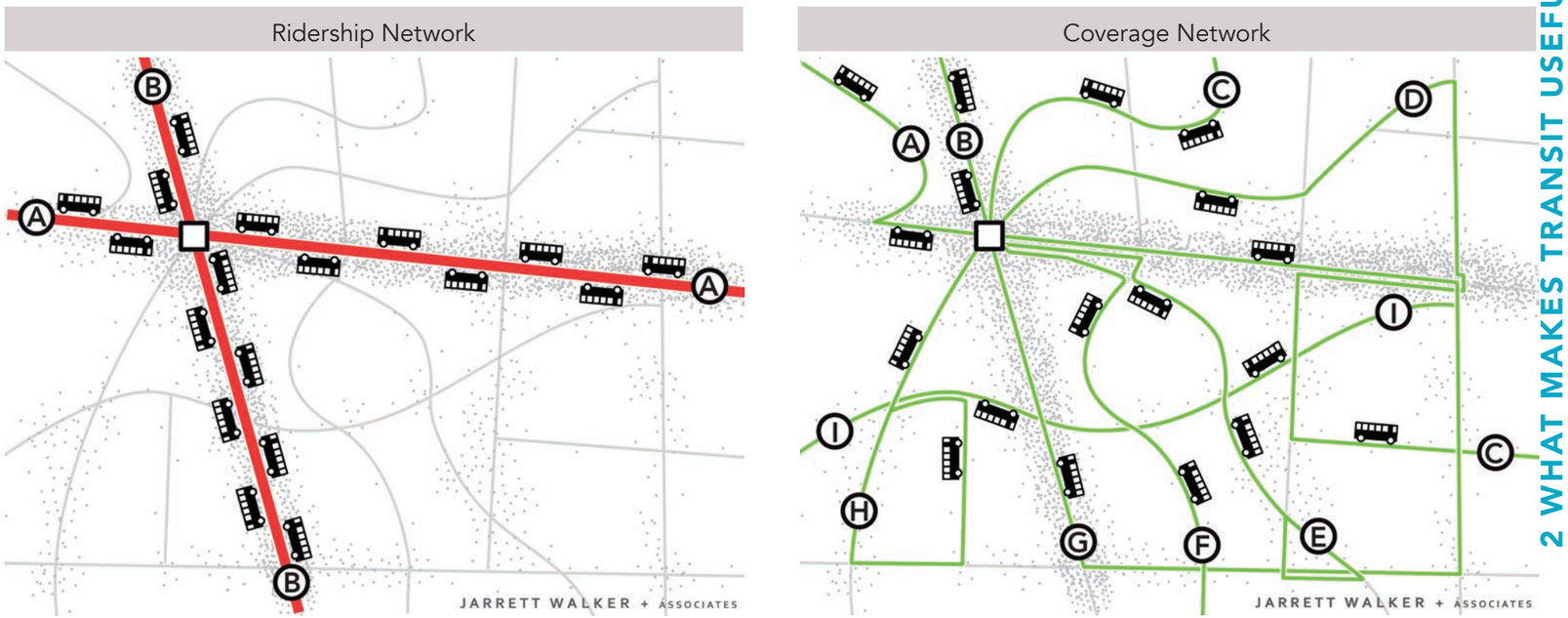


Figure 11: The Ridership / Coverage Trade-off. Imagine you are planning a network for the imaginary area above. If you wanted to create a service with the highest possible ridership, you would put all your buses on the two main streets with the most people and destinations (dots in this diagram). If you want to cover as much territory as possible, you will create many routes, but none of them will be very frequent, which means they aren't likely to generate much ridership.

Ridership and Coverage Goals are in Conflict

Ridership and coverage goals conflict. Within a fixed budget, if a transit agency wants to do more of one, it must do less of the other. Consider the fictional neighborhood in Figure 11. The little dots indicate dwellings, jobs, schools and other destinations. The lines indicate roads. As in many places, most activity is concentrated around a few roads.

A transit agency pursuing only ridership would run all its service on the main streets, since many people are nearby, and buses can run direct routes. Service would be very frequent and convenient, but only available in certain areas. This would result in a network like the one at top left.

If the transit agency were pursuing only coverage, it would spread out so that every street had some service, as in the network at top right. Service would be available almost everywhere, but all routes would then be infrequent, even on the main streets.

These two scenarios require the same number of buses and cost the same amount to operate, but deliver very different outcomes. To run buses at higher frequency on the main roads, neighborhood streets will receive less coverage, and vice versa.

An agency can pursue ridership and provide coverage within the same budget, but not with the same dollar. The more it does of one, the less it does of the other.

These illustrations also show a relationship between coverage and complexity. Networks offering high levels of coverage – a bus running down every street – are naturally more complex.

The choice between maximizing ridership and maximizing coverage is not binary. All transit agencies spend some portion of their budget pursuing each type of goal. One particularly clear way for cities and transit agencies to set a policy balancing ridership and coverage goals is to decide what percentage of their service budget should be spent in pursuit of each.

Useful transit is frequent transit.

How Frequency Increases Freedom

A transit network is a pattern of routes and services, in which each line has:

- a path
- a span (what hours and days it runs.)
- an average speed
- a frequency — how often a transit vehicle serves a stop.

Of these, frequency needs the most explanation. Frequency is invisible and easy to forget, but on transit it is often the dominant element of travel time, determining where you can go in a given amount of time.

More frequent service dramatically improves access

Frequent service reduces travel time by providing several linked benefits for customers:

- **Shorter Waits.** Waiting for the bus may be the most onerous part of riding transit, since you're not moving at all. The more often the bus comes, the less time you wait.
- **Faster Connections.** The ability to change from one vehicle to another is critical to reach the many places that are inevitably not on the line you happen to be on. Connections are the glue that combines a pile of lines into a network. Frequency makes connections easy, because the next bus is always coming soon.
- **Easier Recovery from Disruption.** Frequent service is more reliable. If a bus breaks down, the next bus is coming soon.
- **Spontaneity.** Rather than building your life around a bus schedule, customers can turn up at the stop and go.

Because these benefits are independent of each other, the payoffs in usefulness and ridership are greater as frequency improves. In similar environments, routes that operate every 15 minutes or better tend to see higher ridership than less frequent routes.

Figure 12 plots the frequency and productivity of each route operated by large number of US transit agencies. The horizontal axis is frequency (more frequent service is to the left). The vertical axis is productivity — ridership divided by the amount of service. Each hexagon is shaded by the number of unique routes occupying that point on the graph. This shows that **ridership rises with frequency even though the cost of frequency should pull productivity down.**

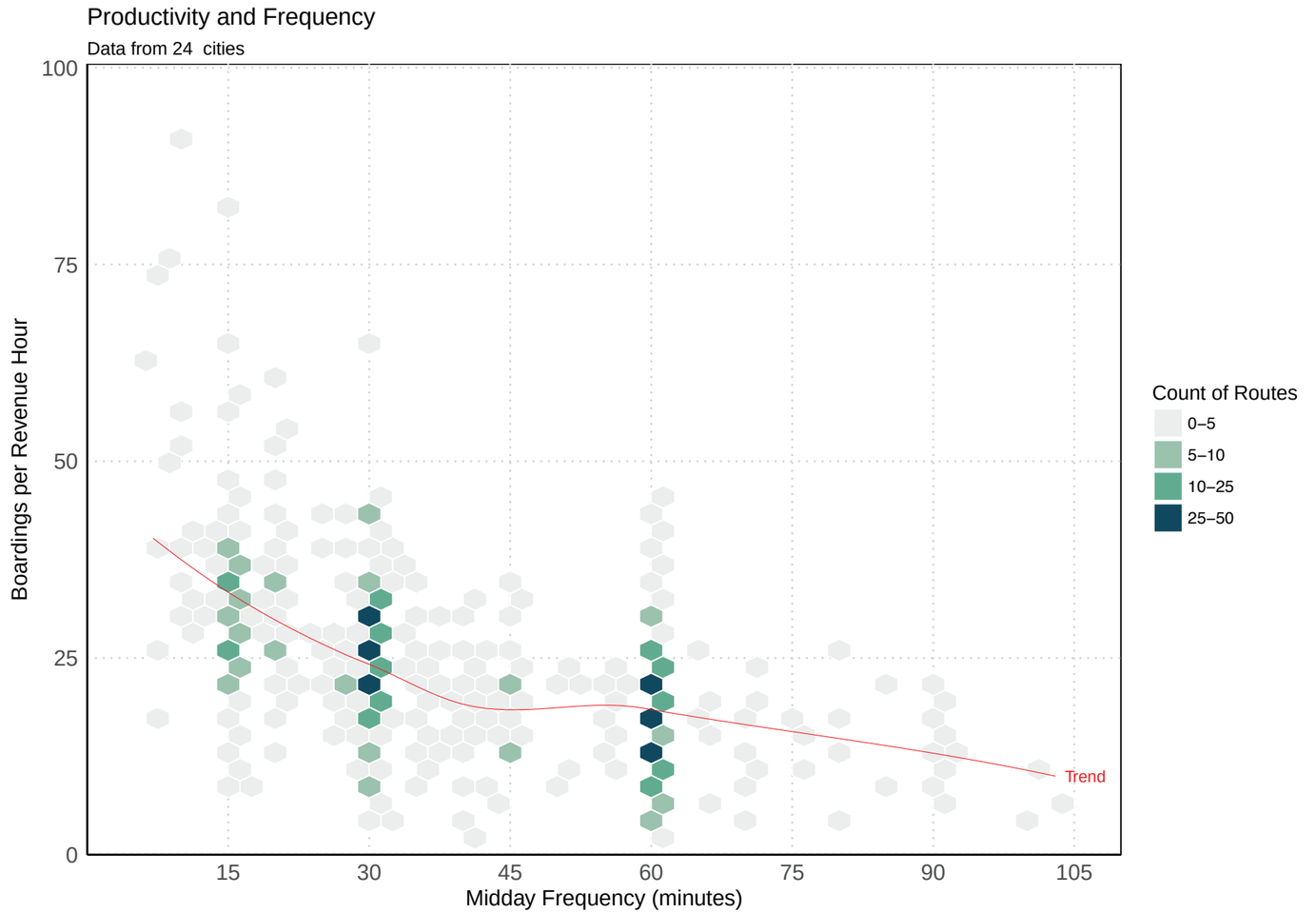


Figure 12: Transit Productivity and Frequency in 24 cities across the USA. Routes that operate more frequently tend to attract a higher number of riders per hour of service. This is because frequency makes transit trips shorter and more reliable.

How much frequency is enough?

Frequency is expensive: when you double the frequency of a bus line, you double its operating cost. So it's important to think about just how frequent service needs to be.

- For most urban purposes, **a frequency of 15 minutes or better has a chance of being useful** for someone whenever they have to travel. At frequencies of this level or better, stronger payoffs begins to appear.
- **Adequate frequency depends on trip length**, because it doesn't make sense to wait long to go a short distance. For example, downtown circulators often don't make sense unless they can run at frequencies at or under 10 minutes. If the bus isn't coming very soon, it's probably quicker to walk.

How does this work in Tucson?

We can see the effect of frequency by looking at how existing Sun Tran, Sun Link and Sun Shuttle routes perform. The most frequent routes operate every 10 minutes at midday on weekdays (18-South 6th Ave, Sun Link, and 16-Oracle). These show significantly higher ridership and productivity than other routes.

On average, routes that operate every 15 minutes have higher ridership and productivity than routes that operate every 30 minutes, but there's a lot of variation. Routes 7-22nd, 9-Grant, 15-Campbell and 34-Craycroft are less productive than other 15-minute routes. This may mean that demand is relatively low along their paths. But it is likely also tied to low evening and weekend frequency (every 60 minutes on these four routes), which makes them less useful.

In the 30 minute category, variations in productivity have a lot to do with the neighborhoods each route serves. Routes that connect to many jobs (e.g. 19-Stone, 25-S Park Ave), and routes that serve lower-income communities where many people don't own cars (e.g. 10-Flowing Wells, 24-12th Ave, and 29-Valencia) tend to be more productive than others.

Sun Shuttle routes are very infrequent and serve small populations. As such, it is not surprising that they show very low productivity and ridership.

Sun Tran express routes' ridership varies a lot from one route to another. Because they only run a few times per day and serve very specific origins and destinations, they can be directly affected by the personal decisions of relatively few people.

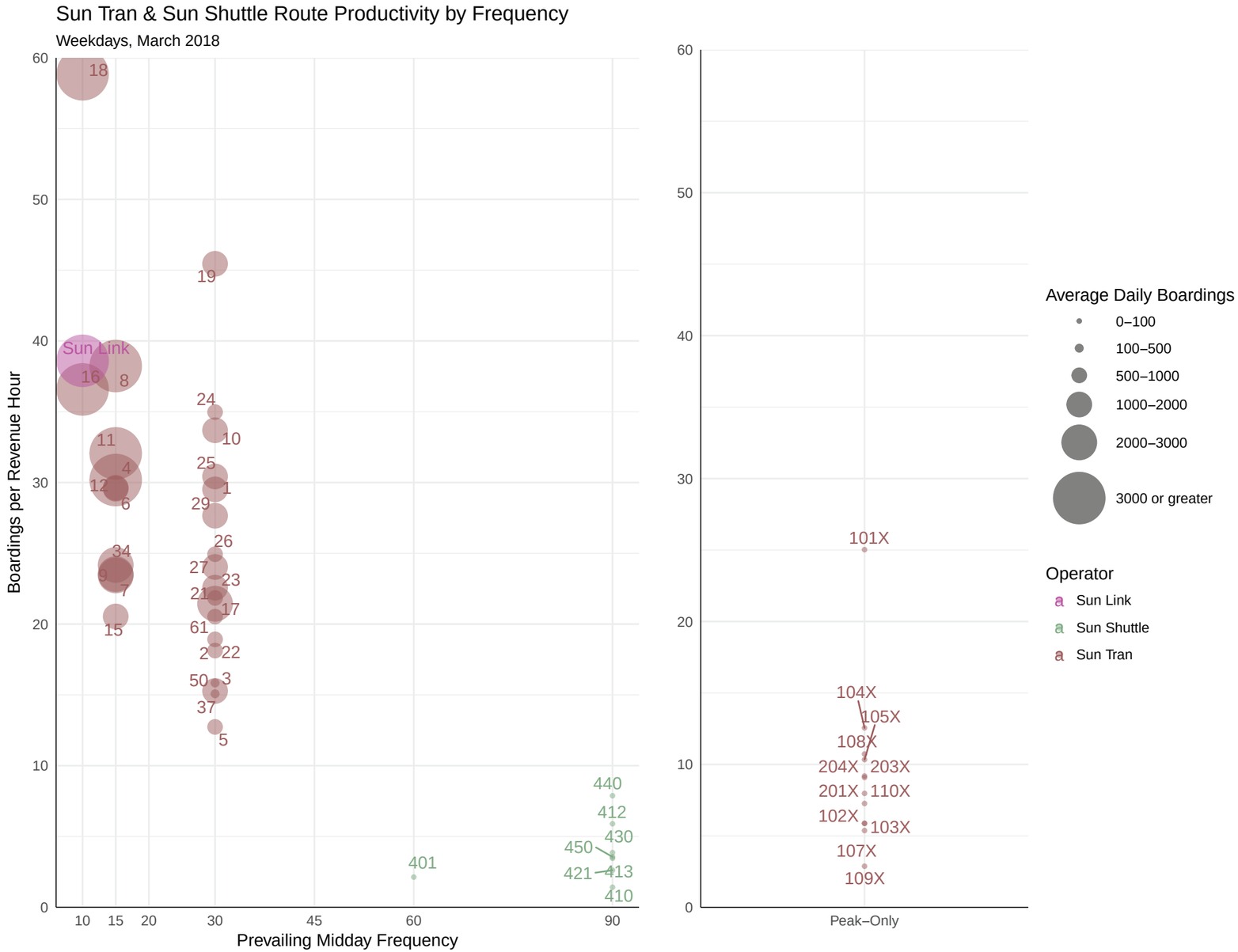


Figure 13: Frequency and Productivity of Sun Tran and Sun Shuttle Routes. Ridership varies a lot according to where a route runs, but more frequent routes tend to have higher ridership and higher productivity. Ridership on peak-only express routes is generally very low and tied to exact origins and destinations; productivity thus can vary considerably from one express route to another based on the personal decisions of relatively few people.

The built environment determines how useful transit can become.

How Urban Form Governs Transit Outcomes

Because frequency is expensive, it can't be offered everywhere. This means it is important to focus frequent service in the places where it can provide the most benefit. This comes down to two questions:

- **How many residents and useful destinations can be easily reached from each stop?**
  - » In areas with higher density, more people will be near a stop.
  - » In places with better walkability, the stop serves a larger area.
- **Is it easy and convenient to serve high demand stops?**
  - » Linearity is about whether a route can be straight, while still providing reasonable service to major destinations.
  - » Proximity is about how many gaps of low or zero demand a route must cross to connect areas with higher demand.

These geometric facts are the basis of a difficult political challenge around transit — a transit system focused on the most useful service, and generating the highest possible ridership, serves its city very unevenly, concentrating service where demand is high and relatively easy to serve.

Imagine that Mrs. Smith lives in an apartment downtown (dense, walkable, linear, proximate) while Mrs. Jones lives in a large house in a suburban cul-de-sac (not dense, not walkable, not linear, not proximate). The objective fact is that it would cost much more to provide the same level of service to Mrs. Jones than as to Mrs. Smith.

Is it fair to give Mrs. Jones and Mrs. Smith the same level of service regardless? Or is it fair to spend the same amount serving each of them, which would mean very little service for Mrs. Jones?

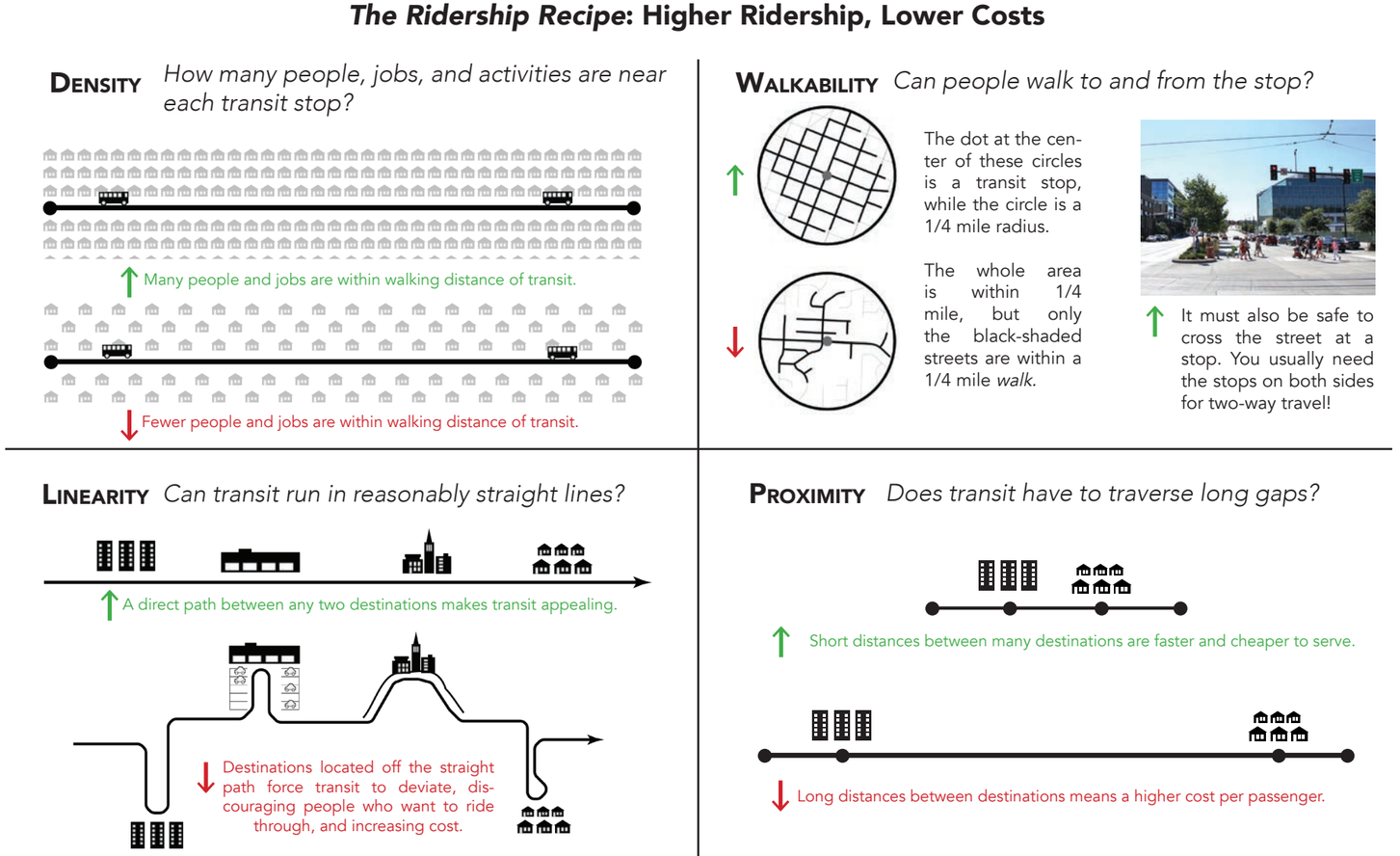


Figure 14: Land-use factors supporting high transit productivity: the ridership recipe

Examples from the Tucson region: Density and Walkability

Because dense areas often support multiple land uses in close proximity, density and walkability often go hand in hand. The aerial imagery shown here contrasts two local examples of areas at the high and low end of the spectrum.

- **Higher density and walkability:** The vicinity of University Boulevard, west of the University of Arizona features a mix of smaller homes and apartment buildings, on the edge of an area with significant employment and institutional use (see Figure 15). The area is connected by a dense network of gridded streets with sidewalks that make it easy to walk to nearby bus and streetcar stops.
  - » This means that many people are likely to be present near any transit stop, and that it is likely to be a relatively short distance from any point to the nearest bus stop.

Figure 15: University Boulevard, west of the University of Arizona features a relatively dense mix of apartments and smaller homes, on a tight grid of walkable streets.

Aerial Image by Google Maps.

- **Lower density and walkability:** Orange Grove Road in the Catalina Foothills is surrounded by large, scattered single-family homes located on isolated cul-de-sacs (see Figure 16). It's not possible to walk from one cul-de-sac to another, and in any case there are very few destinations within walking distance of any home. Orange Grove Road itself features no sidewalks in this area.
  - » There are no bus stops in this segment of Orange Grove Road. But even if there were, very few people would be nearby at any time, and the environment would make it very inconvenient and potentially unsafe to use them.

Because these two sites have vastly different density and walkability, the same amount of transit service would not have the same outcome. Any service near University Boulevard will be useful to far more people, and will generate far more ridership than on Orange Grove Road.

Figure 16: Orange Grove Road in the Catalina Foothills features low densities, with scattered large homes on isolated cul-de-sacs that make walking difficult.

Aerial Image by Google Maps.

Examples from the Tucson region: Linearity

Figure 17: In close-in areas of east Tucson, arterial and collector streets are long and straight. This street pattern makes it easy to lay out a grid of useful bus routes that hits many major destinations.

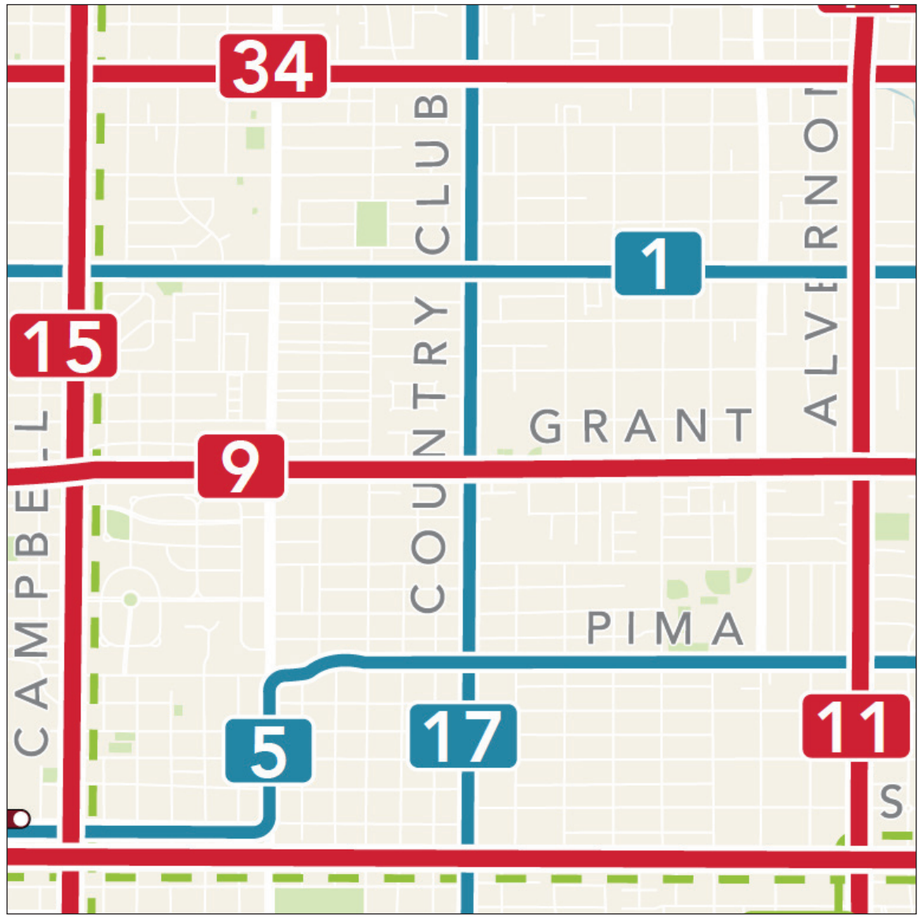
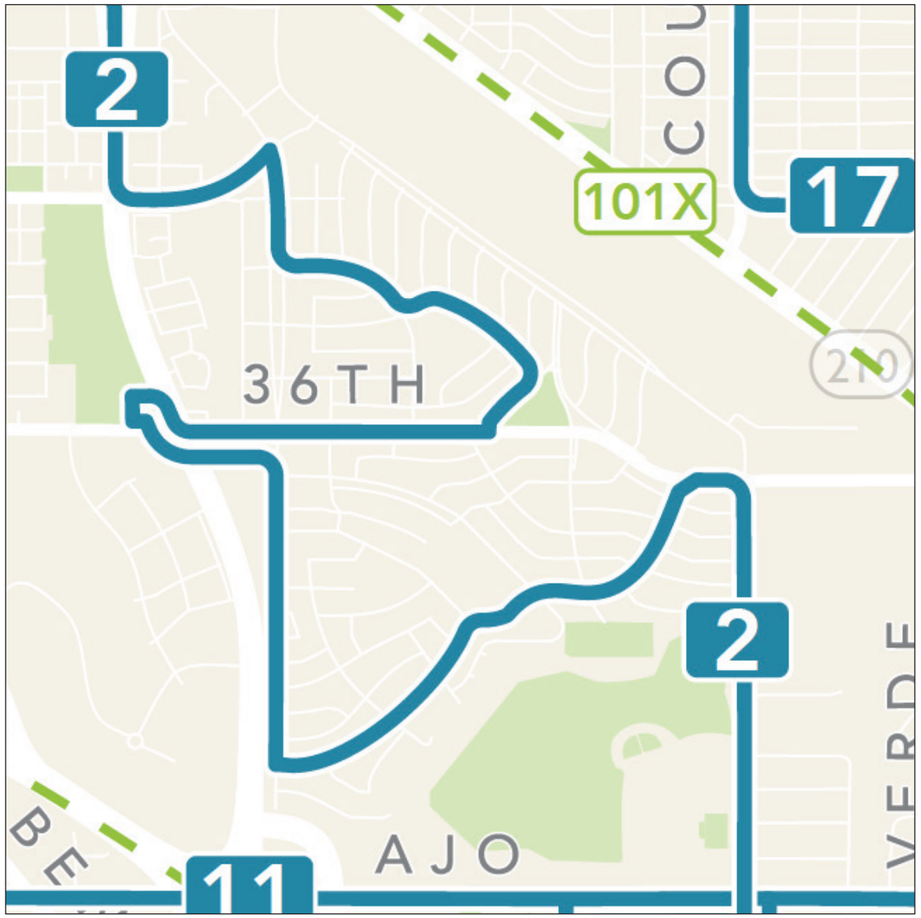


Figure 18: Four miles further south, the situation is much more complicated. Country Club Road and Campbell Avenue are interrupted by freeways and parkways; there's no straight path through that also serves key local destinations like multifamily housing, schools and community centers.



Because of differences in historic land use and road network decisions, some parts of the region are served by much more linear routes than others. For example:

- **More Linearity:** close-in areas east of Downtown Tucson are marked by a half-mile grid of arterial and collector streets, and most commercial, shopping and institutional uses are on arterials. This makes it easy to design fast and direct bus routes, as shown in Figure 17 for the area between Campbell Avenue, Alvernon Way, Speedway Boulevard and Fort Lowell Road.
- **Less Linearity:** just four miles south, the pattern of streets and major destinations is much more complicated for transit to navigate. In the area shown in Figure 18, Route 2 must deal with the absence of a continuous north-south path on either Country Club Road or Campbell Avenue. In addition, schools and social services are scattered throughout the neighborhood and sometimes far from main streets.
  - » As a result, Route 2 follows a long and circuitous path. This makes it very unlikely that anyone coming from south of Ajo Way would want to travel to Downtown Tucson by transit.

Because of the way the roads are laid out, it's easier to provide straight routes useful to many people in inner east Tucson than in much of southern Tucson. So achieving the same level of service will always require more resources in southern Tucson than in inner east Tucson.

Examples from the Tucson region: Proximity/Continuity

The longer and more frequent a transit route becomes, the more expensive it is to provide. So it's important to locate routes on paths that serve many useful destinations. That's easier to do when those destinations are close together.

Take the example of two similarly-sized major hospitals, Banner University Medical Center and Northwest Medical Center. Large hospitals like these generate lots of trips at all times of day, and for many different reasons, and they can generate lots of transit ridership. But location matters in determining how much service even such a large facility can receive.

- **More Continuity:** Banner University Medical Center is surrounded by relatively dense neighborhoods for miles on all sides, and is near many other destinations valuable to large numbers of people, like the University of Arizona. As a result, any bus route that serves Banner also serves the University and connects both places to many homes. In that context, it makes sense that Banner is near several frequent bus routes, and the terminus of the streetcar.
- **Less Continuity:** Northwest Medical Center is located in Casas Adobes, surrounded mostly by very low-density neighborhoods, and isn't very near any other major destinations. Any bus route that serves Northwest Medical pretty only serves Northwest Medical, or has to continue for 1.5 more miles to reach Foothills Mall. This makes it hard to justify more than one bus route nearby or a high-frequency service.

Because Banner University Medical Center is located near many other destinations, and Northwest Medical Center is more isolated, transit routes that serve Banner are useful to more people than routes that serve Northwest.

Figure 19: Banner University Medical Center is located immediately next to the University of Arizona, and is surrounded by miles of relatively dense development. Any route that serves this hospital serves many other destinations too.

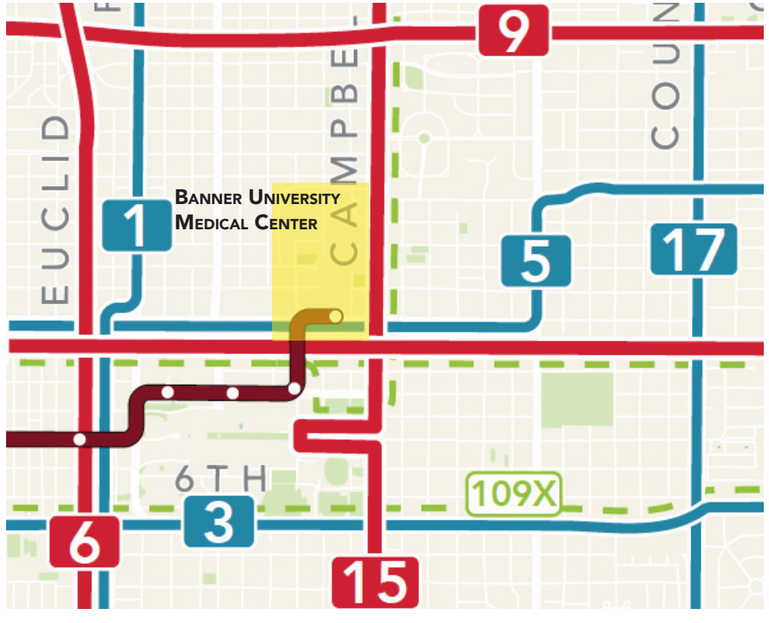
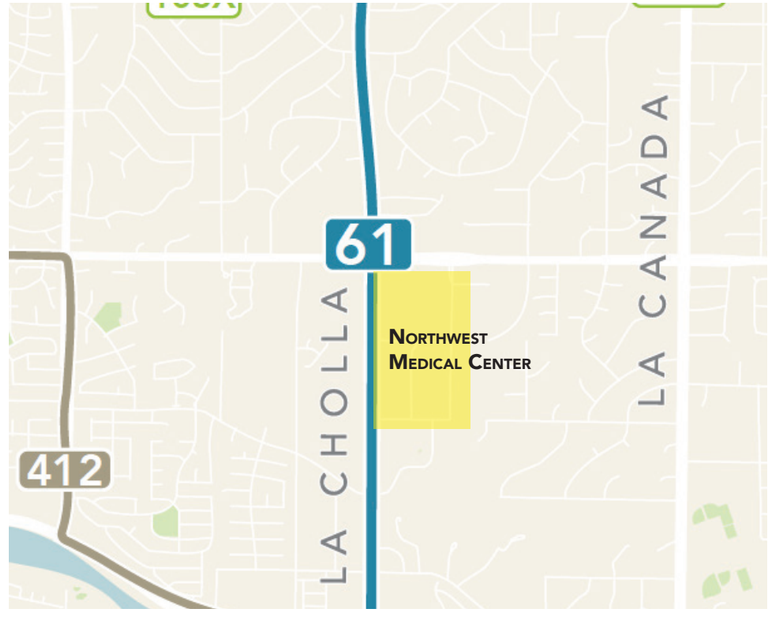


Figure 20: Northwest Medical Center is almost the same size, but there are fewer other destinations nearby, and development for miles around is at a much lower density. A route that serves this hospital doesn't serve much else.



3 What is the Market for Transit?

Indicators of Demand: Residential Density

This chapter presents an overview of maps displaying key measures of the market and need for public transit service in and near Tucson. It's important to distinguish between measures of transit demand and measures of transit need, since focusing on one or the other means focusing on different transit objectives.

Measures of transit demand focus on identifying the strongest overall ridership markets. This means focusing the most useful service on areas with high population and employment densities. Similar to how a retail business will locate near as many potential customers as possible, ridership-oriented transit will seek to offer service in places with the highest densities of potential customers.

Measures of transit need focus on identifying and locating disadvantaged populations, such as households without vehicles, people in poverty, and seniors. Many people in these categories will have a higher-than-average need for transit service. Understanding where those populations are located makes it possible to see whether a transit system is providing coverage equitably.

Locating disadvantaged populations is also useful from a civil-rights perspective. Pursuant to Title VI of the Civil Rights Act of 1964, transit agencies are required to ensure that their services do not discriminate on the basis of race, color or national origin and that service changes do not disproportionately impact minority and low-income populations.

Residential Density

Residential density is a key metric in assessing the strength of transit markets, since most people's daily travel behavior begins and ends at home. Figures 21 and 22 are maps of residential density in the Tucson region based on 2012-2016 American Community Survey (ACS) data.

From these maps, we can observe that there is a fairly continuous level of density in Tucson, South Tucson, Flowing Wells, and parts of the Northwest. Beyond this, there are isolated areas of residential density in Rita Ranch, Sahuarita, Green Valley and Oro Valley. However, other suburban areas generally have very low densities, especially in Tanque Verde, the Catalina Foothills and Marana.

It's important to understand that this map only represents one side of the travel market. The other half is where people go once they leave home, such as offices, schools, universities, retail, industries, recreational areas, houses of worship and other gathering places.

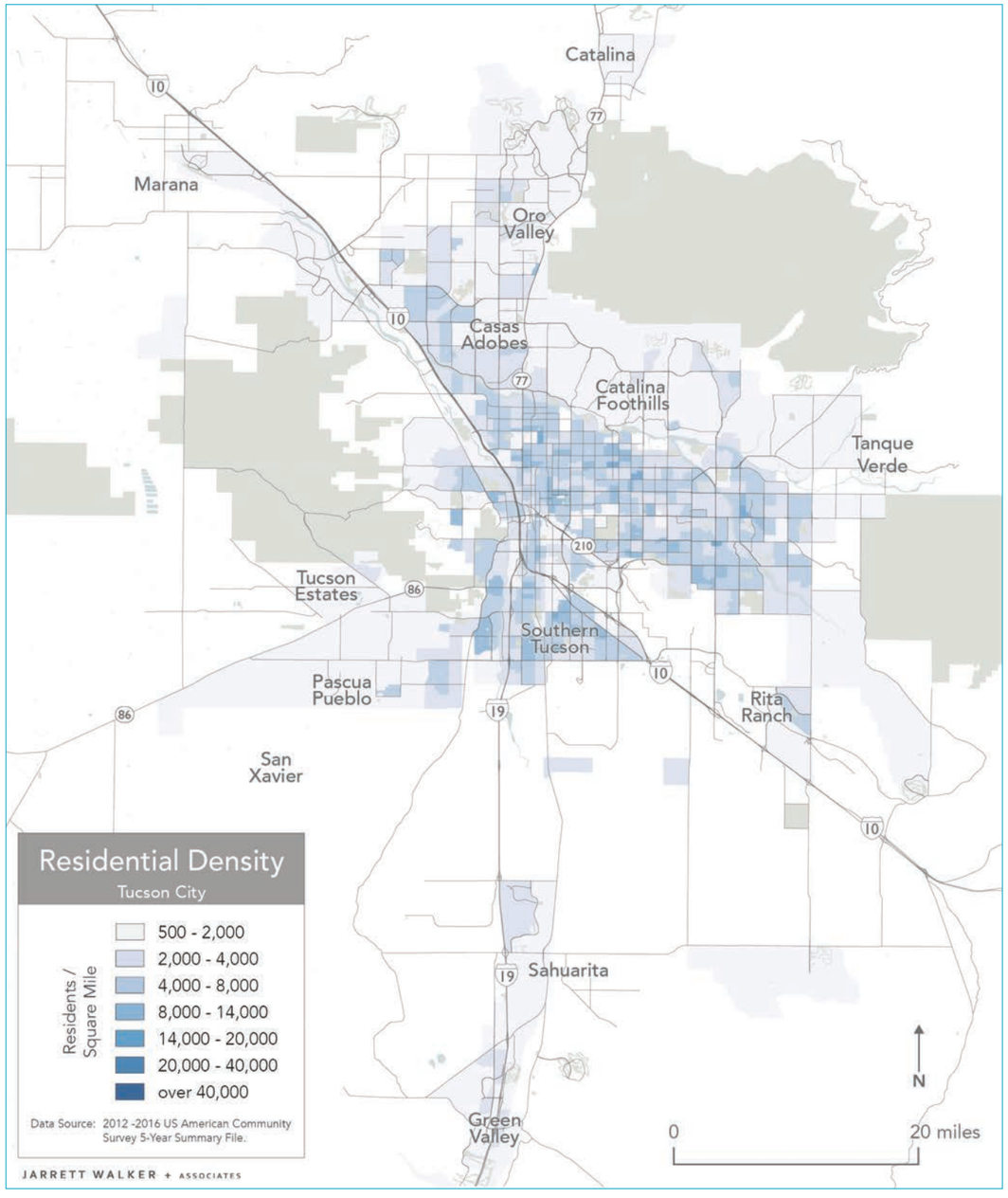
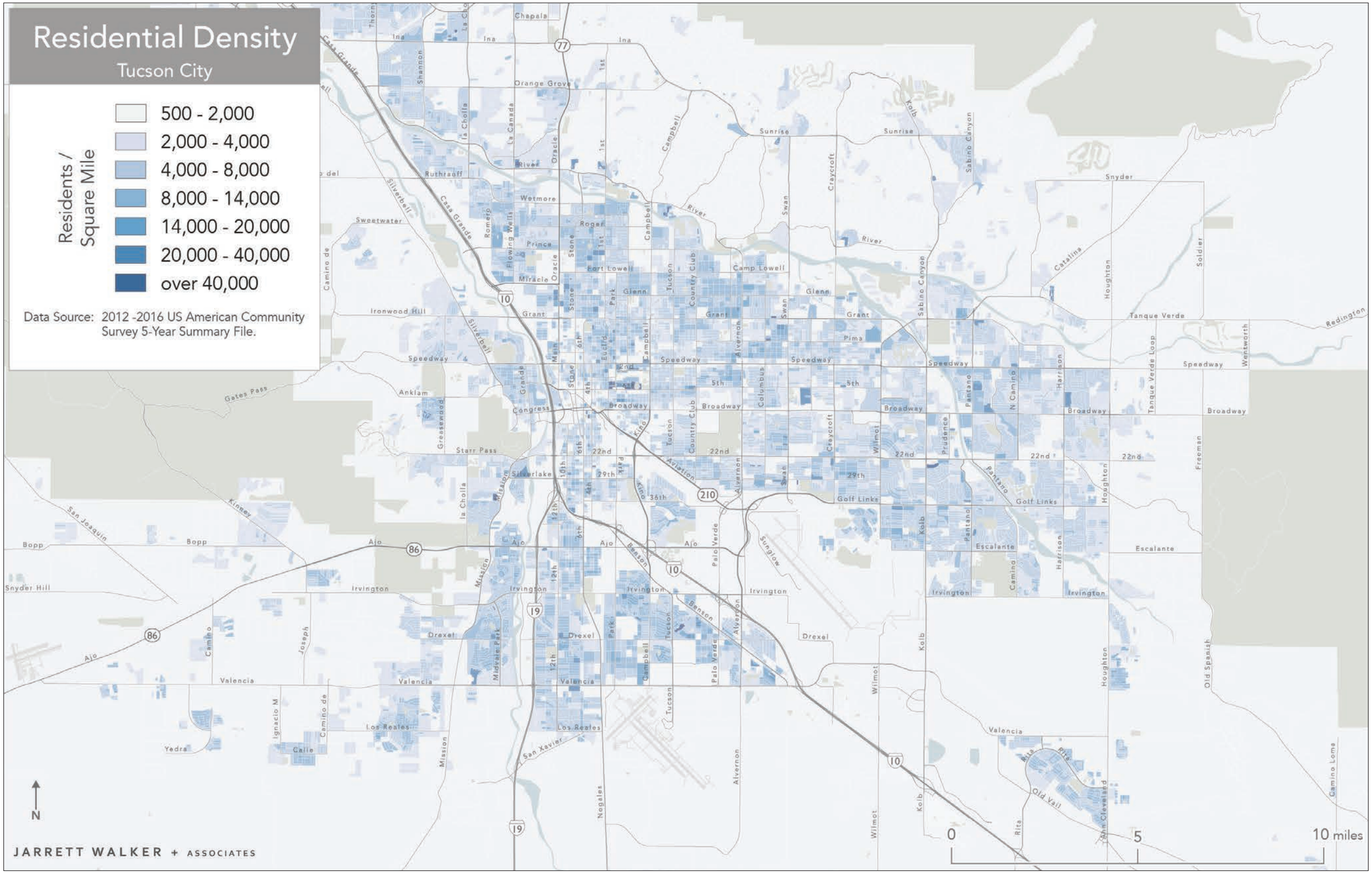


Figure 21: Residential density by census block group in the Tucson region.

Figure 22: Residential density by census block in and near the City of Tucson.



Employment Density

Examining employment density is a primary method of understanding the most important destinations people travel to. Employment doesn't just tell us about where people might be going to work. In the retail and service sectors, high employment density also indicates places that are likely to attract lots of customers.

The maps in Figures 23 and 24 show employment density in the Tucson region based on U.S. Census Longitudinal Employer Household Dynamics (LEHD) data from 2015.

The densest employment areas in the region by a significant margin are Downtown Tucson and the University of Arizona. Other significant concentrations of employment density visible on this map include:

- Hospital, office and retail employment in eastern Tucson, especially in the vicinity of Broadway Boulevard, Wilmot Road, and Speedway Boulevard.
- The I-10 industrial corridor in southern Tucson, and the vicinity of Tucson International Airport.
- The vicinity of Tucson Mall in north Tucson.
- Vicinity of Rita Ranch (UA Tech Park)
- Near Ina Boulevard in Casas Adobes (Foothills Mall).

Because this is a density map, but not a map of total jobs, many large employment sites are not immediately apparent. This indicates of the fact that such sites, while economically significant, are relatively isolated and hard to reach, making them difficult to serve by transit. Examples of such sites include:

- Davis-Monthan Air Force Base
- Arizona State Prison and U.S. Penitentiary
- Mission and Sierrita copper mines
- Multiple resorts on the edges of Dove Mountain, Tucson Mountain and the Catalina Mountains.

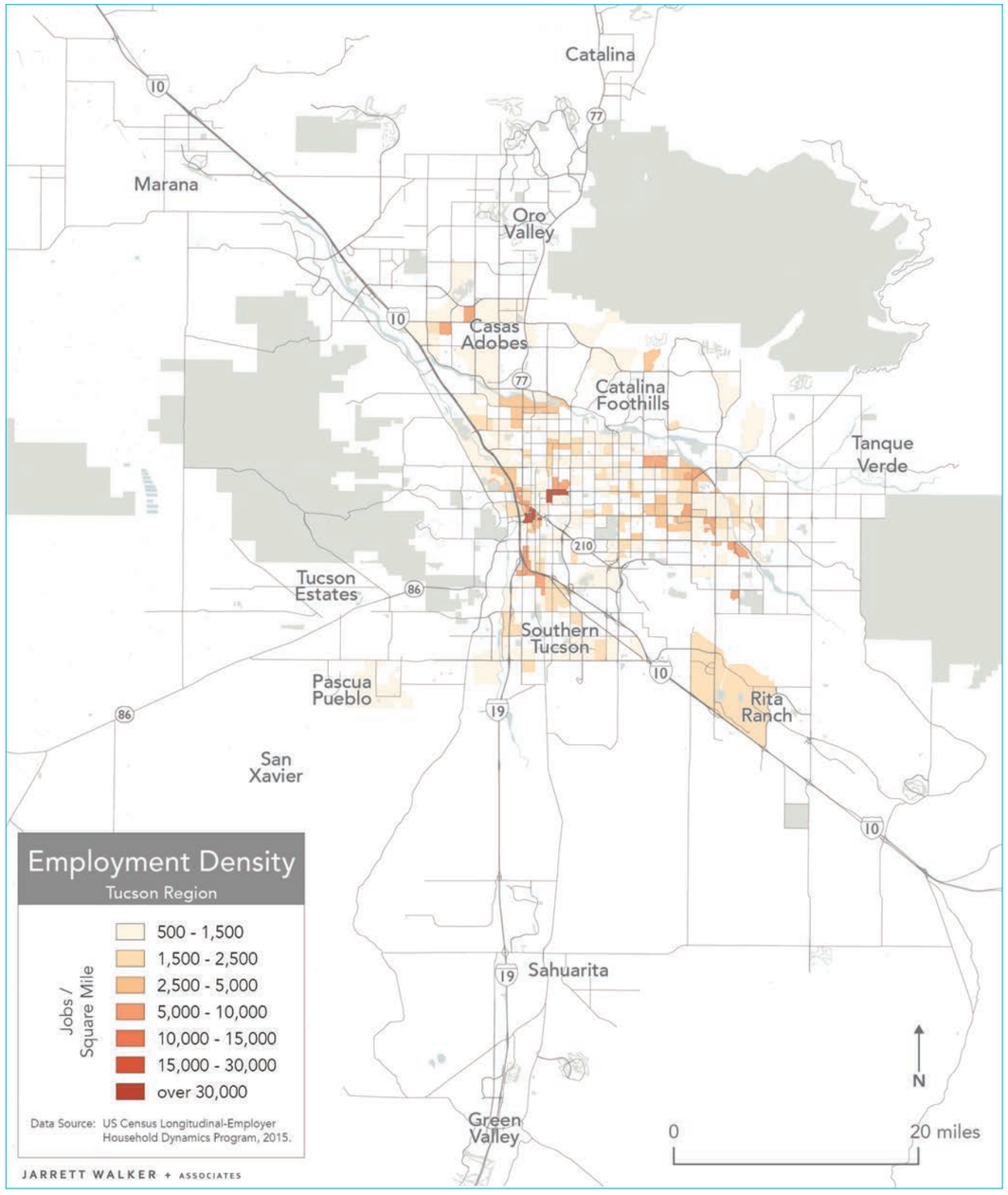
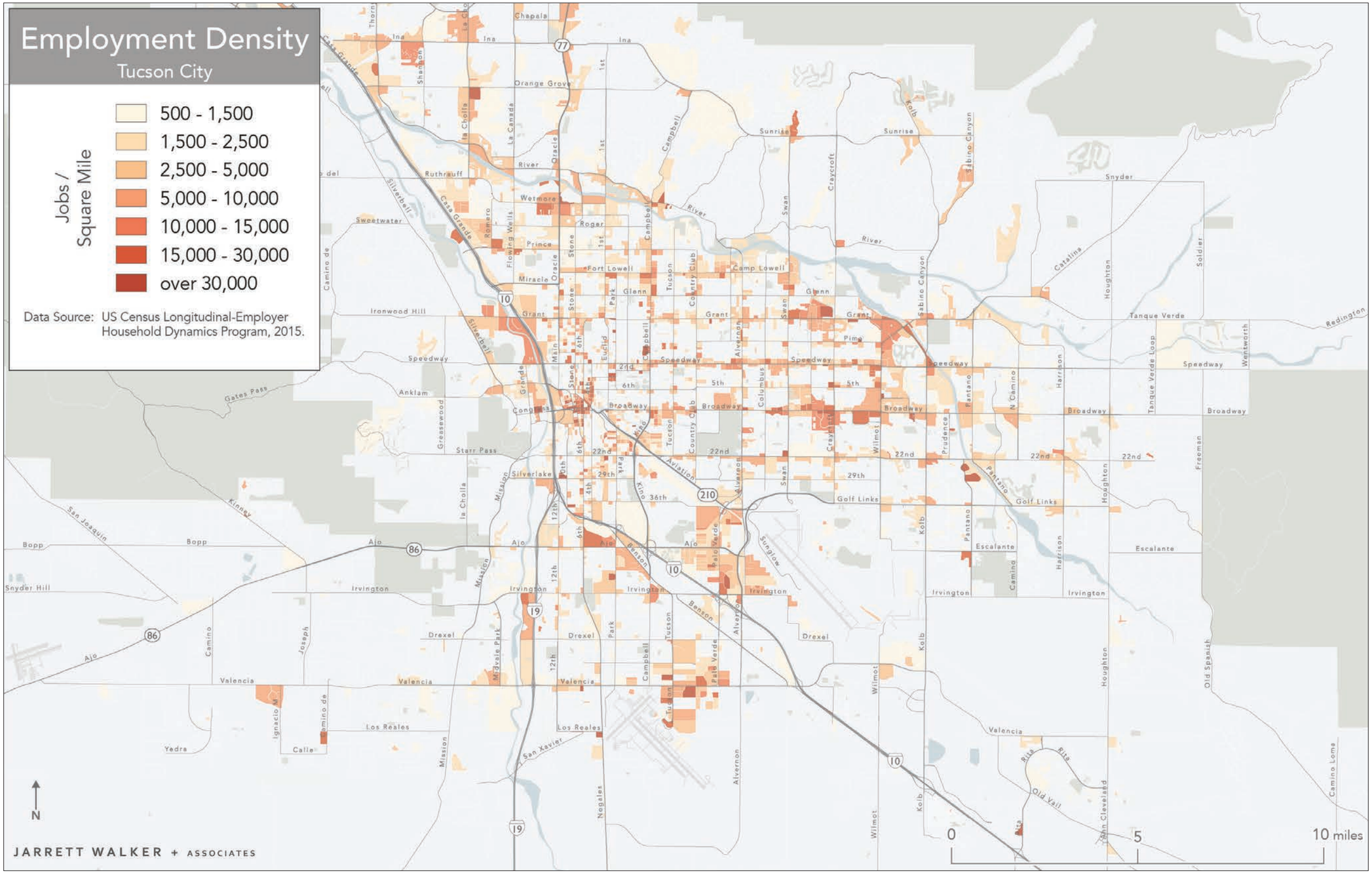


Figure 23: Employment density by census block group in the Tucson region.

Figure 24: Employment density by census block in and near the City of Tucson.



Activity Density

Figures 25 and 26 presents the combination of residential and employment density in the Tucson region. This gives us a more comprehensive view of travel demand in the metro area.

Most trips people make are between residences, workplaces, and major destinations and commercial areas. Overall travel demand is typically greatest where high residential and employment densities are found in combination. Places with a mixture of uses are more likely to have travel demands that are balanced throughout the day, compared to areas dominated by a single use.

On this map, places that are predominately residential are shown in increasingly saturated shades of blue. Employment is shown in yellow. Purple and orange signify places with varying degrees of mixed residential and employment density levels.

These maps show that:

- There is a high level of separation between residential and other uses in the Tucson region. The only significant area of mixed use is the vicinity of the University of Arizona. This may be changing slightly as Downtown Tucson redevelops along the streetcar, but the general pattern remains.
- Southern parts of Tucson (including areas in the City of Tucson, in South Tucson, and just outside city limits) have large continuous areas of high residential density combined with low employment density. In contrast, employment and residences are located much nearer each other in north Tucson. This suggests a strong demand for transportation from southern Tucson to areas north and east.

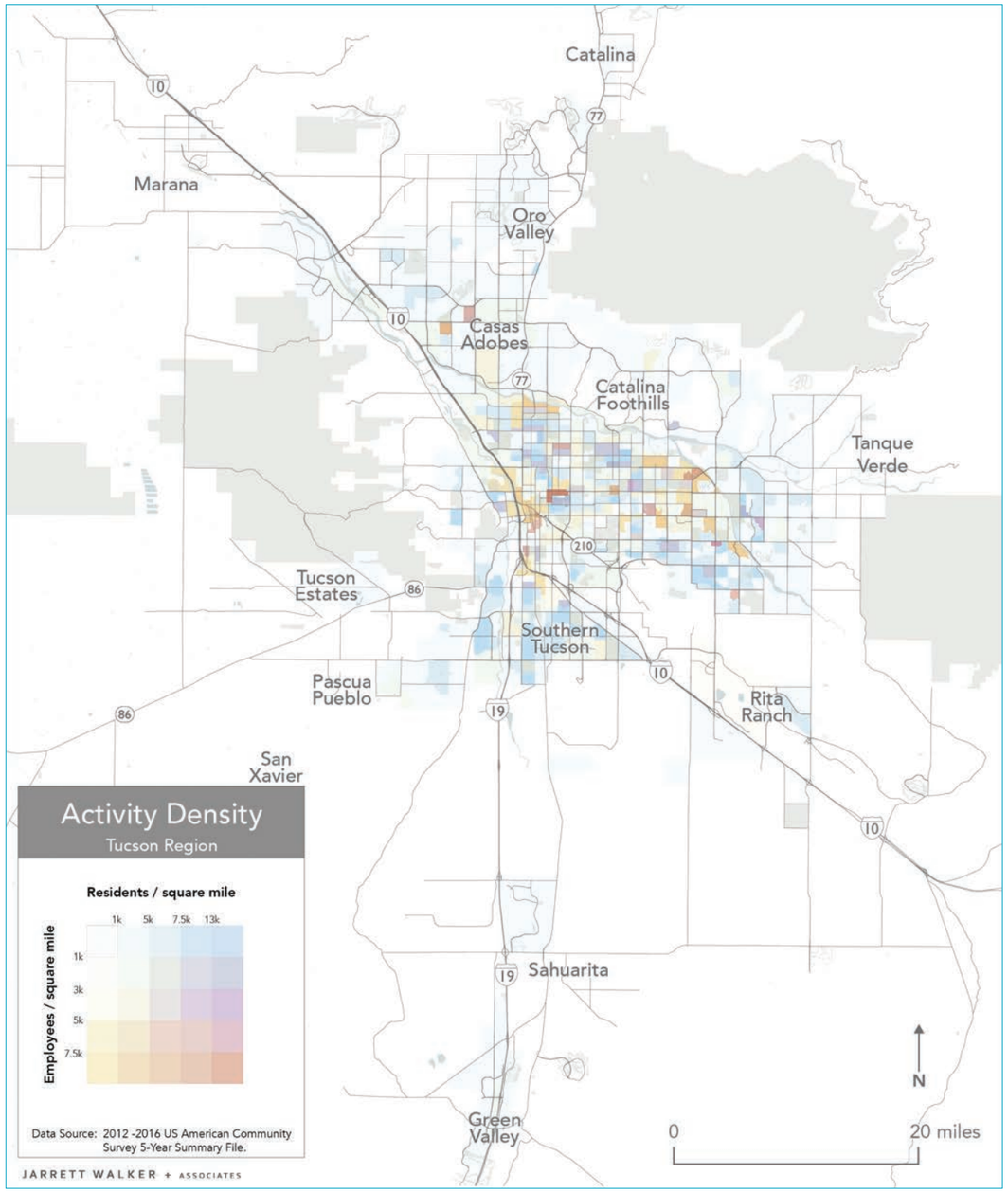
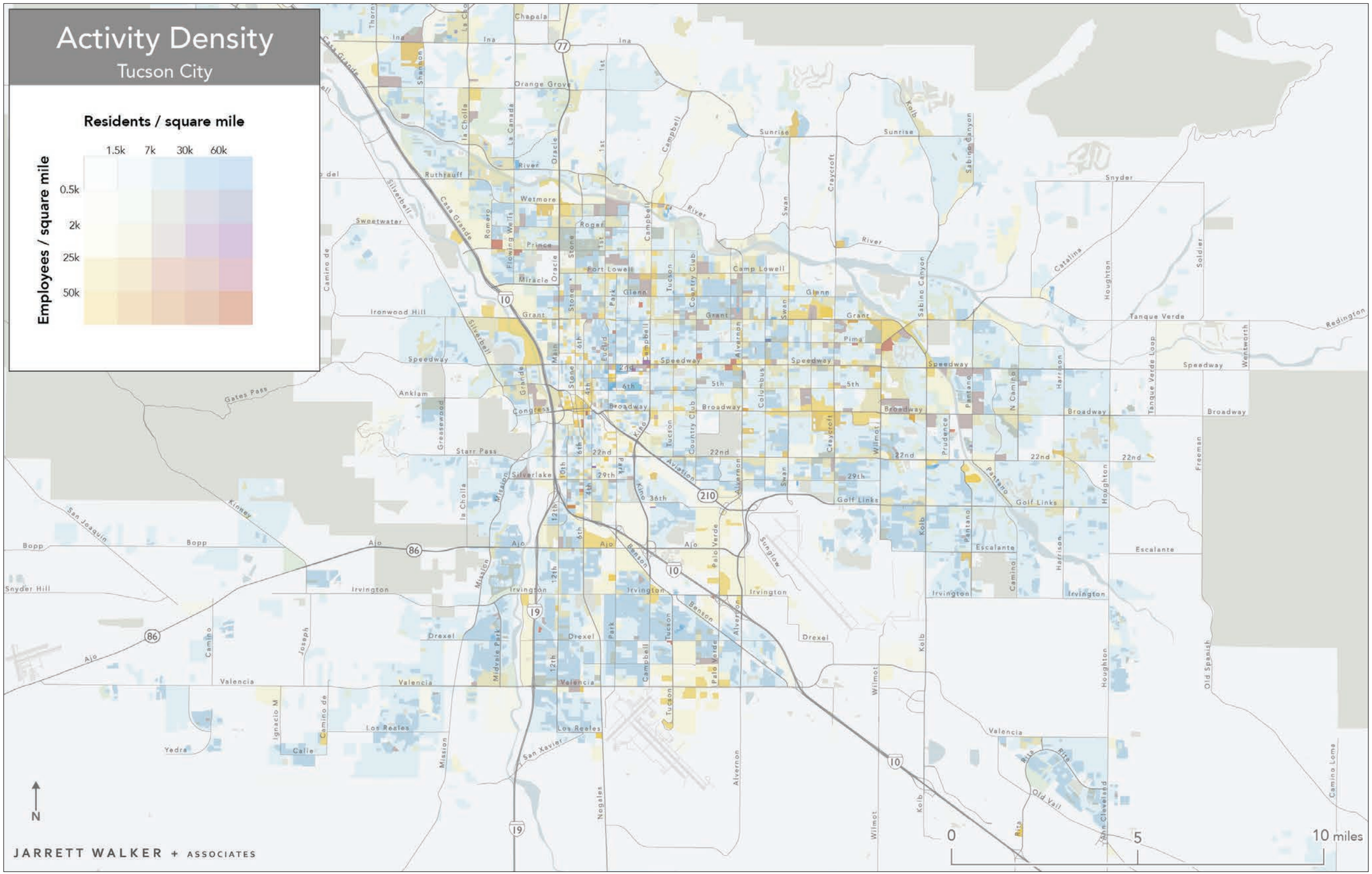


Figure 25: Activity density (residential and employment) by census block group in the Tucson region.

Figure 26: Activity density (residential and employment) by census block in and near the City of Tucson.



Existing Transit Commuters

Figures 27 and 28 shows the density of people reporting to commute by transit, as inferred by data from the 2012-2016 American Community Survey (ACS).

Existing transit commuting behavior is a good partial indicator of demand for transit. However, this data should not be construed as a measurement of transit use, for a variety of reasons:

- These map shows only the home end of work commute trips: the commuters captured by this data are all headed to work somewhere else, and will also generate demand there.
- The journey to work is only one of the average person's daily trips, and not everyone takes this trip. Commutes account for only 11.6% of trips in the Tucson region (although they do account for 26.5% of transit trips).
- Many people combine their commute with a variety of different purposes such as shopping, appointments, socializing, school, and many others. Transit can be useful for all of these.
- Existing transit riders are people who find the existing network more useful or practical than their alternatives. But transit accounts for only 1.5% of all trips in the Tucson region. This suggests that the majority of potential demand for transit, even transit commuting, is not represented by these maps.

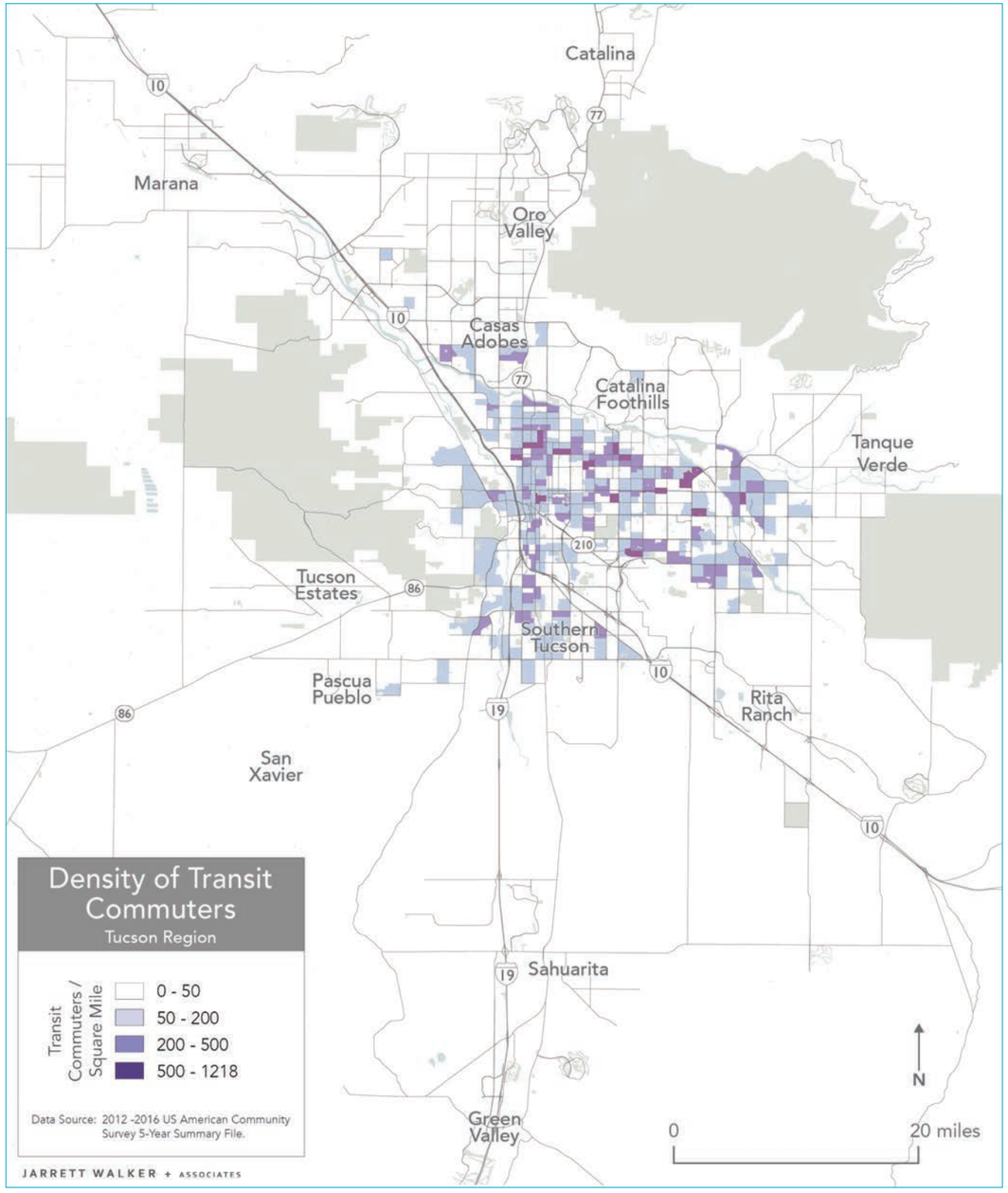
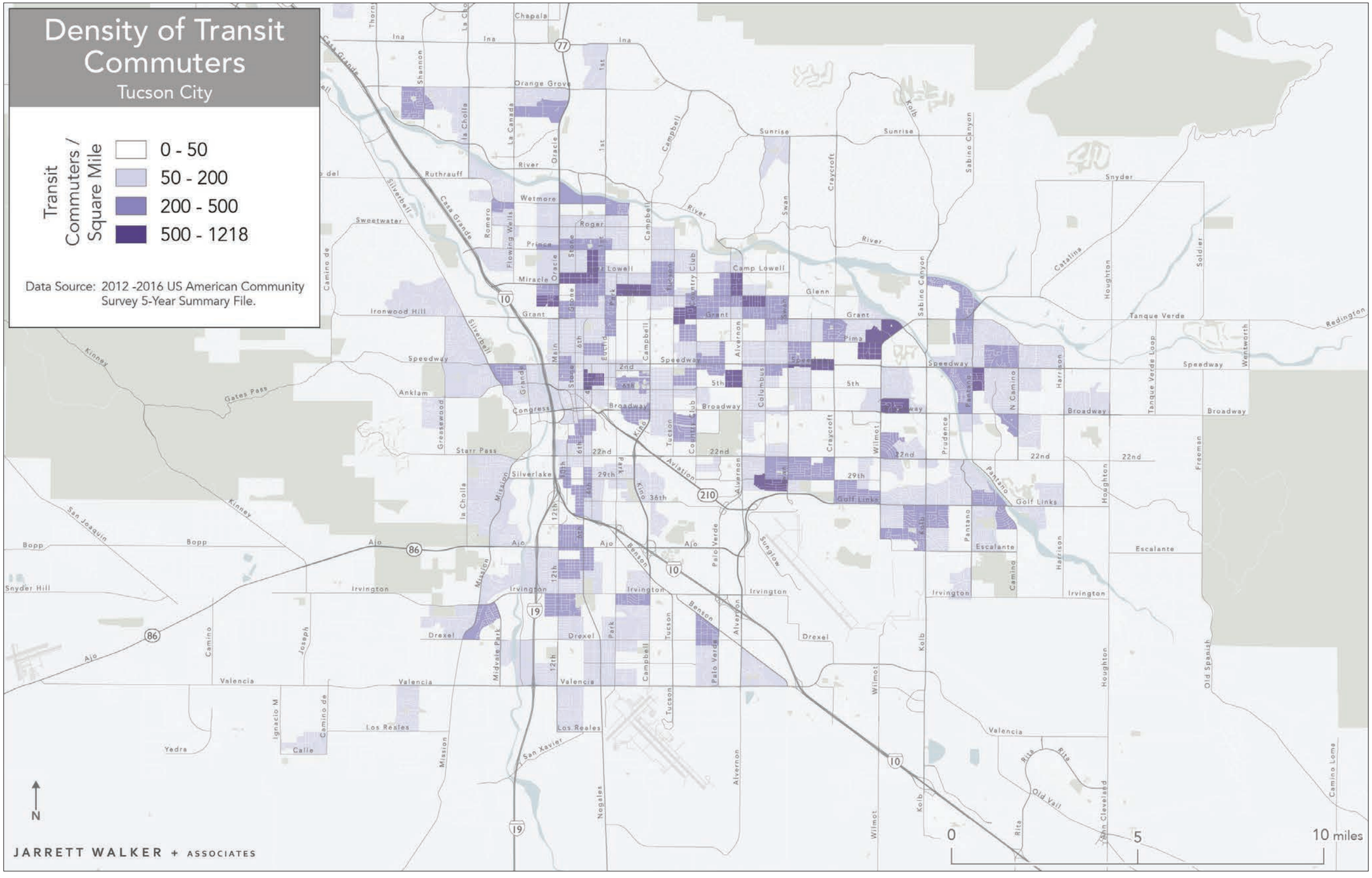


Figure 27: Density of transit commuters by census block group in the Tucson region.

Figure 28: Density of transit commuters by census block group in and near the City of Tucson.



Indicators of Need: Poverty

In many places, one of the most important goals for transit service is to provide an affordable transportation mode for lower-income people, who are less likely to own cars.

This is particularly important in a place like Tucson, where much of the potential demand for transit service consists of people with fewer cars than adults at home, but who don't find the current network useful enough for their needs.

In addition, understanding where low-income populations are located is a key civil rights requirement pursuant to Title VI regulations.

Transit can be an attractive option for low-income people due to the low price and low barrier to entry. In medium to high density areas, with walkable street networks, this can be a powerful ridership generator.

However, if transit isn't actually useful for the type of trips people need to make, in a reasonable amount of time, even lower-income people will not use it, if they have other choices. And they will seek other option, even if those other options cause personal or financial stress (e.g. driving a worn-out vehicle that breaks down frequently, or relying on friends and family for rides).

The majority of people in poverty in Tucson reside within a square bounded by Valencia Road to the south, Alvernon Way to the east, the Rillito River to the north, and Mission and Silverbell Roads to the west.

In Southeastern Tucson, there are also significant numbers of people in poverty living more or less between 22nd Avenue and Golf Links Road, between Alvernon Way and Wilmot Road.

Within all these areas, though, there are few areas of highly concentrated poverty; except in the most affluent areas, most neighborhoods feature a mix of incomes.

There are also people living in poverty in suburban and outlying areas, but they are generally more isolated in very small communities. As such, it is far more difficult for transit to reach them.

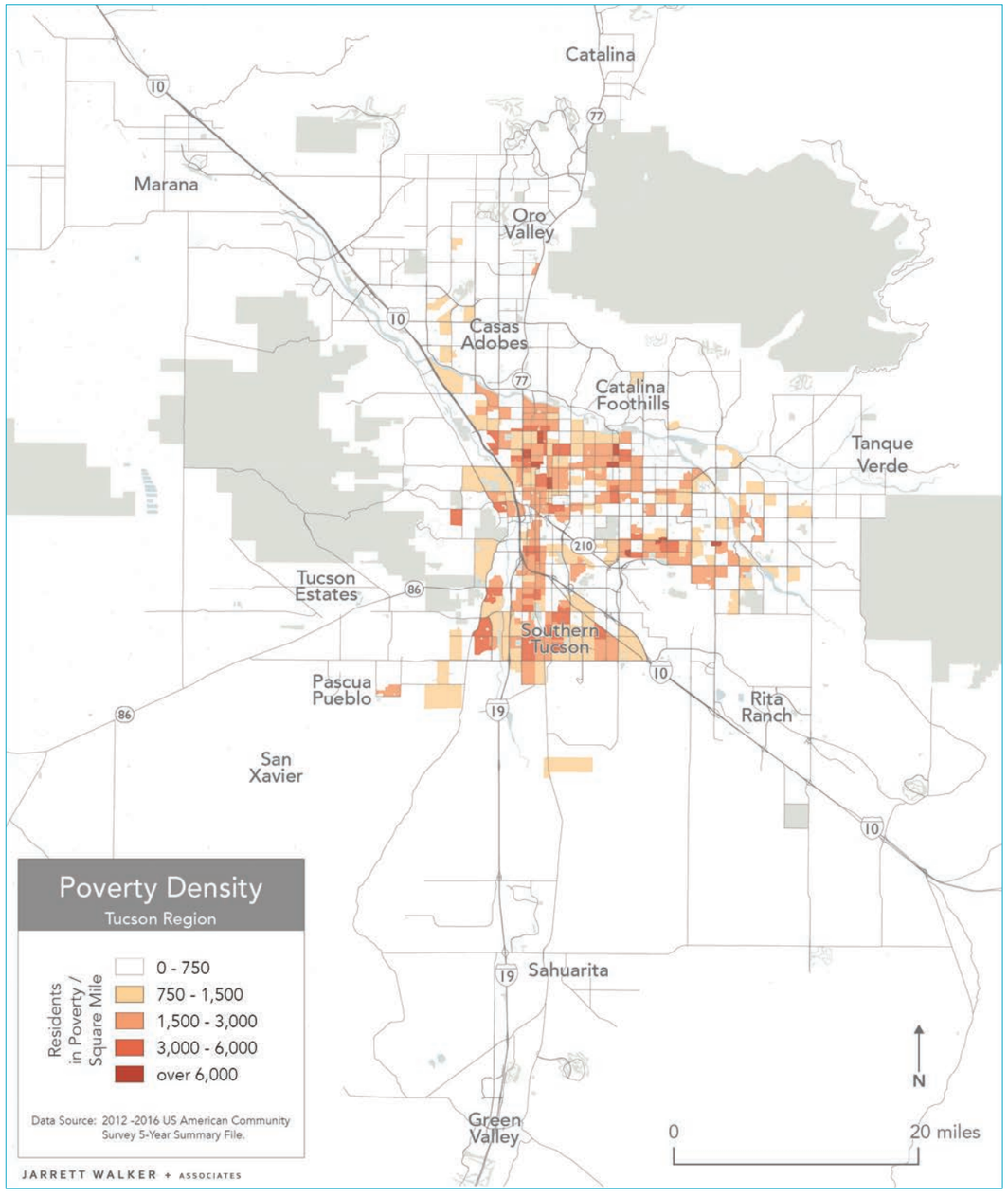
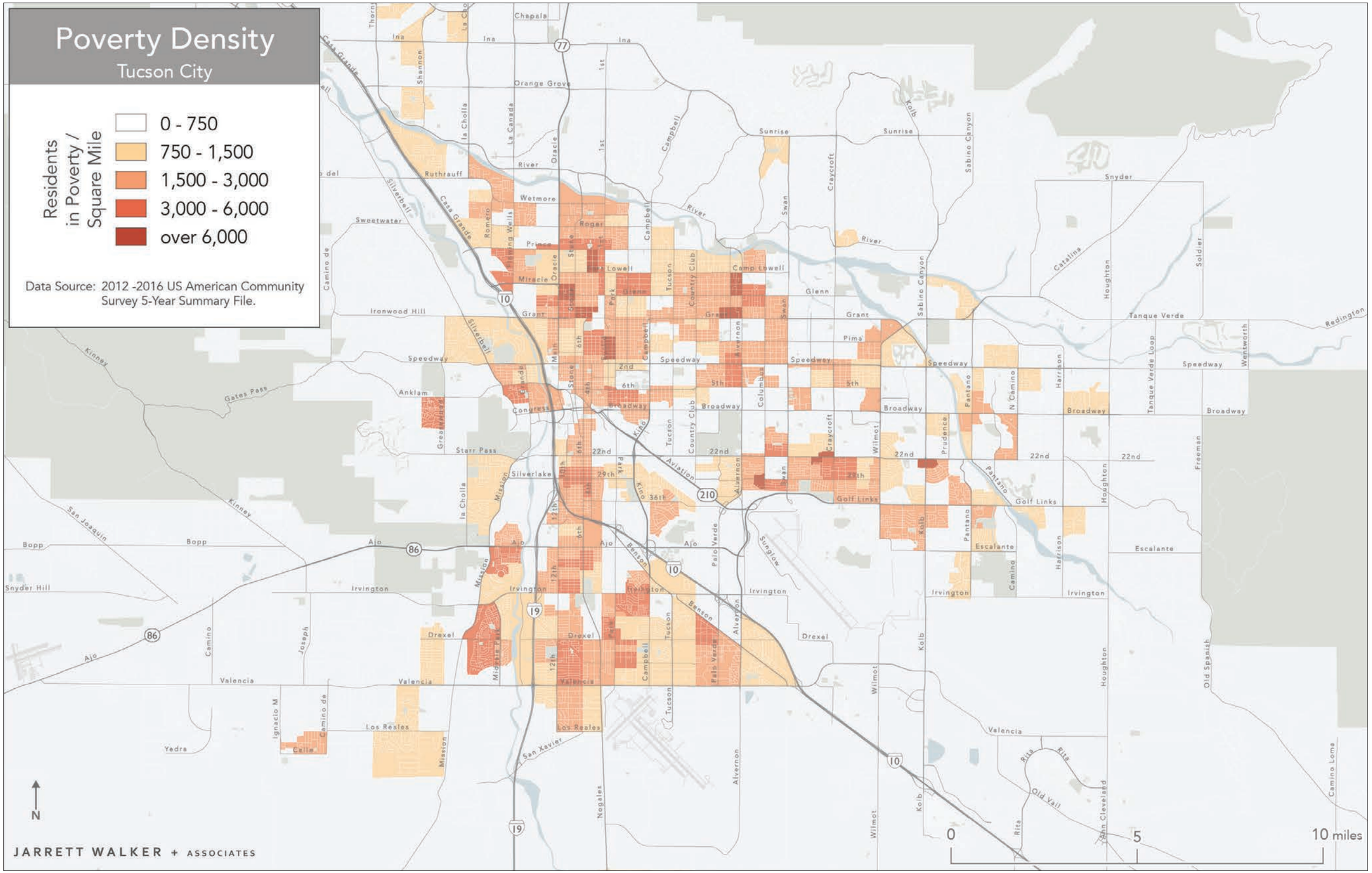


Figure 29: Density of residents in poverty by census block group in the Tucson region.

Figure 30: Density of residents in poverty by census block group in and near the City of Tucson.



Zero-Vehicle Households

Figures 31 and 32 are maps that show the density of households with zero vehicles, based on American Community Survey (ACS) 2012-2016 data.

While people who don't own cars don't use transit by default, they have fewer options than those people who do have access to personal vehicles. As a result, if transit is a useful (fast, reliable, available when they need to travel) method of reaching the places they need to go, it can be a compelling option.

If transit does not present a realistic travel option, then people without cars will find other ways of reaching the places they need to go, by getting rides from friends or family members, cycling, walking, or using taxis or ridesharing services.

The highest densities of zero vehicle households in the region are in southern Tucson south of I-10, and in the Flowing Wells area.

Two types of outlying areas have concentrations of zero-vehicle households:

- Places where many seniors live, such as Tucson Estates and parts of Green Valley.
- Places where there are many people in poverty, such as Pascua Pueblo,and scattered neighborhoods in the Northwest.

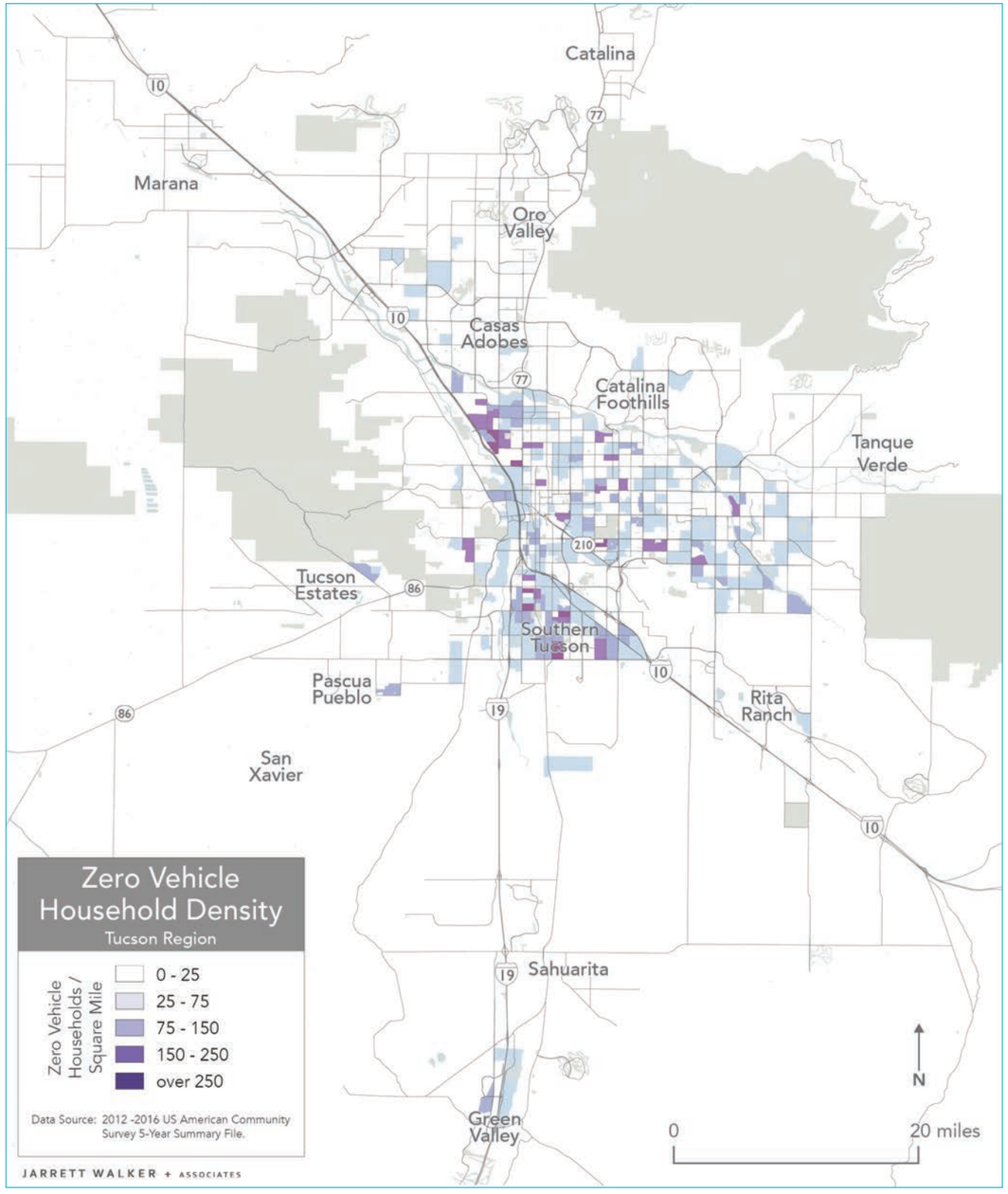
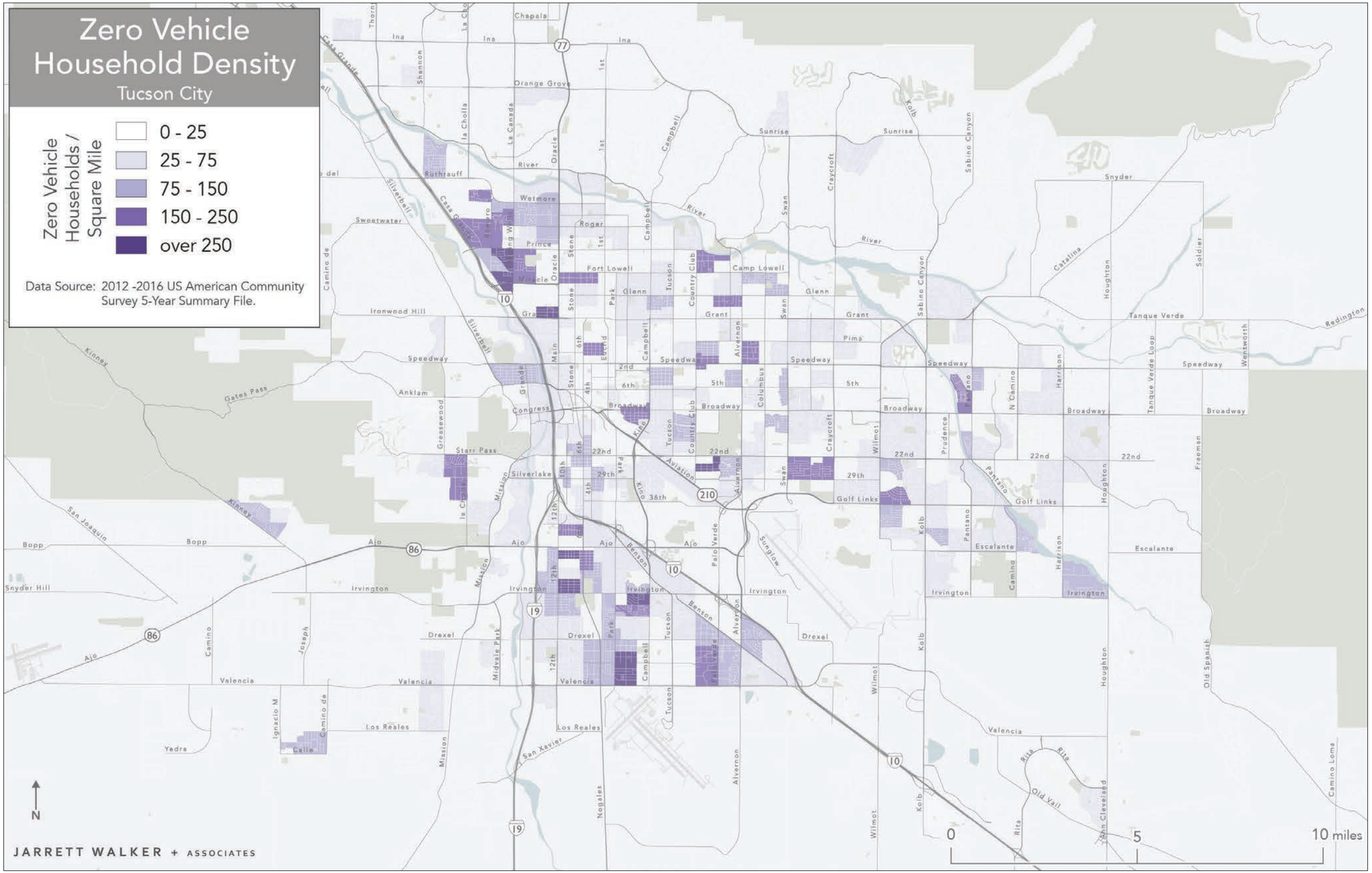


Figure 31: Density of households with no vehicles by census block group in the Tucson region.

Figure 32: Density of households with no vehicles by census block group in and near the City of Tucson.



Seniors

Seniors (persons age 65 and above) are an important constituency for transit. Seniors constitute 17% of the total population in the Tucson urbanized area, and this percentage is increasing over time.

As a demographic group, seniors are less likely to own cars than the general population, a built-in advantage for transit in places where the other preconditions for high ridership (density, walkability) are present.

However, seniors tend to be more spread out in far suburban and outlying areas than the general population, so many are in locations where it is difficult or expensive to provide useful transit service.

Figures 33 and 34 show how senior residents are spread out in the Tucson region, based on American Community Survey (ACS) 2012-2016 data.

Significant numbers of seniors live in all parts of the Tucson area, but there are clear concentrations of senior communities in outlying areas, such as in:

- Green Valley
- Tucson Estates
- Trails West (south of Rita Ranch)
- Far eastern parts of the City of Tucson

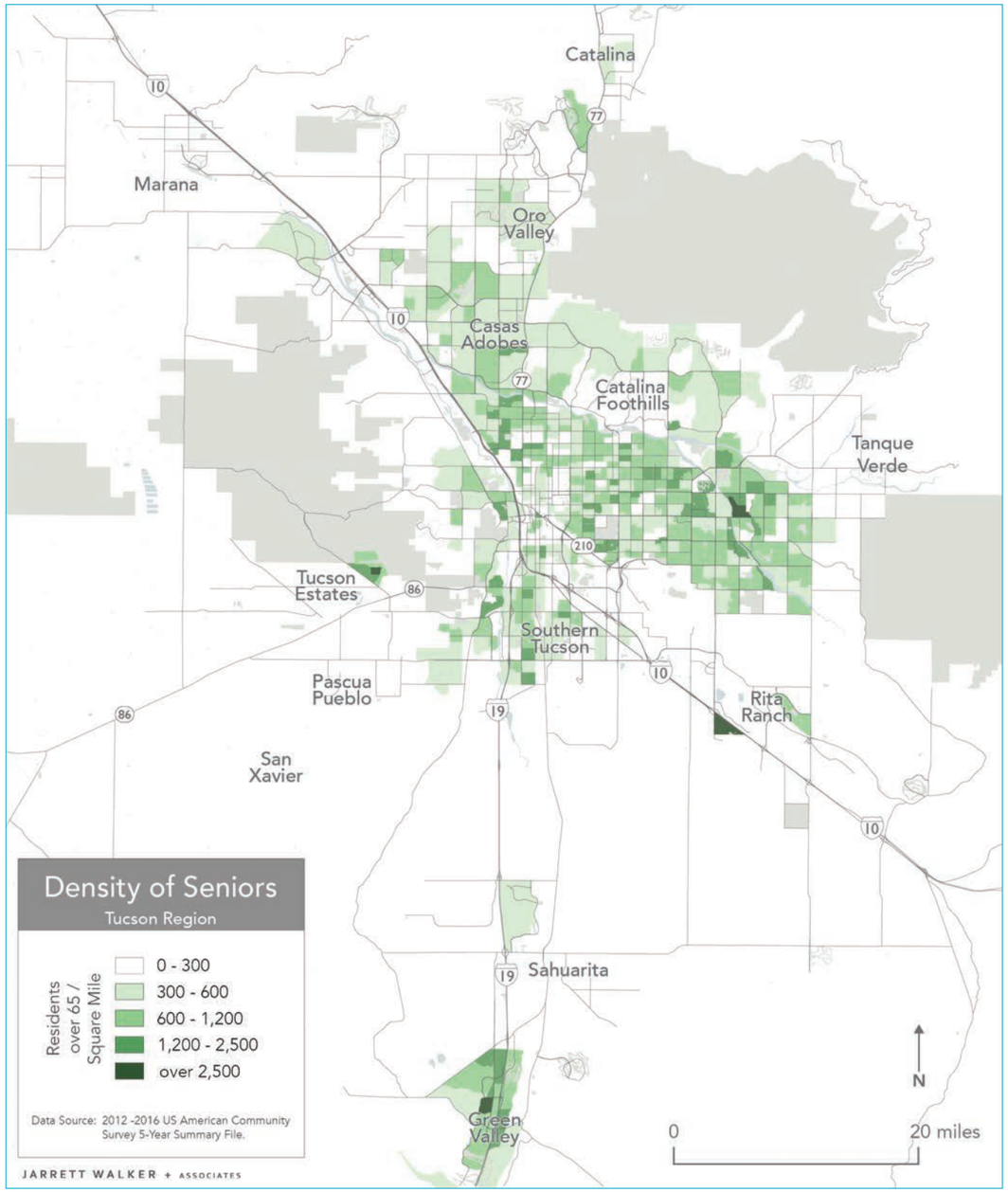
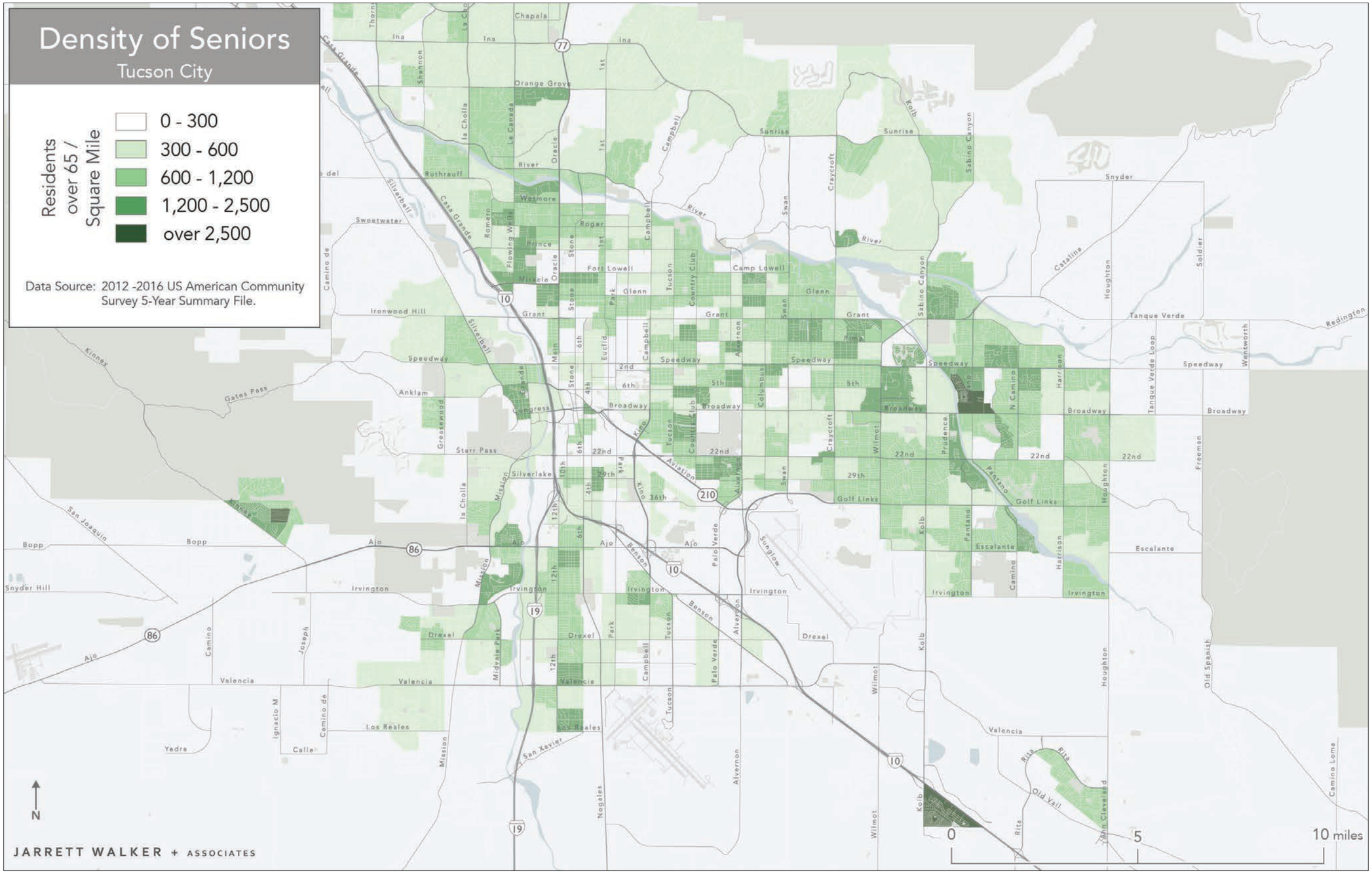


Figure 33: Density of senior residents (ages 65+) by census block group in the Tucson region.

Figure 34: Density of senior residents by census block group in and near the City of Tucson.



Indicators of Civil Rights: Minorities

There is no direct link between race, ethnicity and the likelihood to use public transit. Nonetheless, transit agencies are required by Title VI of the Civil Rights Act of 1964 to ensure that the services they provide do not discriminate on the basis of race, color or national origin.

All agencies are also required to adopt measurable policies to show that no major service change should disproportionately impact non-white populations. For this reason, it is useful to understand where minority populations are located.

The maps in Figure 35 and 36 show how different racial and ethnic groups (as defined by the U.S. Census Bureau) are distributed across the Tucson region. These are dot-density maps, where 1 dot is equal to 50 people. The number of people of each race/ethnicity in each census block group is determined based on American Community Survey (ACS) 2012-2016 data.

38% of the population of the Tucson urbanized area identifies as Hispanic, and these maps show a very distinct concentration of Hispanic populations in southern Tucson and adjacent areas, such as the vicinity of the Pascua Yaqui and San Xavier reservation lands.

There are also significant minority populations of multiple backgrounds in north Tucson, Flowing Wells, and to a lesser extent in the Northwest.

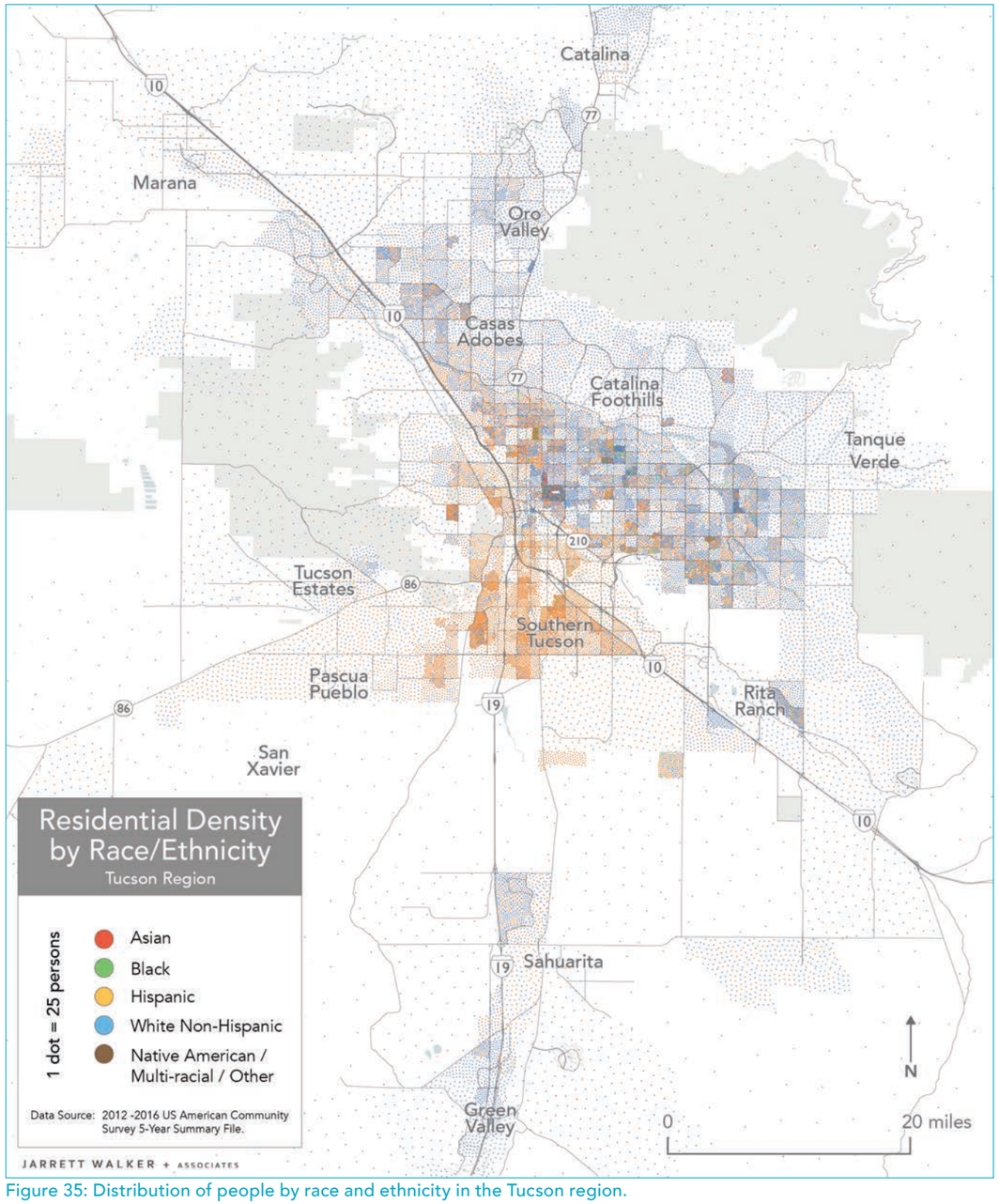
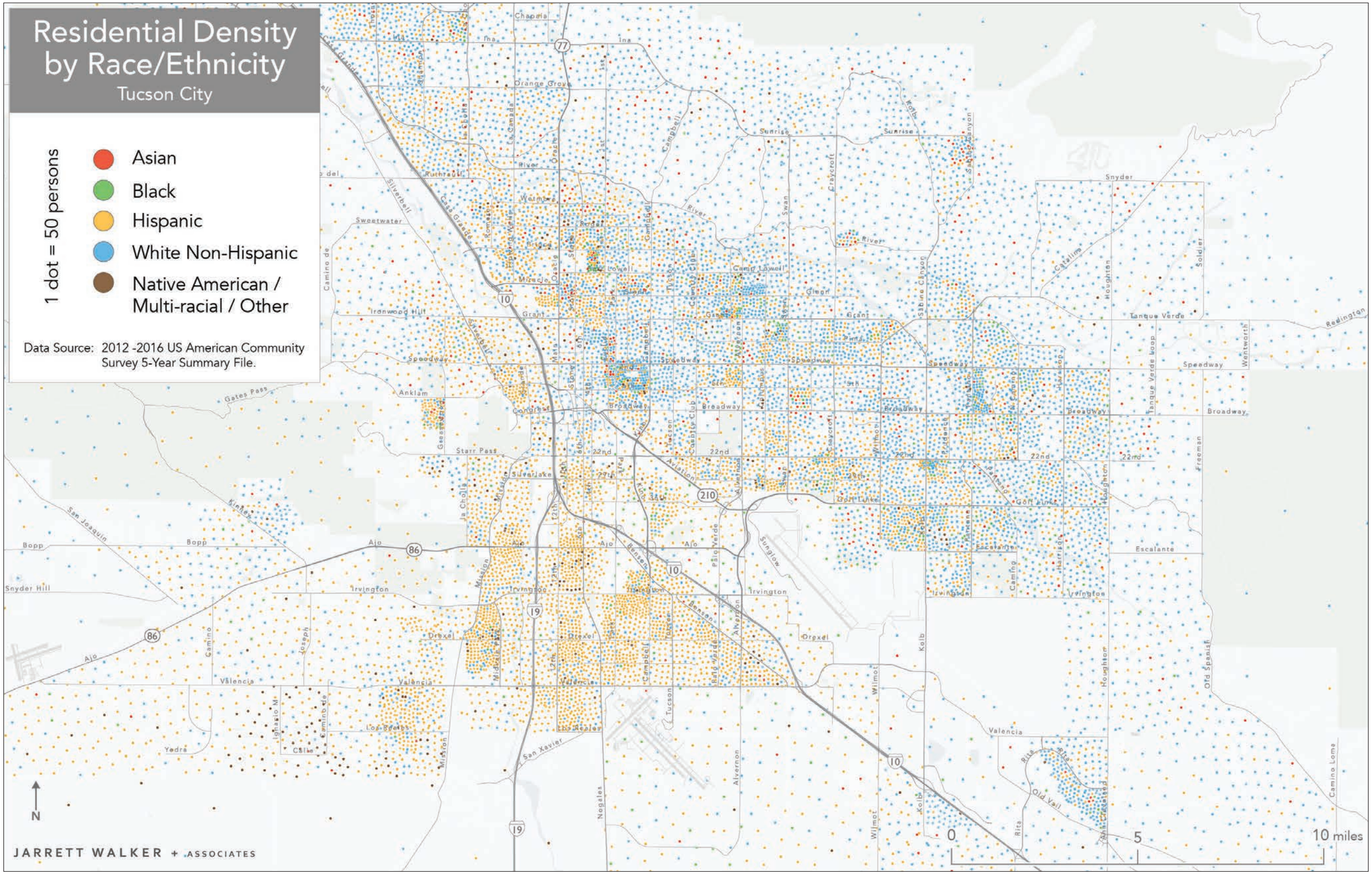


Figure 35: Distribution of people by race and ethnicity in the Tucson region.

Figure 36: Distribution of people by race and ethnicity in and near the City of Tucson.



4 How do Existing Services Perform?

Description of the Transit Network

In this chapter, we will focus on the characteristics, performance and competitiveness of the Tucson region's network fixed-route transit network. We will be specifically discussing the service provided under the following brands:

- **Sun Tran**, the City of Tucson's bus transit system.
- **Sun Link streetcar**, operating between Downtown Tucson and the University of Arizona.
- **Sun Shuttle**, the Regional Transportation Authority (RTA)'s transit shuttle system that provides connections from outlying areas to the Sun Tran network.

These are not the only public transportation services in the region, but they are intended to function as a single network, and they account for over 96% of all ridership.

Other public transportation provided in the region includes ADA paratransit service provided by Sun Van and Sun Shuttle. Sun Shuttle also provides general-public demand-responsive service in Oro Valley and Sahuarita/Green Valley, and in the vicinity of Route 410 in Marana.

In describing the fixed-route network, we will focus on the factors that control how the network provides access to useful destinations. This means we will often refer to frequency, as this is the single most powerful factor affecting how far people can reliably travel within a given amount of time, and the difference in travel time between transit relative to cycling or driving.

Transit frequency determines how long a passenger must wait to board a bus or make a transfer to another route. With more frequent services, the "worst-case scenario" wait (if the bus just passed by less than a minute ago) is shorter; as a result, frequency also helps improve the customer experience of reliability.

The maps in Figures 36 and 37 show transit routes in the Tucson region organized and displayed by their weekday daytime frequencies.

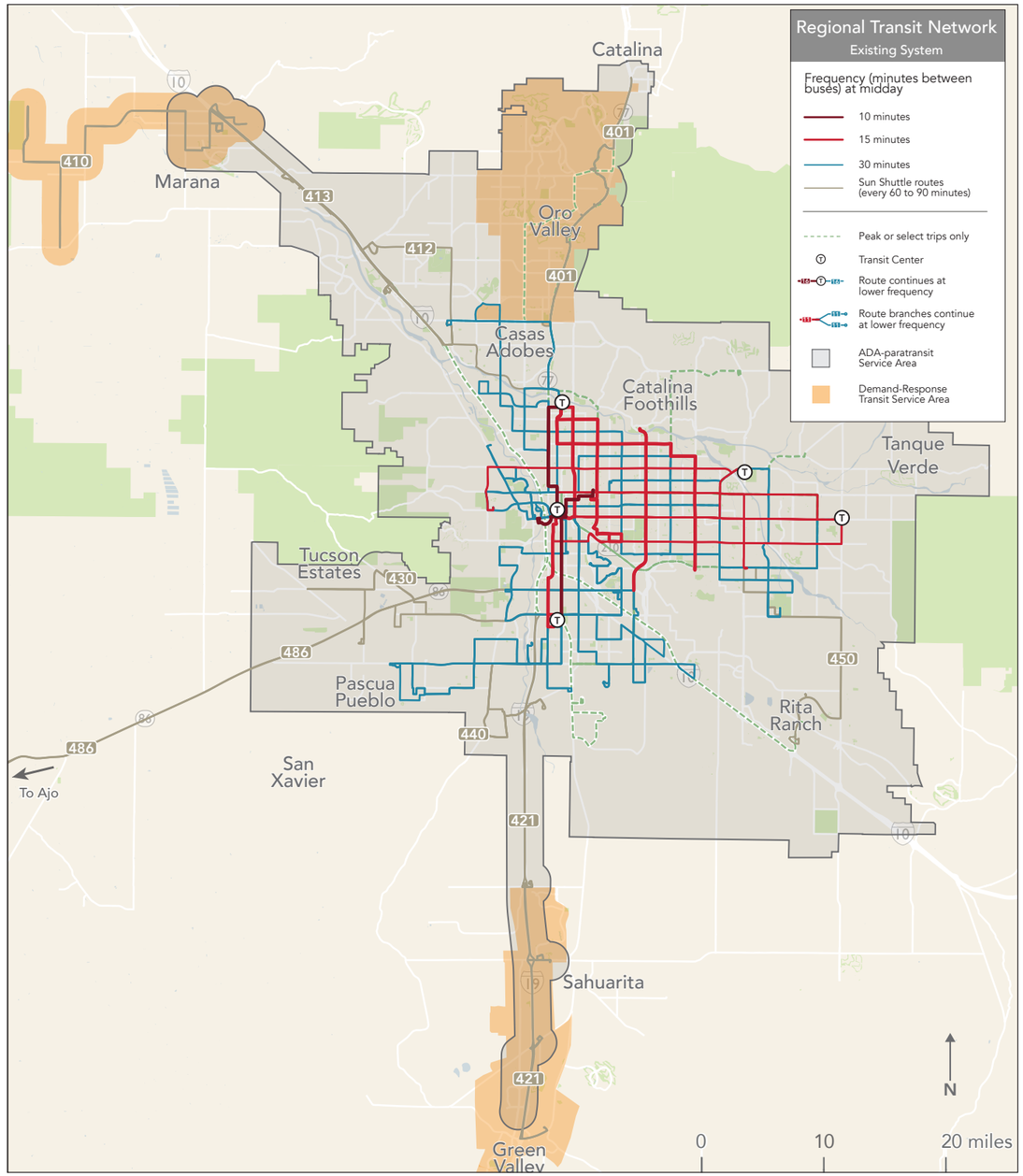
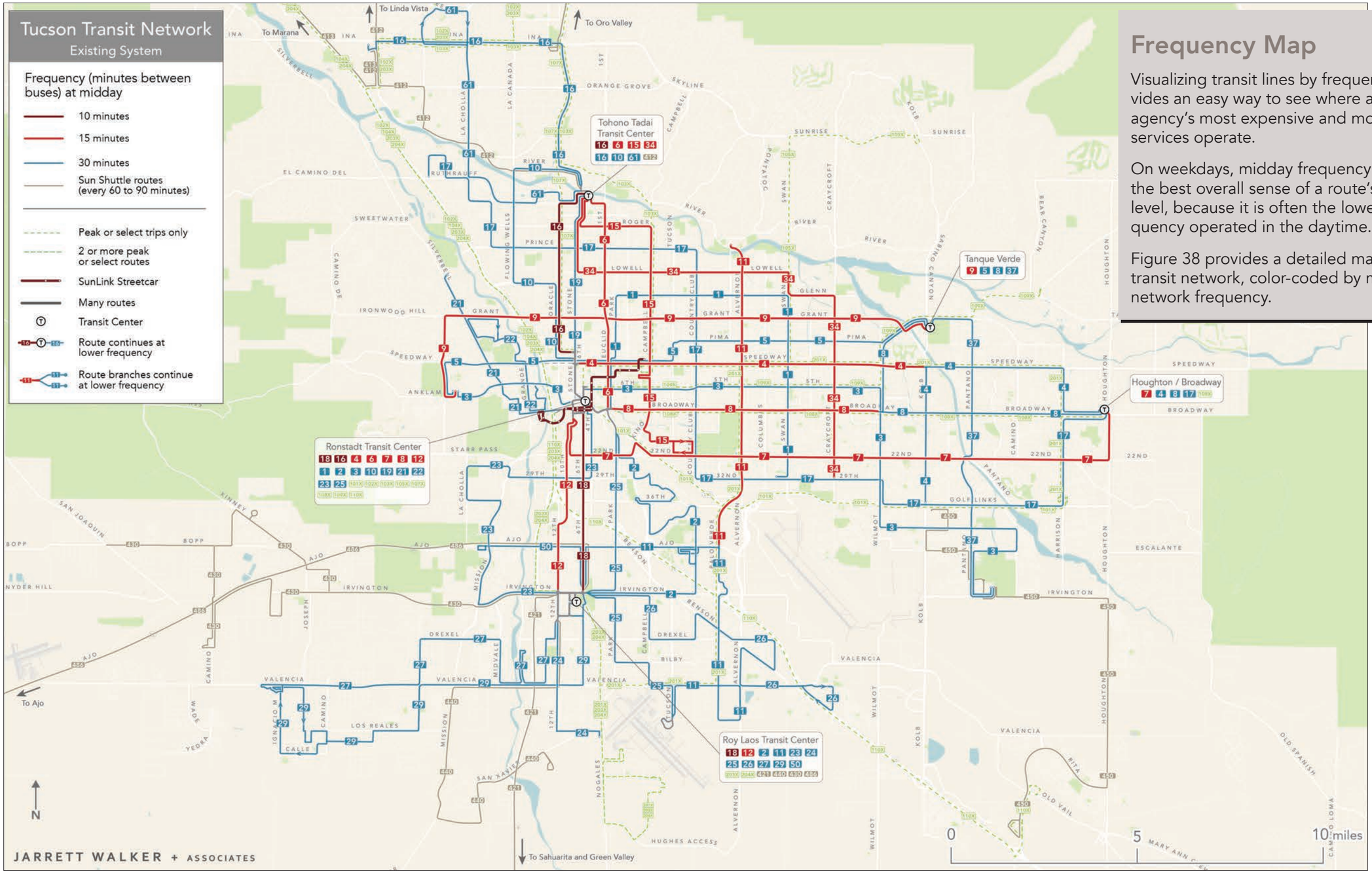


Figure 37: Map of public transit services and their weekday midday frequencies in the Tucson region.

Figure 38: Public transit network and midday weekday frequencies in and near the City of Tucson.



Frequency Map

Visualizing transit lines by frequency provides an easy way to see where a transit agency's most expensive and most useful services operate.

On weekdays, midday frequency provide the best overall sense of a route's service level, because it is often the lowest frequency operated in the daytime.

Figure 38 provides a detailed map of the transit network, color-coded by midday network frequency.

Network Layers

Transit routes in the Tucson region are explicitly branded and organized according to their frequency. Each tier of frequency acts like a different layer in the network. There are four of these tiers: the Frequent Transit Network, 30-minute routes, peak-only routes (Sun Tran Express), and Sun Shuttle.

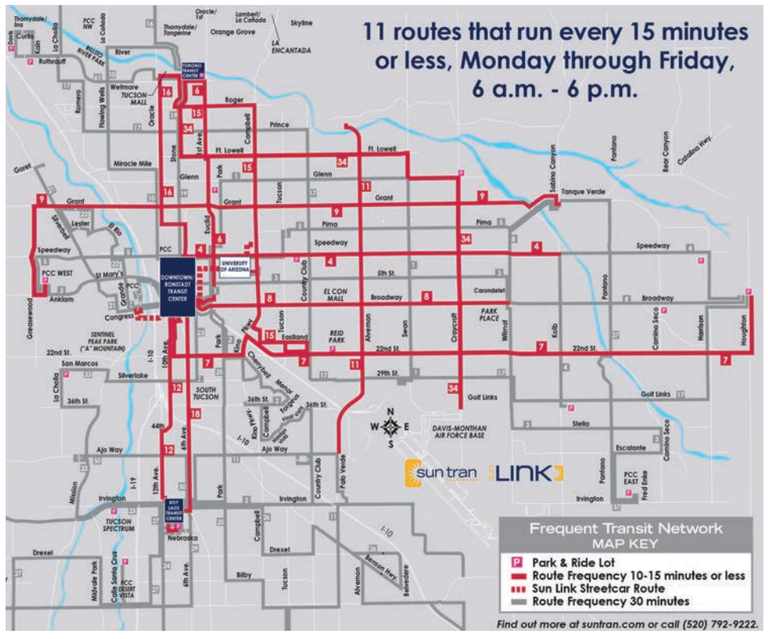


Figure 39: Sun Tran Frequent Transit Network (FTN) map.

Frequent Transit Network (FTN)

Tucson's Frequent Transit Network includes the most frequent services operated by Sun Tran as well as the Sun Link streetcar. **The FTN is a brand and service distinction: all FTN routes provide service every 15 minutes or better from 6 AM to 6 PM on weekdays.**

In recent years, Sun Tran has made the Frequent Transit Network brand an increasingly central element of its customer information, and now publishes a separate Frequent Transit Network map (see Chapter 1, Figure 3) in addition to its general system map and other materials.

The Frequent Network includes the following routes:

- Sun Link Streetcar
- 4-Speedway
- 6-Euclid/North 1st Ave
- 7-22nd St
- 8-Broadway
- 9-Grant
- 11-Alvernon
- 12-10th / 12th Ave
- 15-Campbell
- 16-Oracle / Ina
- 18-South 6th Ave
- 34-Craycroft / Ft Lowell

On a typical weekday, **the FTN (including less frequent branches) provides about 53% of service hours provided in the network, and attracts 64% of total ridership**, based on data from March 2018.

Not all FTN routes are equal, though. The streetcar and Routes 8, 16 and 18 are distinct in providing more service than others: they remain frequent on Saturdays, provide service every 20 minutes on Sundays, and every 30 minutes or better in the evening.

Conversely, Routes 7, 9, 15 and 34 provide distinctly less evening and weekend service than other parts of the FTN. Evening and weekend service on these routes drops to every 60 minutes.

Infrequent Routes

30-Minute Routes

In addition to the FTN, Sun Tran also operates 18 less frequent all-day routes across Tucson, Flowing Wells, Casas Adobes and Drexel Heights. These routes mostly operate every 30 minutes on weekdays, and every 60 minutes on evenings and weekends.

These infrequent routes serve different functions, depending on their locations:

- In close in neighborhoods of east and north Tucson, 30-minute routes fill in the gaps in the grid between routes on the Frequent Transit Network. With the notable exception of Route 19-Stone, these routes generally have significantly lower ridership than nearby frequent routes.
- Anywhere south of 22nd Street, as well as in Flowing Wells and parts of Casas Adobes, 30-minute routes provide basic coverage to areas that are far from any frequent service. Many of these routes have ridership levels comparable to routes on the Frequent Transit Network.

Peak-Only Routes (Sun Tran Express)

Sun Tran also operates several rush-hour-only express commuter services like the 101X and 110X which provide direct, limited-stop commute options to high-demand employment areas, such as Downtown Tucson, the University of Arizona and Aero Park. These routes offer a limited number of trips for 2 or 3 hours across each peak period.

Regional Routes (Sun Shuttle)

The Sun Shuttle system focuses on routes that connect areas in suburban and outlying areas to the Sun Tran network. Most Sun Shuttle routes operate every 90 minutes, from about 6 AM to 6 PM on weekdays only.

As a result, these routes don't make up a very large portion of either the system's ridership or service offering, but they do represent a critical connection and mobility option for people living in places that are otherwise only accessible by personal or for-hire auto transportation.

Evening and weekend service is much less than weekday service.

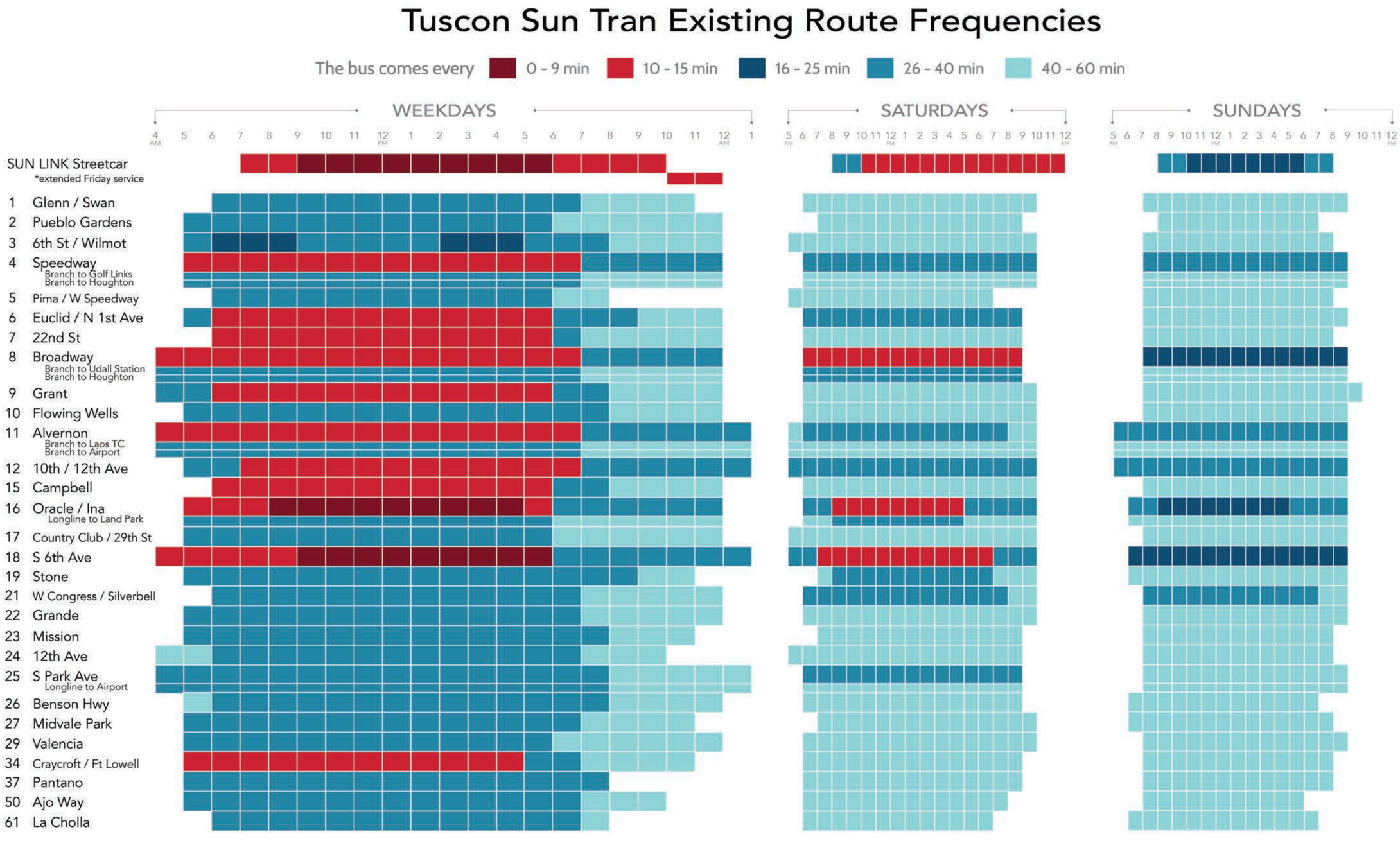


Figure 40: Frequency table by day and hour for Sun Link and Sun Tran all-day routes.

Sun Tran Express Routes & Sun Shuttle Existing Frequencies

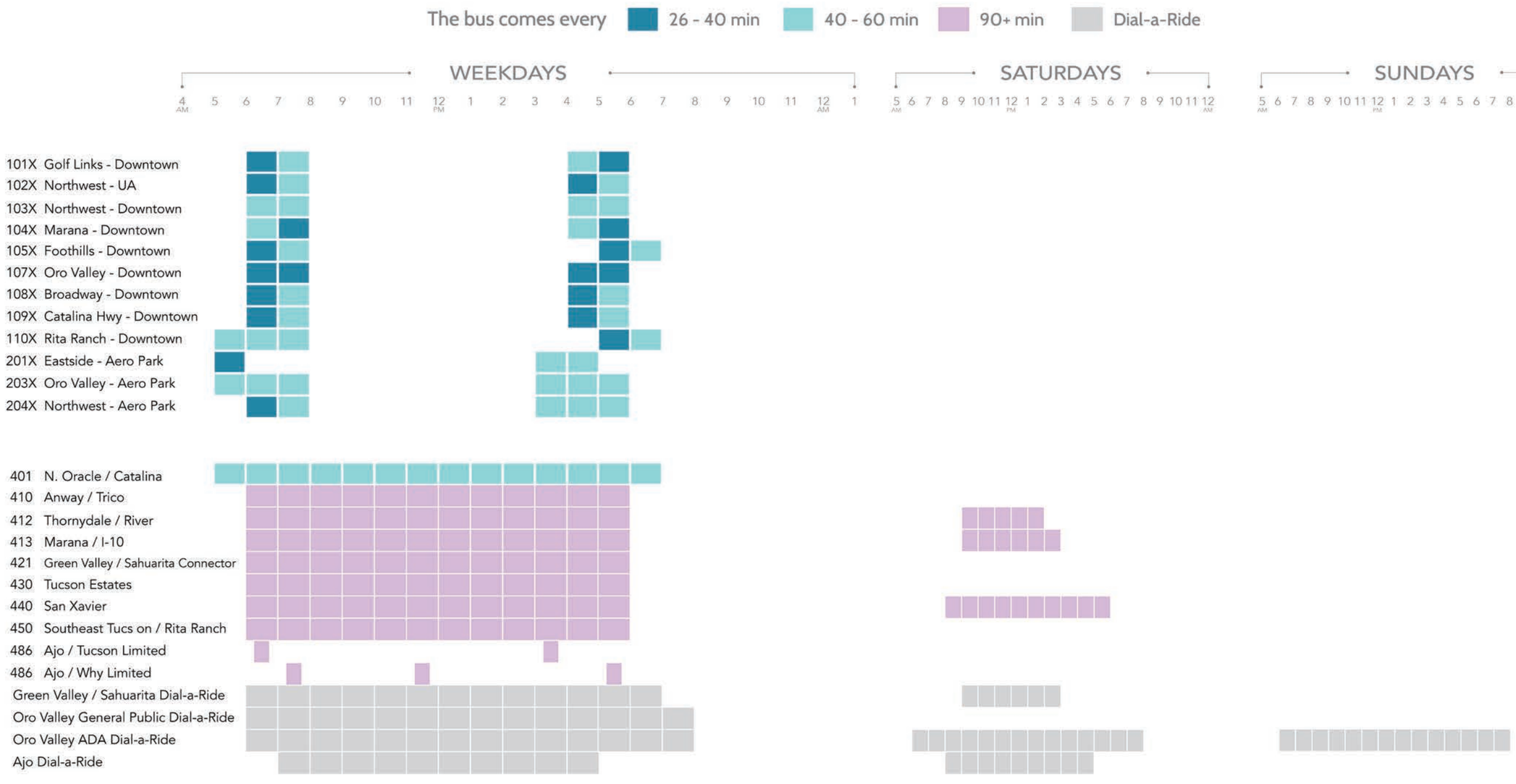


Figure 41: Frequency table by day and hour for Sun Tran Express and Sun Shuttle routes, and regional Dial-A-Ride service hours.

Most people in Tucson can walk to transit, but few can use transit to reach their jobs.

Most service is in the City of Tucson

Because the City of Tucson is the primary funder and provider of transit in the region, service is primarily geared to areas within the City. 98% of Tucson residents live within a half-mile of a bus or streetcar route, but only 59% of all Pima County residents live near transit.

Given that Tucson accounts for just half of Pima County's population, this means that less than a third of county residents outside Tucson have access to any regular transit service.

This is very low, but it also needs to be put into the context of population density. As seen in Chapter 3, the region's population outside Tucson is scattered at low densities over a very large area. It's much more expensive to reach all of these communities than to serve people in the core of the urbanized area.

Suburban job dispersal limits job access by transit

Similarly, while 95% of jobs within the City of Tucson are located within a half-mile of transit, this is only true of 73% of all jobs in Pima County.

Only one quarter of the jobs located outside Tucson city limits are located near transit. Many of these jobs have been created in isolated and difficult to reach locations, on massive military, industrial and resort sites. These sites are expensive to serve by transit, because they pose challenges in terms of linearity (they are at not on the way to anything else) and proximity (surrounding residential and job densities are very low).

Minority and low income residents are more concentrated and better covered by the transit network; seniors are more dispersed and harder to reach.

70% of minority residents and 79% of low-income residents live within a half-mile of transit service, compared to only 59% of the general population. Low-income residents are also significantly more likely than average to live near a frequent service, which is more likely to be useful. Even so, only 42% of low-income residents in Pima County live within a half-mile of a frequent transit route.

In contrast, because seniors live in much more dispersed communities, and many more live in far suburban and outlying areas, their access to transit is lower than average: fewer than half of seniors live within a half-mile of any transit service, and only 21% live within a half-mile of frequent service.

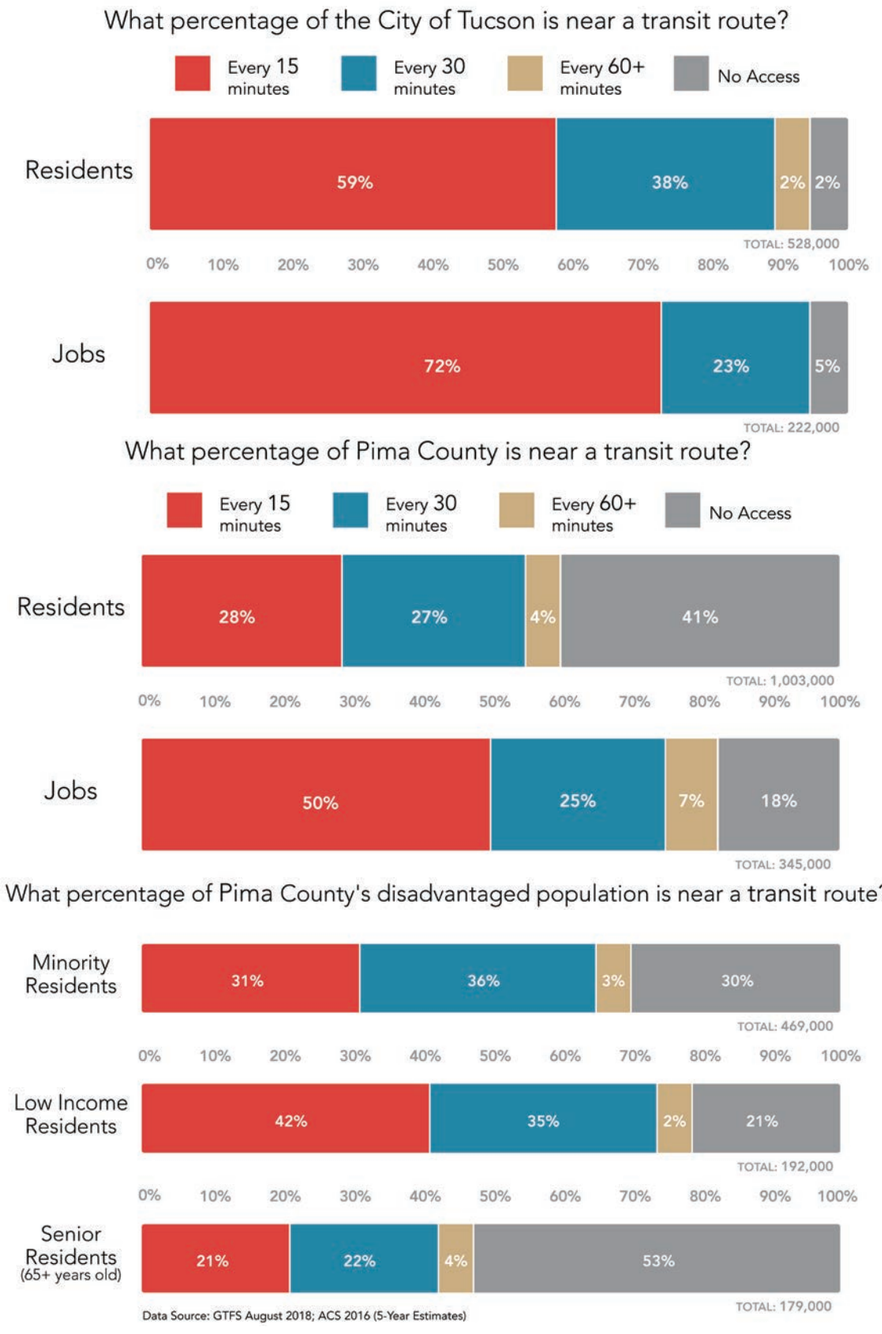


Figure 42: Coverage analysis. This shows the percentages of people and jobs within a half-mile of transit service at different frequencies in Tucson (top), and in Pima County as a whole (middle). The bottom three bars show coverage of disadvantages populations discussed in Chapter 3.

More frequent and useful services are more productive.

Productivity refers to the average number of people boarding a bus or streetcar in an hour of service. High productivity services are the ones where an investment in service hours produces the most ridership. Transit agencies often target their most frequent services toward the places where they are likely to be most heavily used. As a result, higher frequency and higher productivity often track closely when plotted together, as in Figure 43.

Even at the same frequency, there are considerable variations in the productivity of different routes. Nonetheless, **routes in the Frequent Transit Network (FTN) are 30% more productive on average than routes that come every 30 minutes on weekdays (31.5 vs. 24.1 boardings per hour on weekdays).**

The following observations can be made from this chart:

- **The least productive FTN routes are those with the lowest levels of evening and weekend service.** These are Routes 7-22nd Street, 9-Grant, 15-Campbell and 34-Craycroft/Fort Lowell. It is possible that these routes also have lower overall demand than other FTN routes. However, demographic and employment data mostly suggest otherwise: there is significant employment along Grant and Craycroft, the University of Arizona is located on Campbell, and there are sizeable low-income and low-car populations near 22nd Street.
- **Many of the most productive 30-minute routes provide unique coverage to relatively dense and severely disadvantaged communities.** Routes 10-Flowing Wells, 24-12th Ave, and 25-S Park Ave all attract more than 30 passengers per hour on weekdays, despite relatively low service levels. This suggests there may be pent-up demand for transit in low-income communities, which might respond positively to higher frequency service.
- **Very infrequent or peak-only routes, such as Sun Tran's commuter expresses or the Sun Shuttle network, have very low productivity.** These routes are designed for a very limited market; the service is only useful for a small number of trips between a small number of places. Many of these routes feature long stretches on highways with no pick-ups. In some cases, these routes are not more productive than what might be expected for a general public dial-a-ride service. This is particularly true for Route 410 (a local deviated fixed route in Marana), and Route 421 (which actually competes with general public dial-a-ride in Sahuarita and Green Valley).

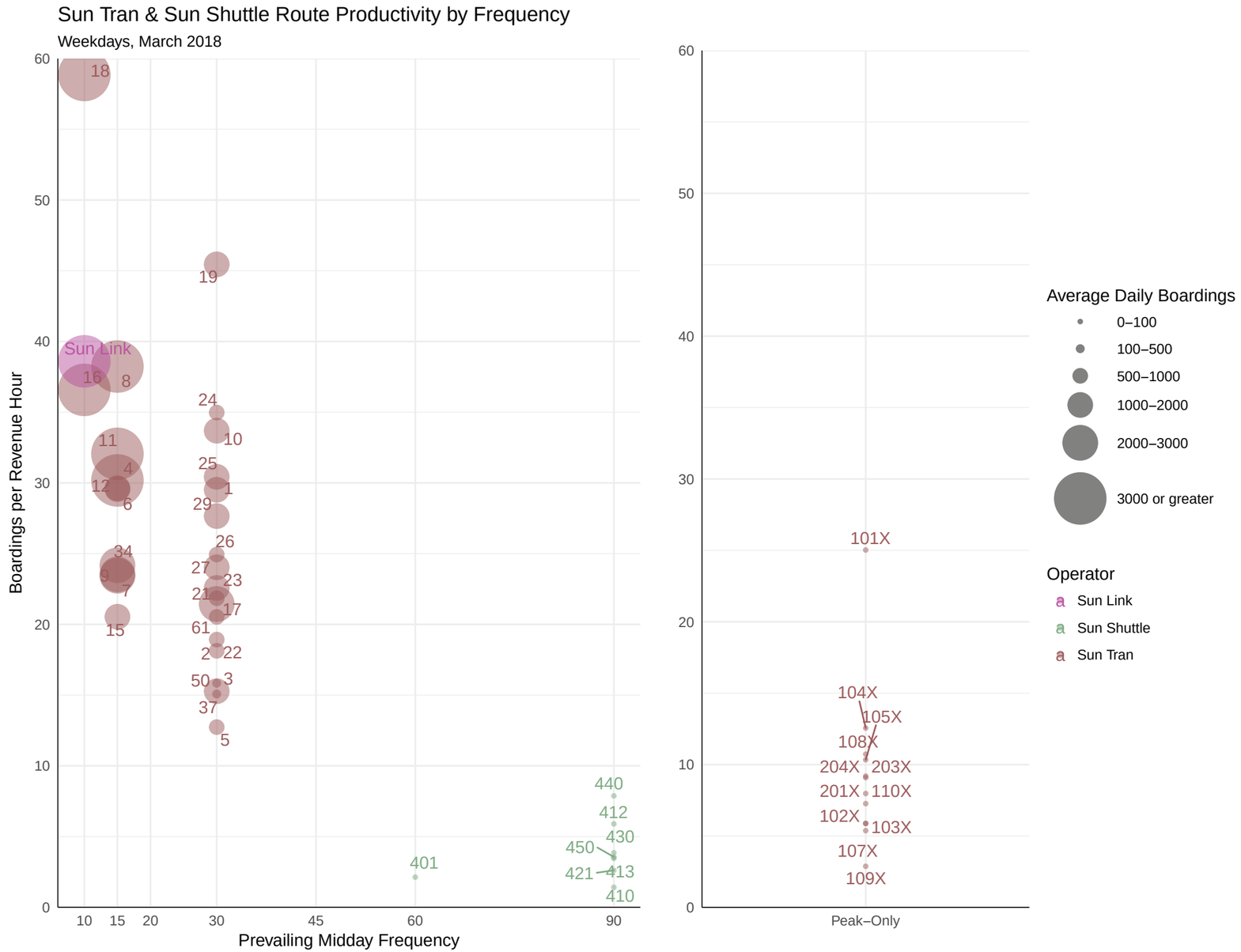
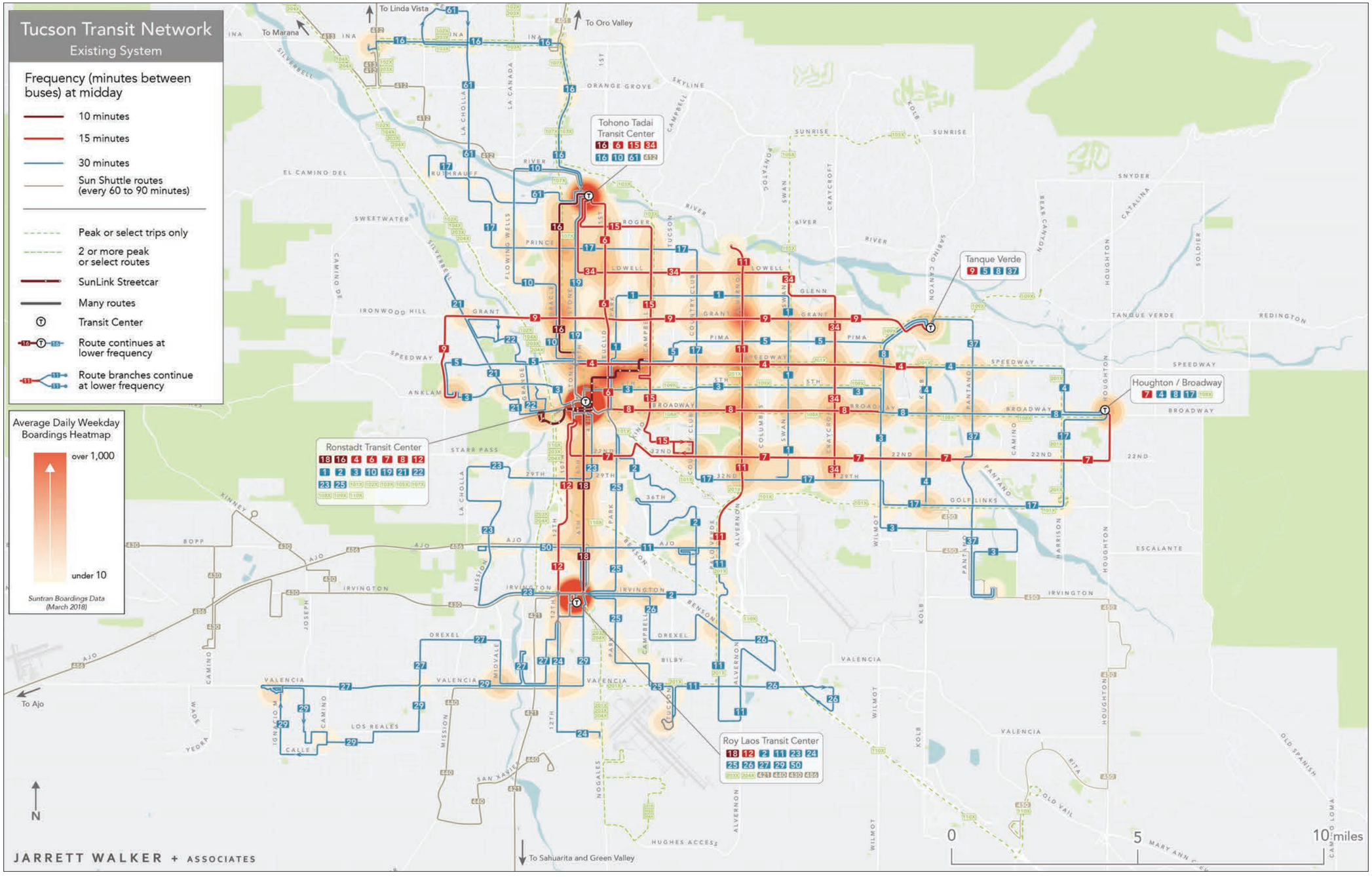


Figure 43: Frequency and productivity of Sun Tran, Sun Link and Sun Shuttle routes. More frequent routes are generally more productive.

Figure 44: Weekday Ridership Heatmap in and near Tucson. The strongest ridership points in the network are in places with high numbers of jobs, in places where many lines meet, and in places where any two frequent lines meet.



High ridership occurs where transit provides a high level of access to jobs and services.

Ridership by Stop and Area

Figure 44 (previous page) maps average weekday ridership across the Tucson transit network, using a heatmap technique that combines ridership at stops that are very close together. The brightest red areas on this map are those with the highest average daily boardings. These include:

- Downtown Tucson
- Tohono Tadai Transit Center (by Tucson Mall)
- Laos Transit Center in southern Tucson.
- Areas along the 3 most frequent routes in the network: Sun Link, 16-Oracle, and 18-South 6th Ave.
- Points where frequent routes meet, including Grant & Alvernon, Speedway & Alvernon, and Grant & Oracle.

Few locations outside the Frequent Network and away from transfer points display comparable ridership to the places on this list.

Ridership and Access

Figure 45 (across) shows how the transit network works to produce access to jobs within 30 minutes of any point in and near Tucson, including time spent walking, waiting and travelling in-vehicle, on a weekday in the middle of the day. The number of jobs that can be reached in this amount of time varies from one place to another based on:

- The number of jobs located immediately near any point, and in nearby areas within 1-5 miles.
- The frequency of transit service provided from that same point.

Comparing Figures 44 and 45 shows that **most of the places that generate high transit ridership are places where the network provides high job access within 30 minutes**, such as:

- Sun Link corridor from Downtown to the University of Arizona.
- South 6th Avenue between Downtown Tucson and I-10.
- Laos Transit Center.

Furthermore, **the locations that show high job access within 30 minutes but don't generate correspondingly high ridership are on FTN routes that provide very little evening and weekend service**, particularly along Grant Road (Route 9), Craycroft Road (Route 34) and Campbell Avenue (Route 15).

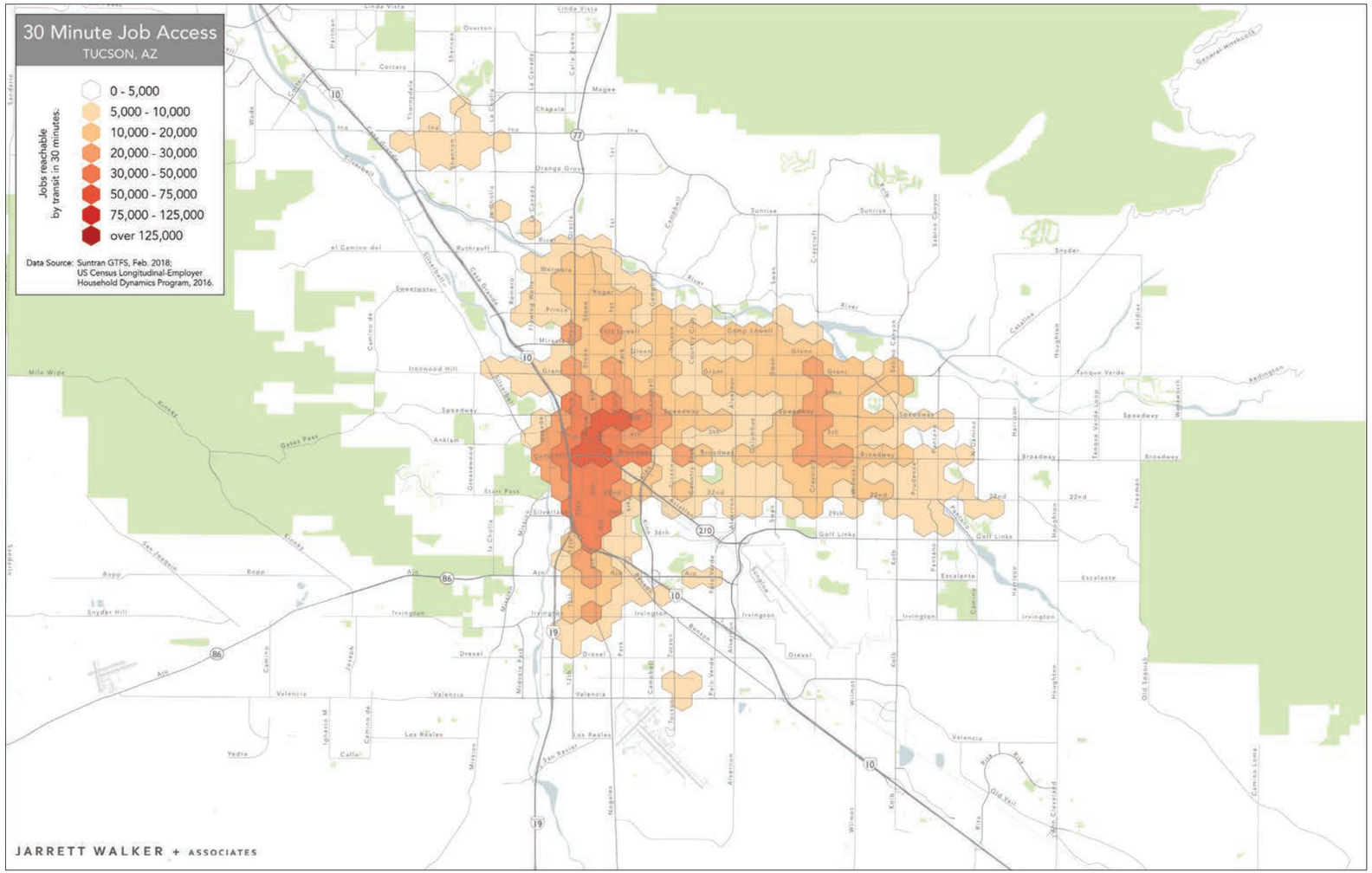


Figure 45: Map of access to jobs within 30 minutes by transit from any point in and near Tucson (at midday on weekdays). Access to jobs is one of the best measures of how useful a transit network can be to many people. Because of where jobs are located and how frequent different routes are, the level of access provided by the transit network varies a lot from place to place. Most of the places where the network provides easy access to many jobs are the same places that generate high ridership (see Figure 44).

Access & Freedom

An access analysis seeks to understand how useful a public transit network is, by measuring the degree to which it is capable of conveniently connecting people to places they need to travel.

One of the most common measures of access is the number of jobs that can be reached in a given amount of travel time. Access to more jobs means not just more potential places of employment, but also more convenient access to retail and services of all kinds.

In measuring this level of access, we typically count not just time in vehicle, but also other elements of travel time, including walking, and waiting. This is the only way to make a fair comparison between transit and other modes of travel.

The average person within the Sun Shuttle and Sun Tran service area can reach around 29,000 jobs in an hour's travel time, while the average person within Tucson's boundaries, including South Tucson, can reach about 40,000 jobs in an hour.

30-minute access

Figure 45 (previous page) maps access across to jobs in 30 minutes across the city. Each hexagon on this map is shaded by the number of jobs accessible in that time from a point at the center of the hex.

The highest levels of 30-minute access in Tucson are found near the most frequent routes, especially when those routes are close to Downtown Tucson.

As discussed on the previous page, there is a clear correlation between average weekday ridership and the level of job access provided within 30 minutes.

45-minute access

Because even the most frequent parts of Tucson's transit network operate only every 10 to 15 minutes, there are few places where a person could access large numbers of jobs within 30 minutes by transit.

However, there are many more places where a person could access many jobs within 45 minutes on transit. The average number of jobs accessible using transit in 45 minutes within the cities of Tucson and South Tucson is more than 4 times the number accessible in 30 minutes.

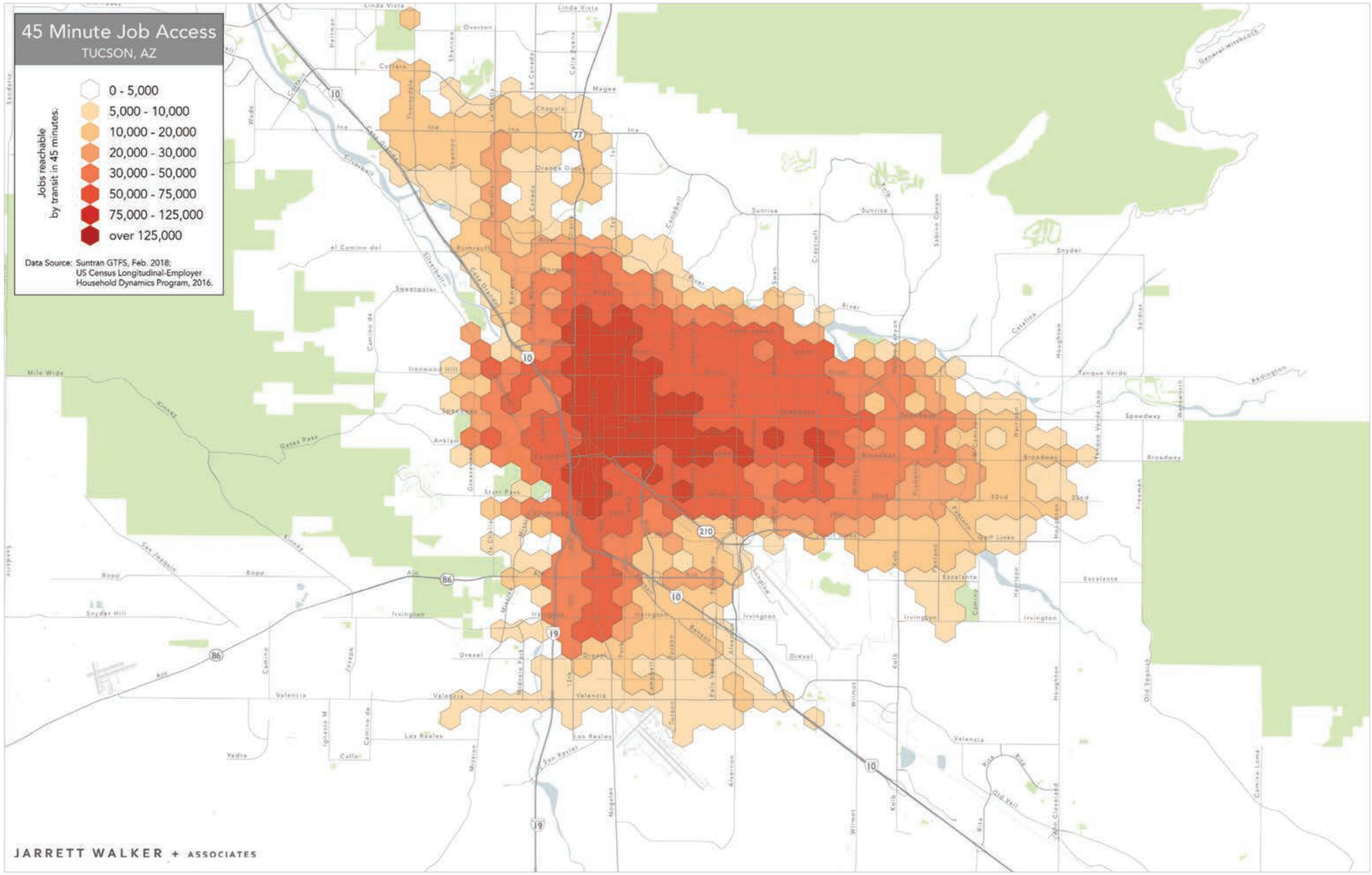


Figure 46: Map of access to jobs within 45 minutes by transit from any point in and near Tucson (at midday on weekdays). Some jobs start being accessible from nearly all parts of the Sun Tran network at a 45 minute time horizon. However, only places near the Frequent Transit Network are able to access the densest job concentrations Downtown and at the University of Arizona.

For most people starting a trip within the extent of the Frequent Transit Network (FTN), 45 minutes is enough time to reach at least part Downtown or the University of Arizona. The area of maximum access extends from Downtown approximately west to Swan Road, north to Grant Road, and south to Broadway Boulevard.

Outside of the FTN, access drops off quickly except in areas with direct service to downtown, such as along the infrequent branches of Routes 4-Speedway and 8-Broadway. Nonetheless, within 45 minutes, significant numbers of jobs start being reachable even from the far northern, southern, and eastern reaches of the Sun Tran network.

60-minute access

Within 60 minutes on transit, it becomes possible to travel between almost any two points on the FTN. It is also possible to reach most of inner eastern, southern and northern Tucson from areas outside the FTN but with direct service to Downtown.

However, there remains a significant gap between these areas and places on infrequent routes ending at suburban transit centers. **Even at 60 minutes of travel time, very few jobs can be reached by transit from places in outer southern Tucson.** In particular, access is poor from places along the following routes:

- Route 24-12th Avenue
- Route 25-South Park Avenue
- Route 26-Benson Highway
- Route 27-Midvale Park
- Route 29-Valencia

Despite this, all of these routes experience above-average productivity. All of these routes serve areas of very significant social disadvantage, including high rates of poverty and low rates of vehicle ownership.

It is likely that many people who might otherwise use transit in this area are getting rides from friends and family, or avoiding certain trips altogether due to the inconvenience. These are areas that would benefit very significantly from more frequent and linear service, and where an investment in such service is likely to generate significant added ridership.

Nonetheless, the built environment in southern Tucson may make it more challenging to design frequent and linear service than in north and east Tucson. Development is less continuous in southern Tucson, and freeways and parkways interrupt the street grid in some areas, as highlighted in the example on page 19.

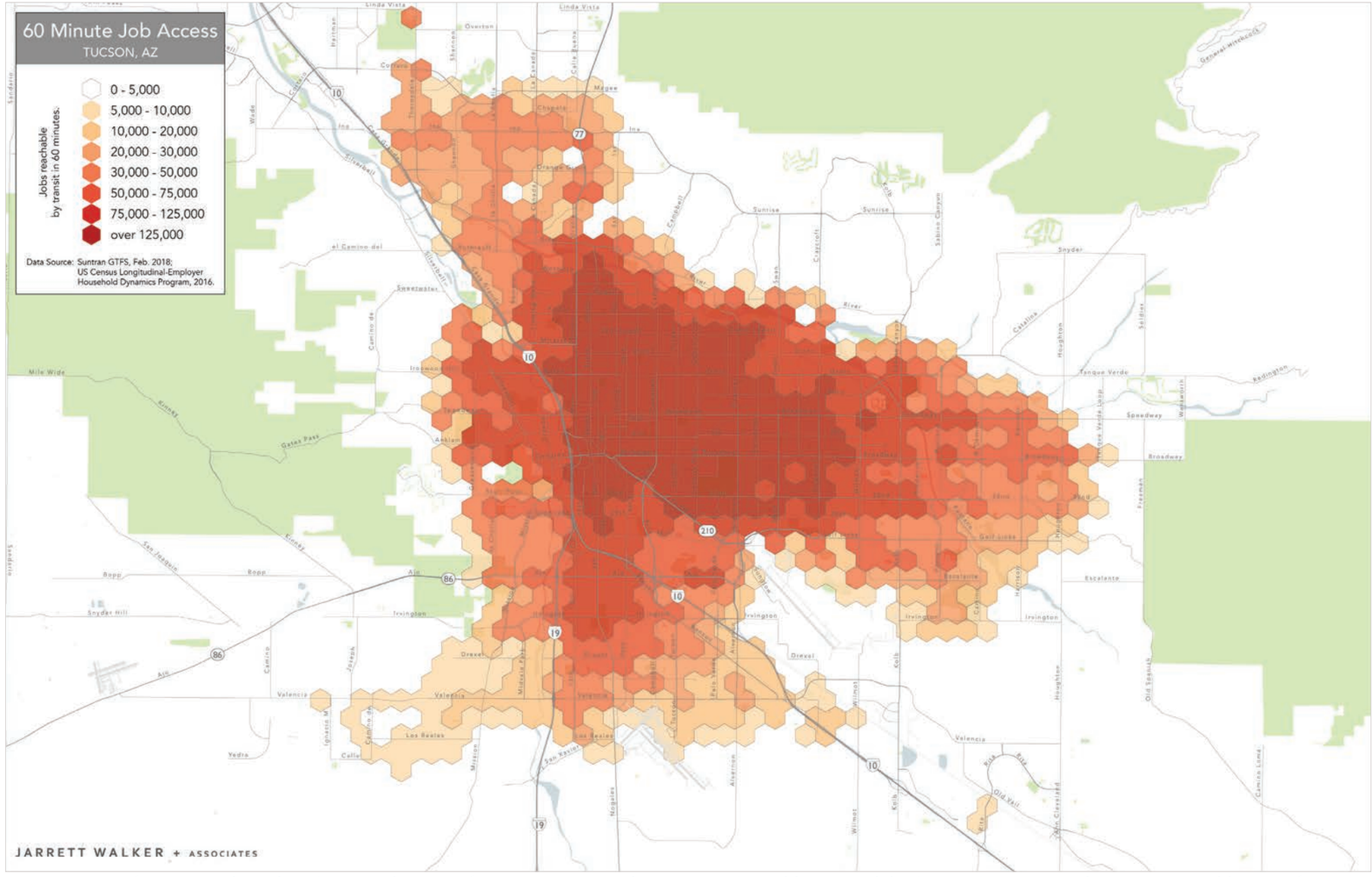


Figure 47: Map of access to jobs within 60 minutes by transit from any point in and near Tucson (at midday on weekdays). At a 60 minute time horizon, it's possible to get from nearly any point A to any point B near the Frequent Transit Network, and more jobs can be reached from far eastern Tucson, as well as the parts of Flowing Wells and Casas Adobes on Sun Tran's all-day network. However, job access is still relatively poor for far southern Tucson. Because Sun Shuttle routes only operate every 90 minutes, they also do not contribute significantly to job access from any given point. Regular job access by transit is thus only possible using Sun Tran or Sun Link.

High frequency makes access to jobs and services more dependable.

Access Dependability and Spontaneity

In the previous section, we discussed access in terms of the average number of residents or jobs reachable from a given place. By 'average', we mean where a person could reach if their trip involved the average wait for each transit route at each point of boarding - half the headway between buses.

While average access provides a sense of how useful the transit network is most of the time, everyone has had the experience of reaching your stop just after the bus pulls away. When service is infrequent, this worst-case scenario could require a wait of or 29 minutes (or 59 minutes in the evening!), greatly increasing your overall travel time.

Frequent services allow you to *dependably* access a larger area than infrequent services, because your worst-case scenario is a 10-15 minute wait rather than a 30-60 minute wait. Transit is more useful and more convenient when it allows for spontaneous travel, but using transit spontaneously requires considerable confidence on the part of the rider that when they turn up at a stop, they won't be subjected to an unbearably long wait.

Figure 48 provides an illustration of this concept. The dark orange area is where a person could reach from Downtown Tucson if they started their trip at almost any time during the midday. The lighter orange area could only be reached if a person happened to leave at almost exactly the right time. We've calculated the number of residents and jobs within each area, in the "Where could you reach?" box.

When the difference between best-case and worst-case access is wider, transit travel times are less dependable. This means travel will require more attention to detailed trip planning. Only people with a high tolerance for a long wait will ride spontaneously, and most people won't bother trying to ride at all.

Because it is the nexus of the Frequent Transit Network (FTN), access from Downtown Tucson is quite dependable: more than 75% of jobs accessible in an hour in a best-case scenario are still accessible in a worst-case scenario. The main areas that drop out of reach between the two scenarios are in the far eastern area of the city, or parts of the northern and southern areas of the city that are only accessible with low-frequency services requiring a transfer.

Where can I travel in 60 minutes from

Tucson Downtown?

Where could you reach?	Jobs	Population
Area reachable some (25%) of the time	220,000	436,000
Area reachable most (90%) of the time	166,000	284,000
90% - 25% ratio	76%	65%

This map shows the area of Tucson you could reach in 60 minutes starting between 12pm and 1pm. The dark orange area could be reached by trips starting at almost any time during this period. The lighter orange area can be reached less reliably with more detailed trip planning.

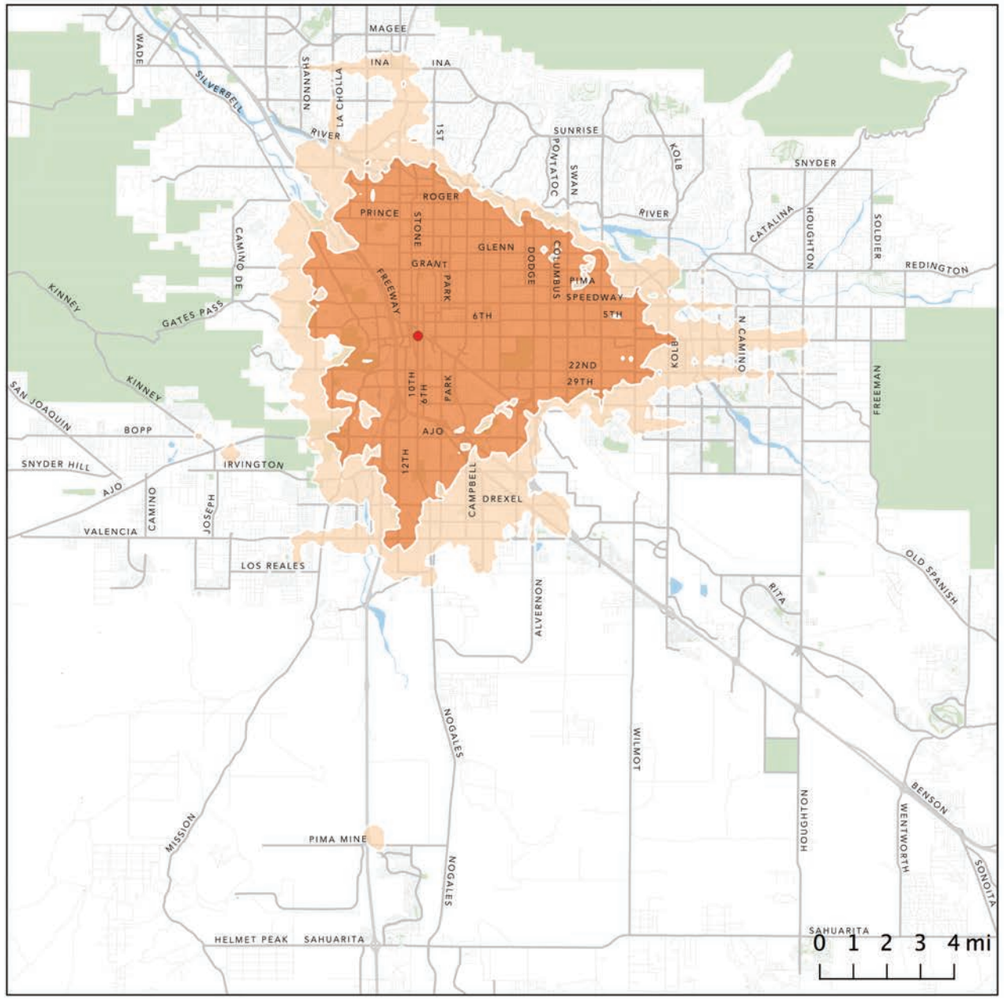


Figure 48: Map of areas reachable within 60 minutes by transit from Downtown Tucson. Because Downtown is the center of the Frequent Transit Network, access is dependable: 76% of jobs reachable from downtown in a best-case scenario are still reachable in a worst-case scenario; this means you don't need to plan most trips.

Outside of the limits of the FTN, the gap between the worst-case and the best-case scenario is much wider. Figure 49 shows a midday isochrone from the Tucson Spectrum mall, an example of a place where the area and number of jobs accessible in an hour is much less dependable. A person leaving this location at just the right time can access nearly 10 times as many jobs as a person who just barely misses the bus.

People traveling to or from Tucson Spectrum on transit must be more mindful of the precise scheduled departure times, or risk a much longer travel time to many destinations. This reduces the usefulness of transit for spontaneous travel.

Tucson Spectrum is an especially high-contrast location, but the maps shown on the next pages illustrate the difference being on the FTN makes in more typical cases.

Figure 50 shows the best-case and worst-case scenario isochrones from near the intersection of Drexel Road and Campbell Avenue in the southern part of Tucson. Here, similar to the isochrone from Tucson Spectrum, there is a wide gap between the two scenarios, because of the long waits required between trips. Only a third of the jobs reachable in a best-case scenario are reachable in a worst-case scenario.

Figure 51 shows the same graphic for the intersection of Fort Lowell Road and Campbell Avenue, eight miles further north. Because this location is at the intersection of two frequent routes, access is much higher in absolute terms, and the drop-off between the two scenarios is much less severe. A person traveling from the this location can count on being able to reach much more of the city's jobs and activity centers, even if they miss their bus or connections (or make an unplanned trip) and have to endure longer waits.

Where can I travel in 60 minutes from

Tucson Spectrum?

Where could you reach?	Jobs	Population
Area reachable some (25%) of the time	56,000	114,000
Area reachable most (90%) of the time	6,000	34,000
90% - 25% ratio	11%	29%

This map shows the area of Tucson you could reach in 60 minutes starting between 12pm and 1pm. The dark orange area could be reached by trips starting at almost any time during this period. The lighter orange area can be reached less reliably with more detailed trip planning.

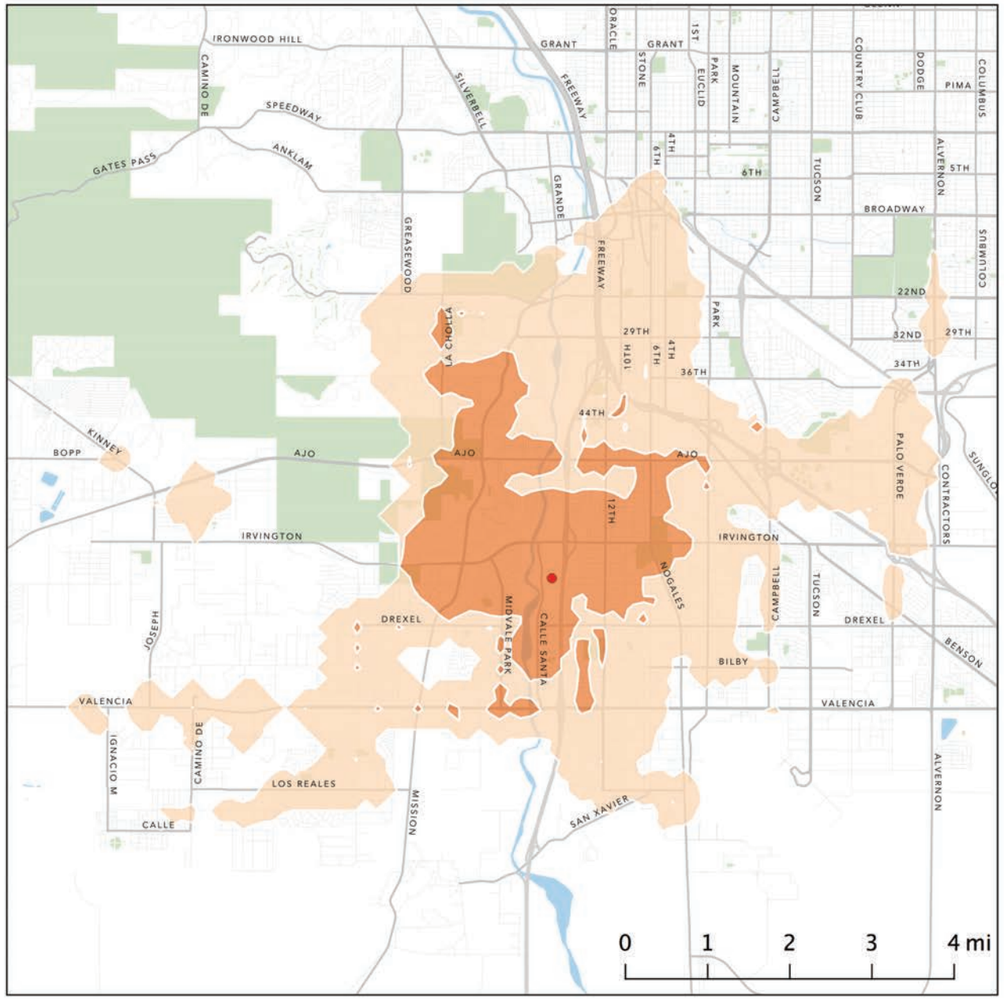


Figure 49: Map of areas reachable within 60 minutes by transit from Tucson Spectrum. Only 11% of jobs reachable in a best case scenario are reachable in a worst-case scenario. This means you would need to plan any trip from here on transit very precisely.

Where can I travel in 60 minutes from

Drexel & Campbell?

Where could you reach?	Jobs	Population
Area reachable some (25%) of the time	69,000	121,000
Area reachable most (90%) of the time	22,000	58,000
90% - 25% ratio	33%	48%

This map shows the area of Tucson you could reach in 60 minutes starting between 12pm and 1pm. The dark orange area could be reached by trips starting at almost any time during this period. The lighter orange area can be reached less reliably with more detailed trip planning.

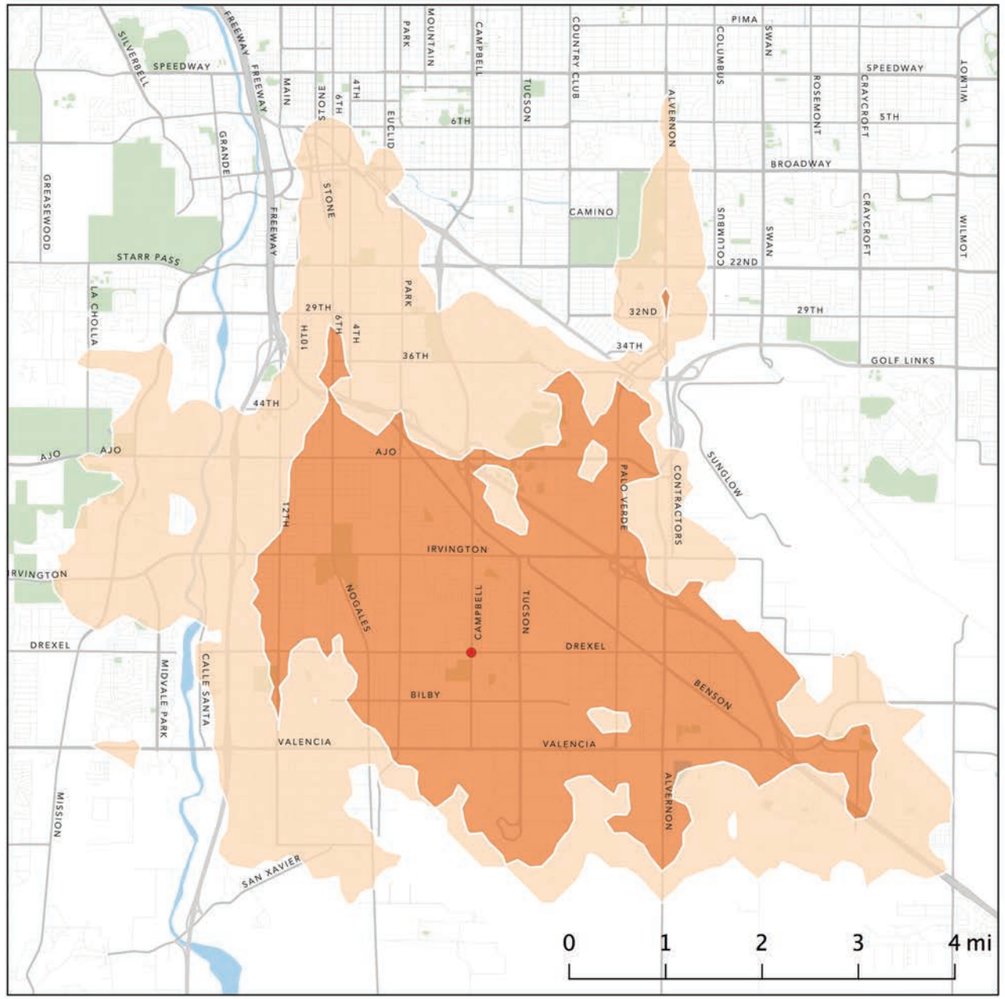


Figure 50: Map of areas reachable within 60 minutes by transit from Dexter & Campbell in southern Tucson. This depends on a single 30-minute route, with a transfer to Downtown.

Where can I travel in 60 minutes from

Fort Lowell & Campbell?

Where could you reach?	Jobs	Population
Area reachable some (25%) of the time	199,000	322,000
Area reachable most (90%) of the time	151,000	222,000
90% - 25% ratio	76%	69%

This map shows the area of Tucson you could reach in 60 minutes starting between 12pm and 1pm. The dark orange area could be reached by trips starting at almost any time during this period. The lighter orange area can be reached less reliably with more detailed trip planning.

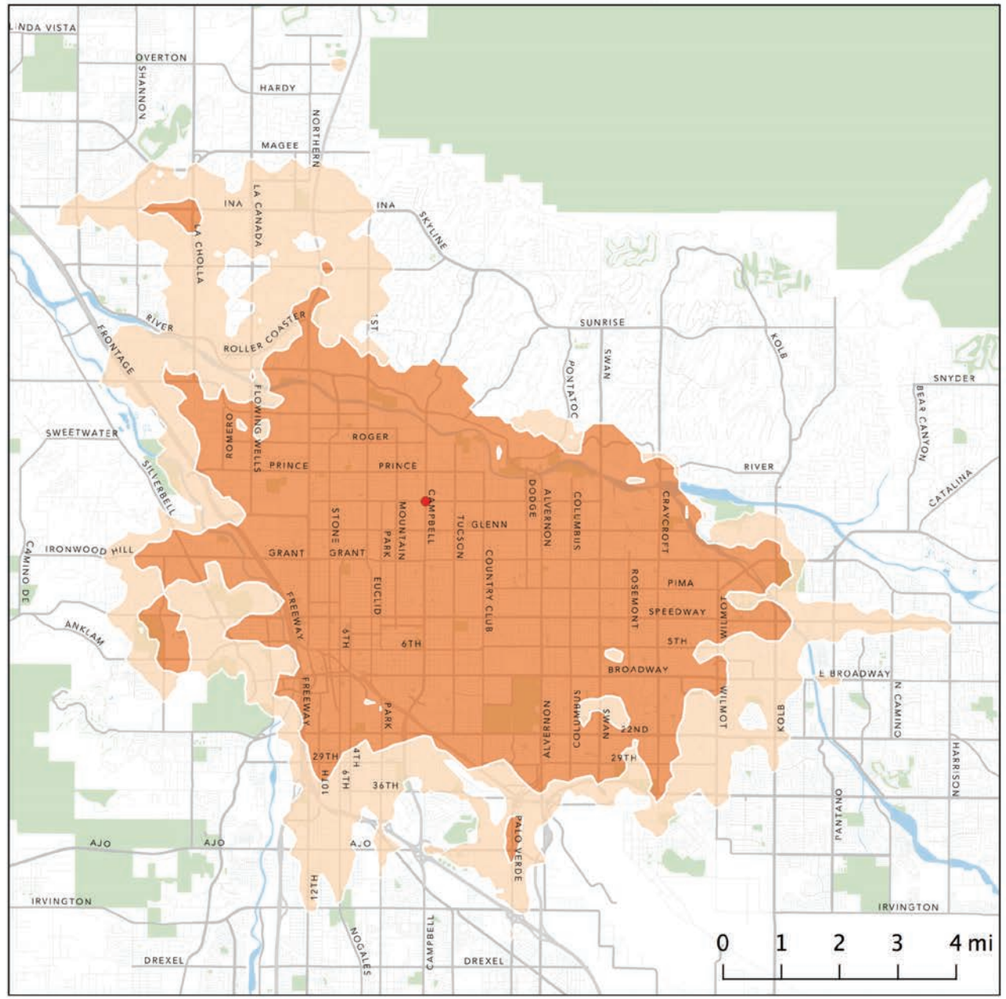


Figure 51: Map of areas reachable within 60 minutes by transit from Lowell & Campbell in northeastern Tucson. This location has access to two frequent routes.

5 How do Local and Regional Policies Address Transit?

Transit Efficiency vs. Meeting All Needs

Overview

This chapter reviews municipal, regional and state policies that govern the design and success of transit services. Transit is highly interdependent with traffic and land use planning, so we also review how policies that impact these topics impacts what transit service can look like.

In the course of this review, we have identified various areas of conflict and alignment, including:

- Where municipal, regional, and state policies agree and disagree.
- Where policies leave a trade-off unresolved or set up an intractable conflict, and
- Where policy documents are silent on questions where policy direction would be helpful to planning transit.

Our distillation of policy statements comes from the land use and transportation policy documents of Pima Association of Governments (PAG) member jurisdictions, as well as the Arizona Department of Transportation (ADOT). These documents include:

- The PAG Region 2045 Regional Mobility and Accessibility Plan
- The Pima County Comprehensive Plan (Pima Prospers- 2015 Update)
- ADOT Long Range Transportation Plan (What Moves You Arizona 2040)
- City of Tucson General & Sustainability Plan (Plan Tucson 2013)
- Sun Tran Comprehensive Operational Analysis (2014)
- Sun Tran FY 2018 Systemwide Objectives
- City of Tucson Transit Task Force Draft 5-year Strategic Plan (2018)
- Oro Valley General Plan (2016)
- Town of Marana General Plan
- Town of Sahuarita General Plan

Among these documents, we find three key trade-offs that warrant further discussion:

- Transit System Efficiency vs. Addressing All Needs
- Sustainable Growth vs. Business As Usual
- Transit as Leading vs. Responding to Development

Efficiency vs. All Needs

In public transit as in other services, there is tension between the goal of "efficiency" and the goal of addressing "all needs".

A desire for efficiency leads us to provide a service that serves the largest number of people at the lowest cost per person. Attempting to address everyone's needs leads us to provide a service that nearly anyone can access; at scale and within a fixed budget, this usually means either providing a relatively low level of service to all.

This tension is illustrated in Chapter 2, in the form of the conflict between ridership and coverage goals. Broadly speaking, a transit system designed exclusively for ridership targets "efficiency"; a system designed exclusively for coverage targets "all needs".

This tension is a universal feature of transit and it would be helpful to have policies that address this tension more directly, so that action in one of these policy directions is not counted as failure in the other. For example, it may be appropriate for policy to spell out how these competing impulses should be balanced, or what resource should be devoted to one as opposed to the other.

Transportation efficiency, in both fiscal and environmental terms, is a common theme throughout relevant high-level policy documents. The 2045 Regional Mobility and Accessibility Plan (RMAP) calls for an "environmentally responsible regional transportation system" and to "increase the mode share of walking, biking and transit". The Arizona Department of Transportation Long Range Transportation Plan aims to "Promote fiscal stewardship". The City of Tucson's General & Sustainability Plan (Plan Tucson 2013) sets the goal of "a reduction in the community's carbon footprint". These, and other goals centered around efficiency suggest a transit network that concentrates service on corridors that produce the highest ridership per service hour.

However, other goals and objectives from these policy documents suggest a focus on expanding geographic coverage to meet all needs, regardless of efficiency. The 2045 RMAP sets a goal of creating transportation choices that meets "all mobility needs" while the City of Tucson's Transit Task Force Draft 5-year strategic plan calls for a "transit network that serves all customers". "All" is a strong word, because in practice it means, "everyone, even those that it will be expensive to serve." The same idea is suggested in references to diversity: "preserve and protect the mobility of seniors and people of all abilities" although "preserve and protect" tempers expectations by suggesting maintaining existing coverage, but not necessarily expanding it.

Some other goals are more ambiguous but still likely suggest a focus on coverage. For example, the 2045 RMAP aims to "Improve the connections between transit facilities and major destinations within and beyond the region to allow for easier travel for non-driving populations". While increasing service within the region may result in high ridership, increasing coverage beyond the region typically expands coverage without drawing high ridership. The Pima County Comprehensive Plan sets a goal to "support transit…especially for those who are transit dependent, where ridership meets minimum thresholds." To the extent that these minimum thresholds may be lower than on high ridership routes, this statement suggests a moderate focus on coverage. The goal of creating a "transportation network that offers choices of routes and modes of travel to all land uses" leaves some ambiguity regarding travel modes but would suggest a focus on geographic coverage if it implies that publicly funded transit should be a choice offered to all land uses.

Figure 52: Efficiency vs. Meeting All Needs. Summary of policy vision, goals and actions from local and regional policies.

	High-Level Vision	Source	Goals	Source	Actions	Source
"Efficiency"	environmentally responsible regional transportation system	2045 RMAP	Reduce annual per capita on-road greenhouse gas emissions	2045 RMAP	Report on riders per revenue hour	TTF Draft 5-year strategic plan
	Increase the mode share of walking, biking and transit	2045 RMAP Objective	Increase the mode share of walking, biking and transit	2045 RMAP	developing and maintaining a frequent service grid	Plan Tucson
	Promote fiscal stewardship	AZDOT LRTP	Number of regional jobs the average person can reach in 45 minutes by transit	2045 RMAP	Maintain, improve, and add to high frequency network	TTF Draft 5-year strategic plan
	A reduction in the community's carbon footprint	Plan Tucson	Efficient transit routes	Oro Valley General Plan		
	enhance the mobility of people and goods	Plan Tucson	Maintaining Farebox Recovery Rate at Above National Average	SunTran 5-year Strategic Transit Plan		
	Ensure an Efficient and Effective Operation	Sun Tran FY 2018 Systemwide Objective	Reduce travel time on route for transit rider.	TTF Draft 5-year strategic plan		
	Build Ridership	SunTran 5-year Strategic Transit Plan				
"Meet All Needs"	A variety of integrated, high-quality, accessible and interconnected transportation choices to meet all mobility needs and changing travel preferences.	2045 RMAP Objective	Improve the connections between transit facilities and major destinations within and beyond the region to allow for easier travel for non-driving populations.	2045 RMAP	Expansion of Service Area	City of Tucson Five-Year Strategic Transit Plan (2013) This will be superceded by TTF 5-year Strategic Plan)
	preserve and protect the mobility of seniors and people of all abilities	Oro Valley General Plan	Increase "Percent of residents/jobs living within ¼ mile of a transit stop"	2045 RMAP		
	transit network that serves all customers	TTF Draft 5-year strategic plan	Support transit service and programs, especially for those who are transit dependent, where ridership meets minimum thresholds.	Pima County Comprehensive Plan		
			...transportation network that offers choices of routes and modes of travel to all land uses	Sahuarita General Plan		

Sustainable Growth vs. Business as Usual

A common theme among the policy documents is to increase "transportation choice", referring to increasing the availability of walking, transit, and cycling as transportation alternatives to driving.

However, it is the comparative usefulness of each "choice" that ultimately determines whether people drive or not. As we have seen in Chapter 5, public transit becomes exponentially more useful as frequency increases, particularly to and from places with many people. So investments in high-frequency service to high- and mid-density places can make transit a more useful choice that many more people will take.

But within a fixed budget, investing in more frequent service in locations with higher potential means not investing in service elsewhere. And the long-term implication that transit will become more useful as more high- and mid-density places are (re)developed is not without disturbance to people who are used to a lower-density environment today.

As such, more nuanced policies must be considered to navigate real budgetary and policy trade-offs. Our analysis of the policy documents reveals a clear tension between the goal of sustainable growth and the goal of minimizing change and disruption.

Many of the adopted regional and municipal plans include policies that imply increased densities within built-up areas and discourage automobile use in favor of walking, cycling, and transit. They call for transit-favorable urban form that "builds on existing public infrastructure", "reduces per capita on-road greenhouse gas emissions", and "make infrastructure expansion more economical". Plan Tucson states support for "development opportunities where there is close proximity to transit" and explicitly calls for "parking management and pricing" as well as "reduced required motor-vehicle parking areas".

In contrast, some transportation goals suggest a more "Business as Usual" approach to "maintain the lifestyle of residents". Goals like "manage traffic congestion and demand through capacity improvements" suggest an attempt to maintain the auto-oriented status-quo, which strongly discourages forms of development that align with higher transit use. Goals of maintaining automobile "Level of Service" standards also indicates a desire to maintain the status quo since the measure only applies to cars. The goal to increase the "number of regional jobs the average person can reach in 30 minutes by automobile" may seem like it encourages residential and employment areas to be located near each other, but in practice encourages these places to be located near high-speed highways and freeways that are typically hostile to walking, cycling, and transit.

Some jurisdictions' development goals maintain an ambiguity that may be resolved either way. Oro Valley's goal to "keep its friendly, small-town, neighborly character" may be favorable for walking, cycling, and transit if it is interpreted as encouraging development in the form of small, walkable, dense street grids; but, to the extent that it limits density in favor of single-family homes, and limits the proximity of jobs to residential areas, it encourages the development of a community where the only mode of transportation that provides access at scale is the automobile, facilitated by highways.

Figure 53: Business as Usual vs. Sustainable Growth. Summary of policy vision, goals and actions from local and regional policies.

	High-Level Vision	Source	Goals	Source	Actions	Source
Sustainable Growth	urban form that builds on existing public infrastructure and facilities	Plan Tucson	Coordinate planning for land use and transportation in order to promote growth areas and transit and commercial corridors	Oro Valley General Plan	Support "moderate to higher density development"	Plan Tucson
	balance support for a growing economy with conservation of resources	Oro Valley General Plan	Reduce annual per capita on-road greenhouse gas emissions	2045 RMAP	parking management and pricing	Plan Tucson
	All Growth Areas should make infrastructure expansion more economical	Oro Valley General Plan	Support multimodal transportation and transit oriented development	Pima County Comprehensive Plan	Support development opportunities where there is close proximity to transit	Plan Tucson
	Increase the mode share of walking, biking and transit	2045 RMAP Objective	Full recovery of the costs of services that serve new development	Oro Valley General Plan	Reduce required motor-vehicle parking areas	Plan Tucson
			Number of regional jobs the average person can reach in 45 minutes by transit	2045 RMAP	Develop meaningful incentives that encourage businesses to locate near transit hubs. - 2045 RMAP Implementation Strategy	2045 RMAP
Business as Usual	"Diverse transportation choices that"… "maintain the lifestyle of residents"	Oro Valley General Plan	Percent of peak hour VMT travelled under Level of Service E or F	2045 RMAP	Pullouts for buses	Oro Valley General Plan
	keep its friendly, small-town, neighborly character	Oro Valley General Plan	Number of regional jobs the average person can reach in 30 minutes by automobile	2045 RMAP	Grow by adding new areas to town limits	Oro Valley General Plan
	enhancing operations and adding system capacity for all modes where necessary	2045 RMAP System Goals	Maintain the Town of Sahuarita transportation network established Level of Service (LOS) standard	Sahuarita General Plan		
			Manage traffic congestion and demand through capacity improvements…	Pima County Comprehensive Plan		

Leading vs. Responding to Development

There is a basic dilemma in the interaction between transportation and land use planning which can be summarized as "Lead or respond?"

In the case of transit, the question is whether transit services should lead development, operating in places where ridership is low today but is expected to be high in the near future. Or should transit services take a more conservative approach and respond to new developments only once they are producing potential transit riders?

In this arena, there may be a tension between suburban and regional goals, when compared to the goals of the City of Tucson. To some extent, this question is a subset of the debate between "efficiency" and "all needs", as the most efficient thing to do in the present is almost always to respond to measurable existing demand.

Regional goals to date have been broadly oriented toward developing transportation facilities and services that facilitate economic development in new locations. City goals have been more focused on strengthening the local transit network in areas where it is most likely to succeed.

The Pima County Comprehensive Plan's goal to "Promote economic development with strategic transportation investments" and to support transportation investments that "bring new and permanent jobs" clearly shows a preference for transportation investments that lead development. Oro Valley's goal to "Coordinate planning for land use and transportation in order to promote growth areas and transit and commercial corridors" may also suggest a "leading" approach if transit is interpreted as a prerequisite for promoting growth areas.

The "leading" approach, however, may be in conflict with transit ridership goals and productivity metrics. The City of Tucson Transit Task Force's goal to "Ensure an Efficient and Effective Operation" and of "Maintaining Farebox Recovery Rate at Above National Average" implies that transit should be focused on markets where there is existing strong transit demand.

Furthermore, the City of Tucson's Frequent Transit Network (FTN) Policy is clearly aimed at encouraging the intensification of transit service in areas with demonstrated demand. The FTN policy is explicitly states that "[an] FTN in the densely populated areas makes most efficient use of the community's resources by making transit a truly viable option for a large portion of the population."

The Sun Link streetcar project is an interesting example of a hybrid between the two approaches. Because Sun Link was planned in a corridor with ample scope for revitalization, this transit service "led" significant redevelopment. On the other hand, because it links areas with the strongest transit demand, it was also designed to respond to measurable existing demand.

However, as stated in Chapter 1, Sun Link is also unique with respect to its location in the region. There are few if any other locations where it would be possible to achieve both goals simultaneously with as much success.

Figure 54: Lead vs. Respond to Development. Summary of policy vision, goals and actions from local and regional policies.

	Goals	Source
Lead	Promote economic development with strategic transportation investments	Pima County Comprehensive Plan
	Support transportation investments that assist current employers as well as bringing new and permanent jobs to Pima County.	Pima County Comprehensive Plan
	Coordinate planning for land use and transportation in order to promote growth areas and transit and commercial corridors	Oro Valley General Plan
Respond	Ensure an Efficient and Effective Operation	Sun Tran FY 2018 Systemwide Objective
	Maintaining Farebox Recovery Rate at Above National Average	SunTran 5-year Strategic Transit Plan
	Support the long-term goal of developing and maintaining a frequent service grid as a basis for providing high quality transit services in the densely populated areas of Tucson where transit demand is strong.	City of Tucson Frequent Transit Network Policy (2017)

6 What Choices Can Improve Transit in the Tucson Region?

How much investment in service?

Different regions invest different amounts in transit service. That level of investment is the most important factor in how useful a transit system can become.

Studies comparing many cities and regions have shown that, over the long term, the single greatest factor in determining transit ridership is the total quantity of service[1]. This factor is more important than any external factors, including population density, fares, vehicle ownership rates, gasoline prices, and availability of non-transit alternatives like bikeshare, Uber or Lyft. **Transit networks that offer more service are useful to more people and generate higher ridership.**

As an illustration of how this applies to a place like Tucson, Figure 55 shows how the amount of service available relates to the relevance of the transit system (how often people ride), in a selection of similarly-sized US regions. The relationship is not strictly linear, as it depends on factors such as land use and how service is deployed. Nevertheless, a clear trend emerges, well-encapsulated by two contrasting cities also in the Southwest:

- Salt Lake City invests twice as much in transit service per person as Tucson; the transit system is used twice as much.
- Albuquerque invests about 30% less in service per person as Tucson; transit is used almost 25% less.

This poses the question of how much transit is right for Tucson and the broader Tucson region, and how much is it appropriate to fund?

Regions and cities that invest more in transit service have more useful networks that generate higher ridership. But any new service would require new local funds. What kind of transit city and region should Tucson be?

The case for more service in Tucson

Several factors suggest a significant untapped demand for higher levels of public transit service:

- The existing regional share of transit trips as a percentage of all trips is extremely low at 1.5%, despite the fact that nearly 10% of all households do not own a car, and that over 90% of trips are longer than 1 mile.
- Low-income and zero-vehicle households are more concentrated in parts of the region that are denser and more central, where transit is more cost-effective to provide.
- In many such denser and disadvantaged communities, such as much of southern Tucson and Flowing Wells, existing transit service attracts significant ridership per service hour despite operating no more than every 30 minutes.
- There is some evidence that providing more frequent evening and weekend service on most Frequent Transit Network routes would increase overall ridership and productivity.

How would we pay for more service?

Any increase in funding for transit service is likely to require a local funding source. So any decision to invest in increased transit service is also a decision to either pay more local taxes, or to invest less in other local public services.

Should this decision be made at the regional level, or by individual cities? There is a case to be made either way:

- The strongest markets for transit service are within the City of Tucson, so residents and businesses in Tucson itself have a stronger incentive to fund transit service than residents in most suburbs[2]. As the owner of Sun Tran, the region's main transit provider, the City of Tucson is in a better position than other local jurisdictions to make a discretionary decision about transit service funding. Different communities in the region have very different levels of tolerance for taxation.
- On the other hand, transit service levels outside the City of Tucson are so low that there may be good reason to increase service even in certainly relatively marginal markets.

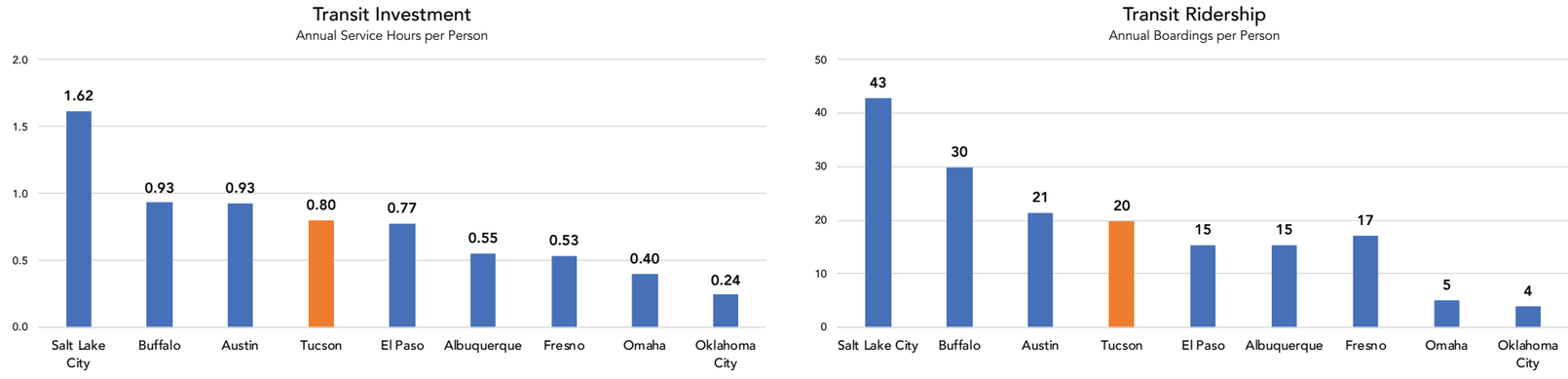


Figure 55: Transit service investment and ridership in Tucson and peer cities. Tucson invests more than many other regions in the US, and gets higher ridership as a result. To generate significant further increases in ridership, the city or region would need to allocate more resources.

1 See Boisjoly et al. (2018). Invest in the ride: A 14 year longitudinal analysis of the determinants of public transport ridership in 25 North American cities. Transportation Research Part A 116 (2018) 434-445. Available at: http://tram.mcgill.ca/Research/Publications/Transit_Ridership_overtime.pdf

2 The City of South Tucson has similar characteristics to many inner parts of the City of Tucson, and potentially similar interests.

How do we make service more useful?

Frequency vs. Coverage

High frequency services allow people to go further, and to reach more jobs and services more reliably, without having to rely on schedules or making detailed trip plans in advance. As a result, there is a clear nexus between frequency and higher efficiency and overall utility of transit. This nexus is already recognized by the City of Tucson in its Frequent Transit Network policy.

At the same time, the share of people and jobs with basic transit coverage is very low outside of the City of Tucson. 98% of people living in the City of Tucson live within a half-mile of transit service, but this is true for less than 60% of all Pima County residents. As a result, there may be some value in extending service to new areas, even if this service will only generate limited ridership and will not be cost effective at high frequency.

Extending transit service into new areas would provide a lifeline to people who have no service now. But improvements to the Frequent Transit Network (FTN) would make existing service useful to more people. Which is valuable?

Frequency in More Places vs. Frequency at More Times

Given the same resources, a case can be made to either expand or intensify the existing Frequent Transit Network (FTN).

The Case for More Places (Expand the FTN)

Sun Tran and the City of Tucson have made significant efforts to expand the FTN since 2015. These efforts have been associated with the redesign of certain routes (especially Route 9-Grant) to realign the network into a clear grid of north-south and east-west lines.

But a look a Sun Tran's FTN map (see Figure 56) still shows significant gaps in this grid. East of Downtown, there's a frequent east-west route every mile (22nd, Broadway, Speedway, Grant, Lowell) but a north-south route only every two miles (Campbell, Alvernon, Craycroft).

And the only frequent service on the south side is on 6th and 12th Avenues north of Irvington, with no frequent east-west grid elements. Expanding the number of frequent routes and bringing the grid structure to new areas could significantly increase the overall level (and dependability) of access to jobs and services provided by the transit network.

This is particularly true on the south side, where we showed in Chapter 4 that both overall job access and reliability of job access by transit is much lower than in areas at similar distances to Downtown in east and north Tucson.

The Case for More Times (Improve the FTN)

All routes in Sun Tran's Frequent Transit Network (FTN) provide service every 15 minutes or better on weekdays, from 6 AM to 6 PM. But the highest ridership routes in the FTN (8-Broadway, 16-Oracle, 18-South 6th and the Sun Link streetcar) also provide frequent service on weekends, and run every 30 minutes or better in the evening.

These routes are more useful in part because they feel more reliable: if you take the bus somewhere, you know it'll still be running at a reasonable frequency when you come back, even if you end up leaving later than planned. If you work on weekends, the service is almost the same as on weekdays, so you can count on it. Improving evening and weekend frequency on all FTN routes would make them more useful, and would likely attract more riders.

Furthermore, the history of FTN expansions also provides some evidence to support intensification rather than expansion of the FTN. All four routes brought into the FTN since 2015 (Routes 7, 9, 15 and 34) were only upgraded in the daytime. These routes are the least productive (in boardings per service hour) of all FTN routes, despite having strong land-use drivers of ridership.

The more we invest in new frequent routes, the less is available to improve weekend and evening frequency on existing routes. Which is more important?

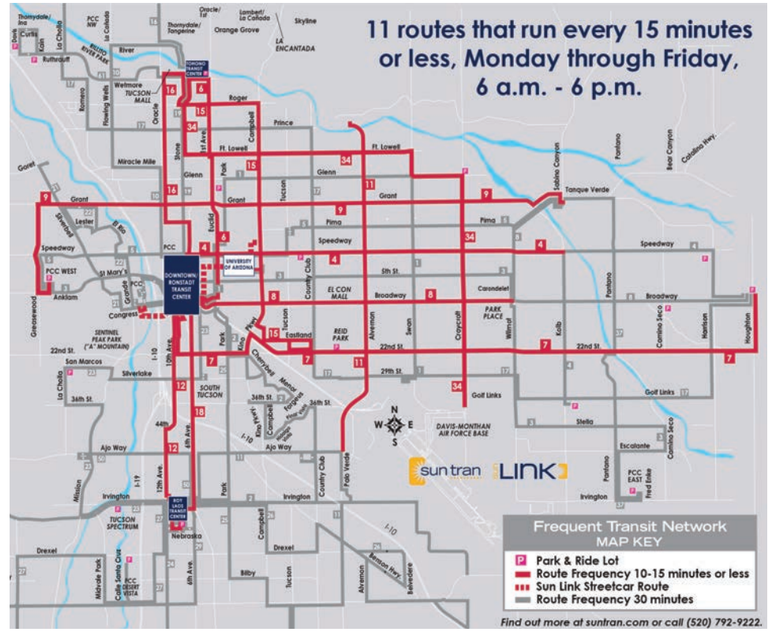


Figure 56: Sun Tran Frequent Transit Network (FTN) map.

How do we improve infrastructure?

Concentrated vs. Diffuse investments

The Case for Infrastructure Improvements

All transit works best when combined with good basic infrastructure, like sidewalks and bus stop shelters. As service becomes more frequent, spreed and reliability improvements (e.g. level boarding, off-board fare payment, signal priority, transit-only lanes) can dramatically improve service quality.

- Frequent routes carry more passengers, so more people benefit from improved travel times.
- In mixed traffic with no priority, frequent buses are likely to bunch, especially in times and places with significant congestion.

Therefore, to the extent the long-term focus is on intensifying or expanding the Frequent Transit Network, it makes sense to think about infrastructure improvements that support and encourage high levels of ridership.

Streetcars vs. BRT

Through efforts like the High Capacity Transit Implementation Plan (HCTIP), the Pima Association of Governments (PAG) has studied options to significantly improveme a limited number of corridors. These include potential streetcar extensions on Stone Avenue, Broadway and South 6th Avenue, and potential Bus Rapid Transit (BRT) corridors on Oracle Road, Speedway and Broadway.

Figure 57 provides a description of the general characteristics associated with the streetcar and BRT modes, as described in the HCTIP. In addition to the charactersitics shown in this table, both modes would likely require investment in transit priority measures.

The HCTIP estimates that streetcar projects would require approximately $40 million in capital costs per mile, compared to about $5 million per mile for BRT projects. It also suggests that the streetcars would generate higher ridership, but that the long-term cost per rider would still be about twice as high for streetcars as BRT.

Such cost estimates are highly preliminary and very likely to rise for both BRT and streetcars as projects are defined more clearly. But the basic point stands: at the same cost, one can build several times more BRT corridors than streetcar corridors. Are there enough added localized benefits in a single streetcar corridor to outweigh the more spread-out benefits of three or more BRT corridors?

Corridors vs. Spot Improvements

Big corridor projects like streetcars and BRTs aren't the only way to improve infrastructure. It is also possible to make smaller improvements to speed, reliability, and other aspects of the user experience throughout the transit network.

These type of improvements can be targeted in response to specific challenges, such as implementing signal priority at known problem intersections, or short bus-only lanes on especially congested road segments. When these improvements are made at critical junctures (e.g. entrances to Downtown), they can improve service on multiple routes at the same time, spreading the benefits over a wide area.

BUS RAPID TRANSIT	RAPID STREETCAR
All-day frequent service	All-day frequent service
High capacity transit service	Urban circulator or high capacity transit service
Operates in mixed traffic or exclusive lanes	Operates in mixed traffic or exclusive lanes
1/2 to 1 mile stop spacing	1/4 to 1 mile stop spacing
Moderate or high speed	Moderate or high speed
40-60 foot bus	65-90 foot rail vehicle; single car train
60-80 passengers per bus	150-225 passengers per rail vehicle
Low floor , multiple doors	Low floor, multiple doors
Diesel, compressed natural gas, hybrid electric, or battery power	Overhead wire or battery power
	Steel wheel on rails (fixed-guideway)

Such smaller projects also have the advantage of being easier to implement without an outside funding source. Although there is nothing preventing a streetcar from being built with exclusively local funds, the high costs of such projects have typically been justified in part by the availability of Federal Transit Administration (FTA) assistance. It is unclear whether such assistance will be available in future.

Smaller infrastructure improvements benefitting many places can be made at similar costs as transformational improvements that benefit a small area. Which is more valuable?

Figure 57: Corridors under study in PAG's High Capacity Transit Implementation Plan. Dashed corridors (South 6th, Stone, and Broadway) have been studied for a new streetcar line. Solid lines (Broadway, Speedway, and Oracle) have been studied for Bus Rapid Transit (BRT) improvements. As defined in this study, one mile of streetcar line costs as much to develop as 8 miles of BRT. Improvements to bus infrastructure may be less transformational, but the benefits can be extended to a much larger area.