Older, Smaller, Better in Tucson:

Measuring how the character of buildings and blocks influences urban vitality in a Southwestern city.

National Trust *for* Historic Preservation
Preservation Green Lab

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ON THE FRONT COVER: *The sun sets over Tucson's older and historic buildings on Congress Avenue in Downtown Tucson. Photo Credit: David Graff (Flickr) under CC-by-NC-ND-2.0 License.*

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The historic Fox Tucson Theatre, constructed in 1930, acts as a cultural hub and an anchor institution in Downtown Tucson. Photo Credit: Lisa's Point of View (Flickr) under CC-by-NC-ND-2.0 License.

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Executive Summary

Tucson's older, smaller buildings and mixed-vintage blocks play a unique and valuable role in contributing to the city's economic vitality, neighborhood livability, and residential density. Noted for lending the city a sense of place and history, these modest, often-overlooked buildings also support more walkable, transit-accessible neighborhoods and provide space for creative entrepreneurship and job growth.

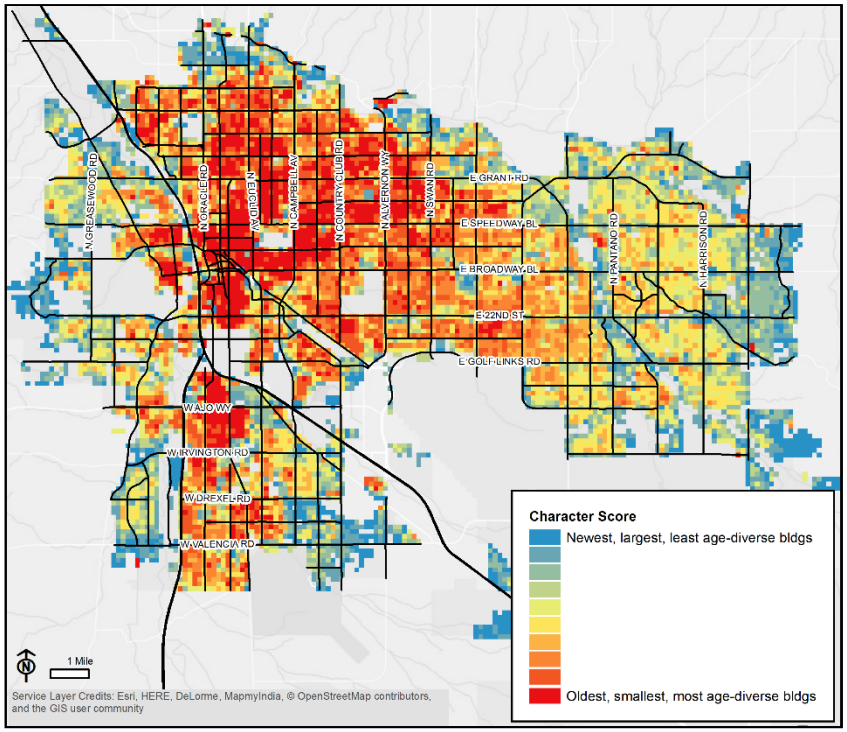
Confirming observations about cities made by urban theorist Jane Jacobs in her 1961 book, *The Death and Life of Great American Cities*, this study shows how Tucson's older, smaller buildings are essential elements of the city's most "vigorous streets and districts." Using local and national data sources, the National Trust's Preservation Green Lab conducted an analysis of Tucson's buildings and blocks to assess the connections between the character of the city's building stock and more than 80 measures of economic, social, and environmental sustainability. Key findings from this research include:

Tucson's older and historic neighborhoods and commercial districts are cooler.

Areas of the city with older, smaller buildings and a fine-grained mix of old and new buildings have greater tree canopy and cooler average surface temperatures than areas with newer, larger buildings. On average, the oldest parts of the city have more than twice as much tree canopy as areas of the city with the newest building stock. In areas of the city with older buildings and blocks, the average surface temperature is nearly a full degree cooler than in areas with mostly newer buildings.

Areas of Tucson with older, smaller buildings are more walkable and more streetcar accessible.

Areas with older buildings and mix of old and new buildings are significantly more walkable and more accessible via Tucson's Sun Link streetcar. Sixty-two percent of areas with older, smaller buildings and mixed-vintage blocks outperform the



Areas of Tucson with older, smaller buildings and mixed-vintage blocks are colored red and orange. Areas with mostly large, new buildings are colored blue and green.

citywide average walkability composite score, compared to just 34 percent of areas with predominantly large, new buildings.

The "Best of Tucson" can be found where old and new buildings sit side by side.

Tucson's older commercial areas house more than 65 percent of the businesses and public spaces listed on *Tucson Weekly*'s "Best of Tucson 2015" list. Tucson neighborhoods with top-rated *Tucson Weekly* or *Tucson Lifestyle* restaurants were twice as likely to also contain buildings constructed before 1945, compared to the citywide average.

Areas of Tucson with older, smaller buildings are resilient job generators.

Areas of Tucson with older, smaller buildings and mixed-vintage blocks have greater concentrations of jobs per square foot of commercial space than in areas with predominantly large, new buildings. Forty-one percent of these areas have more jobs per square foot than the citywide average. Only 26 percent of areas with mostly large, new buildings perform as well. On a per-commercial-square-foot basis, areas of Tucson with older buildings and areas with a mix of old and new buildings gained significantly more jobs during the beginning of the economic recovery (between 2009 and 2013) than areas with mostly new buildings.

The Sun Link streetcar, which launched service in July 2014, connects Downtown Tucson with the University of Arizona campus and passes through historic neighborhoods and historic commercial corridors along its route. Photo Credit: David Wilson (Flickr) under CC-by-2.0 License.

Areas of Tucson with older, smaller buildings support concentrations of jobs in small businesses, creative companies, and startups.

On average, areas with older, smaller buildings and mixed-vintage blocks have about 49 percent more jobs in small businesses than areas with mostly large, new buildings. While only five percent of Tucson's commercial fabric has at least one building constructed before 1920, that small portion supports nearly 11 percent of the city's total number of jobs in creative industries. Areas with at least one building constructed before 1920 have an average of 5.6 jobs in new businesses, compared to an average of 2.5 jobs in new businesses citywide. Compared to the rest of the city, areas with smaller, older buildings experienced a significantly greater increase in the proportion of jobs in new businesses between 2011 and 2013.

Areas with older buildings support distinctive local businesses.

More than 80 percent of restaurants and retailers in high Character Score areas, and more than 90 percent in areas with buildings constructed before 1920, are

independently owned rather than chains. This compares to a citywide average of 66 percent of restaurants and retailers being non-chains. While only five percent of the commercial fabric of the city has at least one structure built before 1920, this small total area houses more than 14 percent of the city's women and minority-owned businesses. Similarly, while just over 25 percent of the city's commercial areas have at least one building constructed before 1945, this one-quarter of the city contains nearly half of the city's oldest businesses.

Neighborhoods of older, smaller buildings and mixed-vintage blocks have denser, younger, and more age-diverse populations.

On average, areas of Tucson with older, smaller buildings and mixed-vintage blocks have nearly 40 percent greater population density and a 16 percent greater density of housing units than areas with mostly, large new buildings. In areas with at least one building constructed before 1920, an average of 45 percent of the population is between the age of 18 and 34, compared to a citywide average of 26 percent.

Adapting existing buildings to new uses is cheaper than new construction, and is a more stable construction activity during economic downturns.

Between 2005 and 2014, rehabilitations of existing buildings cost an average of 60 percent less per square foot for commercial buildings, and 26 percent less for residential buildings, than new commercial and residential construction. Renovation work on commercial buildings was more stable during the Great Recession, and total dollars invested in renovating existing houses increased during that period, while investment in new housing plunged. These trends show how the adaptive reuse of existing buildings helps buffer the local economy from economic downturns.

Older and historic areas of the city attract more investment in construction.

During the recovery from the recession, construction dollars invested in older areas of the city has surpassed investment in newer areas. Over the last decade, building activity has been more widespread in areas with older building stock. Since the recession, construction has become more focused in those areas than in the rest of the city.

A KEY CONCLUSION: ADAPTIVE REUSE SHOULD BE ENCOURAGED.

In addition to highlighting the valuable role that older, smaller buildings play in supporting Tucson's social and economic vitality and livability, the Preservation Green Lab's research points to the importance of conserving, retrofitting and reusing older buildings to achieve a more sustainable Tucson in the future. Below are strategies to help encourage building conservation and reuse:

Recommendation: Conduct outreach to developers interested in building reuse.

City of Tucson officials could benefit from holding facilitated conversations with developers, community organizations, preservation groups, and building owners who are interested in reusing older and historic buildings in the city. These "user focus group" conversations could identify barriers to building reuse which may not be familiar or obvious to those who have not been involved in such projects. Such discussions could point to the need to refine or streamline development review and permitting processes, provide flexibility in building and zoning codes, and create financial incentive programs to reduce the obstacles, costs, and time associated with building reuse projects.

The Preservation Green Lab's *Partnership for Building Reuse* with the Urban Land Institute provides a model to consider.

Recommendation: Create an Adaptive Reuse Program.

The City of Tucson should consider creating an adaptive reuse program that supports and streamlines permitting and plan review for building reuse projects, reduces or waives additional parking requirements following major investment in an existing building, and reduces or waives permitting fees for building reuse projects. The City of Los Angeles's Adaptive Reuse Ordinance and the City of Phoenix's Adaptive Reuse Program offer national best practices that could serve as models for such a program in Tucson.

Recommendation: Encourage building reuse in struggling areas with older fabric.

Though the reuse of older and historic buildings is sometimes associated with boutique development and upscale living, building reuse can be a cost-effective strategy for community development organizations and non-profit developers as well. In areas facing social, economic, and community development challenges, building reuse helps retain and provide affordable spaces for residents, businesses, and nonprofit organizations. Vacant and blighted buildings can be stabilized, cleaned up, and used as community centers, incubator spaces for small businesses and pop-ups, and affordable housing. National organizations such as Artspace, the Local Initiatives Support Corporation (LISC), NeighborWorks America, and Habitat for Humanity offer an array of successful models that could be adopted in Tucson to provide neighborhood anchors that are catalysts for revitalization.

About the Preservation Green Lab

The Preservation Green Lab strengthens the fabric of communities by leveraging the value of existing buildings to reduce resource waste, create jobs, and bolster a strong sense of community. The Preservation Green Lab integrates sustainability with historic preservation through research, demonstration projects, and policies that decrease demolition and promote building reuse.

Funding Support for this Study

This study was supported by funding from the Arizona State Historic Preservation Office, the City of Tucson, and the Tucson-Pima County Historical Commission. Public presentations at the beginning and completion of the study were sponsored by Hotel Congress; Visit Tucson; The University of Arizona Drachman Institute and College of Architecture, Planning and Landscape Architecture; Tucson Historic Preservation Foundation; Herbert Residential; and Downtown Tucson Partnership.

Introduction: Older, Smaller, Better in Tucson

Many cities are looking for innovative ways to stimulate investment, reduce vacancy, increase employment, and decrease carbon emissions. Recent Preservation Green Lab research shows that reusing existing buildings is a powerful strategy for achieving these goals. A 2012 Green Lab report, The *Greenest Building: Quantifying the environmental value of building reuse*, documents how building reuse conserves energy and natural resources. Using life-cycle-assessment analysis, the study compares the relative environmental impacts of building reuse and renovation versus demolition and new construction. The results show that it takes from 10 to 80 years for a new building to overcome, through efficient operations, the negative climate change impacts related to the demolition and construction process.

The value of existing buildings extends beyond environmental sustainability. Another Preservation Green Lab report, *Older, Smaller, Better: Measuring how the character of buildings and blocks influences urban vitality*, examines the relationship between the physical character of existing buildings and a range of social and economic performance data. Based upon statistical analysis of the built fabric of Seattle, San Francisco, and Washington, D.C., this research finds that established neighborhoods with a mix of older, smaller buildings outperform districts with larger, newer structures when tested against a range of economic, social, and environmental indicators. Taken together, these recent Preservation Green Lab reports document how conserving and retrofitting existing buildings and neighborhoods can help cities achieve sustainable development.

The *Older, Smaller, Better* report tests theories about the role of older buildings that were first articulated in one of the most revered and widely read urban planning works, Jane Jacobs's 1961 book, *The Death and Life of Great American Cities.* An outsider to the planning profession, Jacobs called attention to the "need for aged buildings" in urban neighborhoods and argued that the healthiest areas of cities need not just old buildings, but new buildings interspersed with the old (1961, p. 187). Jacobs observed that old buildings and new buildings require differing levels of economic yield—the financial return generated in the buildings—and that new businesses often naturally emerge in buildings with low economic overhead.

By now, more than fifty years later, many researchers have demonstrated that older, smaller structures have positive associations with social, economic, and cultural diversity and vitality. In recent years, a number of scholars have theorized about the value of older buildings in creating a sense of history, a sense of place, and a shared cultural legacy in cities. Stewart Brand's 1994 book, *How Buildings Learn,* shows that older buildings, including

In 2015, a local entrepreneur opened Johnny Gibson's Downtown Market, a grocery store, in an old building by using City of Tucson incentives. Photo Credit: Paul Sableman (Flickr) under CC-by-2.0 license.

those without obvious architectural or historical significance, are more flexible and adaptable to multiple uses and expansions and contractions of businesses. Urban design researchers Reid Ewing and Otto Clemente, meanwhile, establish metrics for quality urban design through regression analysis and field validation in *Measuring Urban Design* and find that older buildings are statistically tied to greater pedestrian activity and constitute an important component of the distinctiveness of a place's urban design. Richard Florida, the creator of the concept of the "creative class," has been outspoken about the value of older buildings.

Older, Smaller, Better: Tucson

Building upon the Preservation Green Lab's research on Seattle, San Francisco, and Washington, D.C., this report focuses on a Southwestern city with a very different history and development pattern. Yet even in this much more auto-oriented city, there is evidence of a connection between urban vitality and older buildings and blocks. More than 50 restaurants and bars in Tucson's downtown occupy historic buildings, and beloved "hole-in-the-wall" cafes and coffee shops are clustered in older, smaller buildings in the North 4th Avenue commercial district, in neighborhoods surrounding the University of Arizona campus, and in a variety of other older commercial districts across the city. These popular culinary enterprises contribute to the distinctive food scene that led Tucson to become the first U.S. city to be recognized as an international City of Gastronomy by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 2015. A recently-opened streetcar provides transit service to the city's close-in neighborhoods, running past historic institutions like the Hotel Congress. From Territorial-period adobe rowhouses in Barrio Viejo to mid-century Modern subdivisions, Tucson wears its history with pride and gusto.

This report explores the relationship between aspects of the built environment and various measures of livability, economic vitality, and residential density and diversity. Funded through the generous support of the Arizona State Historic Preservation Office, the City of Tucson, and the Tucson-Pima County Historical Commission, this report represents the culmination of more than a year of research collaboration between the City of Tucson and the National Trust for Historic Preservation's Preservation Green Lab. The project included mapping of the entire city's built environment according to the age and size of buildings and the diversity of building age.

"From Territorial-period adobe rowhouses in Barrio Viejo to mid-century Modern subdivisions, Tucson wears its history with pride and gusto."

Methodology: Measuring the Urban Landscape

Using geographic information sciences (GIS) and spatial statistics, the Preservation Green Lab aimed to test the hypothesis that older building age, greater diversity of building age, and smaller-sized buildings are associated with greater livability, economic vitality, and residential density and diversity. The study identified significant statistical links between the city's older and historic neighborhoods and commercial districts and more than 80 measures of livability, vitality, density, and diversity. The report includes maps that spotlight sections of the city where these statistical links are especially prominent, as well as areas of opportunity to leverage existing built character to achieve community development goals.

This study extends the methodology established in the Preservation Green Lab's *Older, Smaller, Better* report, which was published in 2014. Whereas that report focused on Seattle, San Francisco, and Washington, DC, this study tests the performance of older, smaller buildings and mixed-vintage blocks in a midsized city with a relatively new building stock and a very different development pattern--Tucson, Arizona. Where the *Older, Smaller, Better* report focused solely on mixed-use and commercial areas, this study also includes residential areas in models focused on social measures, and analysis of the full city to models focused on livability measures. Finally, this study includes new types of data that were not available in other cities, including sales tax revenues generated by businesses over time, detailed data on the locations and openings of Tucson businesses, the locations and values of construction activity for new versus existing buildings over time (calculated from building permit data), a custom-designed walkability index, and relative shade and surface temperatures (calculated from LIDAR and satellite data).

To statistically assess the relationship between characteristics of the built environment and measures of livability, economic vitality, and residential density and diversity, this study focuses on 200-meter by-200 meter sections of the city. For each square section, Preservation Green Lab researchers analyzed parcel and building information using GIS software to compute the median age of all buildings in the section, the diversity of building age for all buildings in the section, and the number of buildings (or partial buildings) that fall within the boundaries of the section. The research team also calculated the percent of all buildings within a grid square that were built before 1945 and before 1920.

The Preservation Green Lab analyzed this data using spatial regression models, including spatial lag and spatial error analysis, to assess the relationships between the predictors of building age, diversity of building age, and the average building size, or granularity, of the built environment on various outcome measures of social and economic density and diversity. Additional statistical models focused on the percent of buildings constructed before 1945 and 1920. In keeping with the methodology established in the original *Older, Smaller, Better* study, the research team also combined data on key characteristics of building fabric into a composite "Character Score" that served as a single measure for testing the role of older, smaller buildings and mixed-vintage blocks. In order to statistically control for other key predictors of vitality, statistical models also accounted for private investment in construction and median income.

As with other forms of multivariate regression, spatial lag and spatial error regression models calculate the extent to which variation in a dependent variable can be accounted for by variation in an array of independent predictor variables. As such, the results of this analysis alone do not signal causal relationships. Furthermore, the research team does not imply that the

buildings by themselves predict or lead to social and economic outcomes. Rather, building on the longstanding theories of Jane Jacobs, Oscar Newman, William H. Whyte, and others, we argue that characteristics of the built environment tend to play a limited—but important—role in influencing behaviors and outcomes.

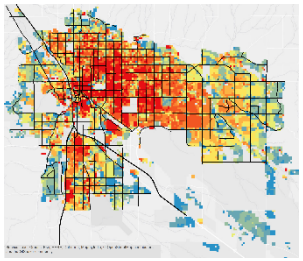
The methodology employed in this study was recently validated by way of publication of a related article, "Jane Jacobs and the Value of Older, Smaller Buildings," in the peer-reviewed *Journal of the American Planning Association* in February 2016.

Defining Terms and Measures

Building age – In *The Death and Life of Great American Cities,* Jane Jacobs points to the importance of older buildings in part because they offer more affordable rents for small and start-up businesses. As she wrote: "Old ideas can sometimes use new buildings. New ideas must use old buildings." For this study, data on building age is drawn from property assessor's records, which were drawn from the Pima County Assessor's database. The measure for building age for each grid square represents the median age of all primary buildings in that grid square.

Diversity of building age – Related to the concept of retaining older buildings is Jacobs' idea that healthy neighborhoods and communities must "mingle buildings that vary in age and condition, including a good proportion of old ones." This is in contrast to districts that are constructed all at once and points to the importance of allowing neighborhoods to change over time at an incremental rate. Diversity of building age is also drawn from property assessor's records. Once building age data was built into the grid squares, the Preservation Green Lab team analyzed and compared the range and distribution of building age within each grid square. The measure of diversity of building age is equivalent to the standard deviation of building ages within a grid square. Neighborhoods with a combination of new and old buildings were assigned higher diversity of building age scores than neighborhoods composed of buildings constructed at around the same time.

Granularity – Granularity refers to the size of buildings and the size of the parcels upon which they are located. Areas of high granularity have many small buildings on small lots, while areas of low granularity have fewer, bigger buildings occupying large lots, sometimes in the form of superblocks. The ability to measure granularity varied in each city according to the data available. In Tucson, granularity is equal to the number of buildings in a grid square.



Median Building Age

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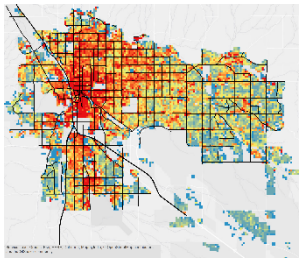

Diversity of Building Age

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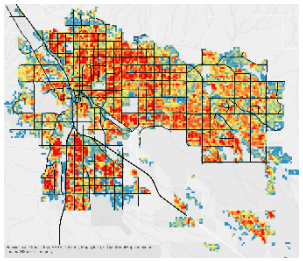

Granularity

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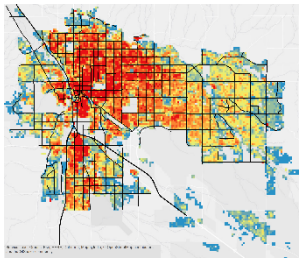

Character Score

From left to right: Maps of Tucson's median building age, diversity of building age, and built granularity. The Character Score measure used in this report combines data on the median age, diversity of building age, and granularity in each grid square.

0.015 Mile
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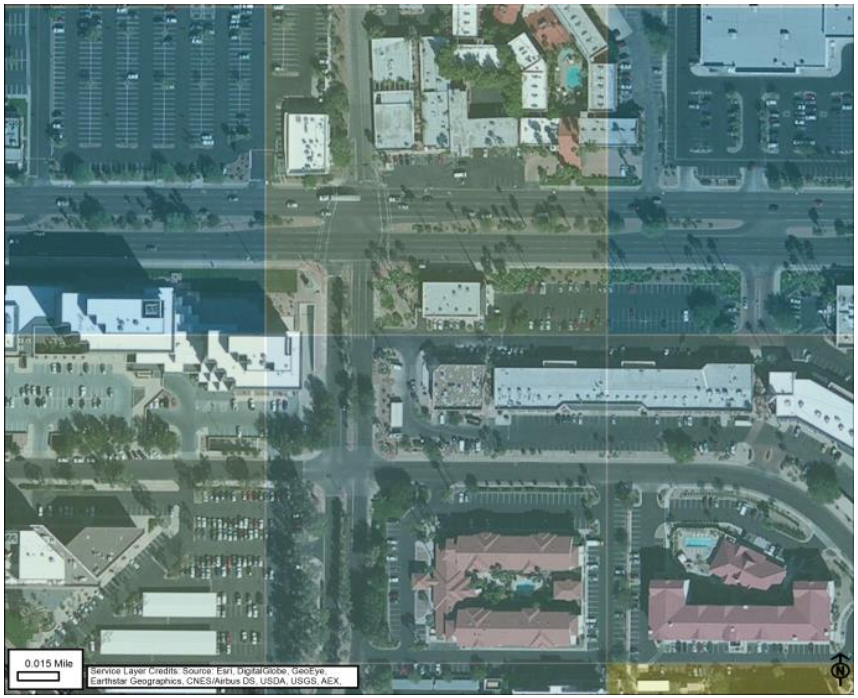

0.015 Mile
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX,

Google

Olive Garden
Google

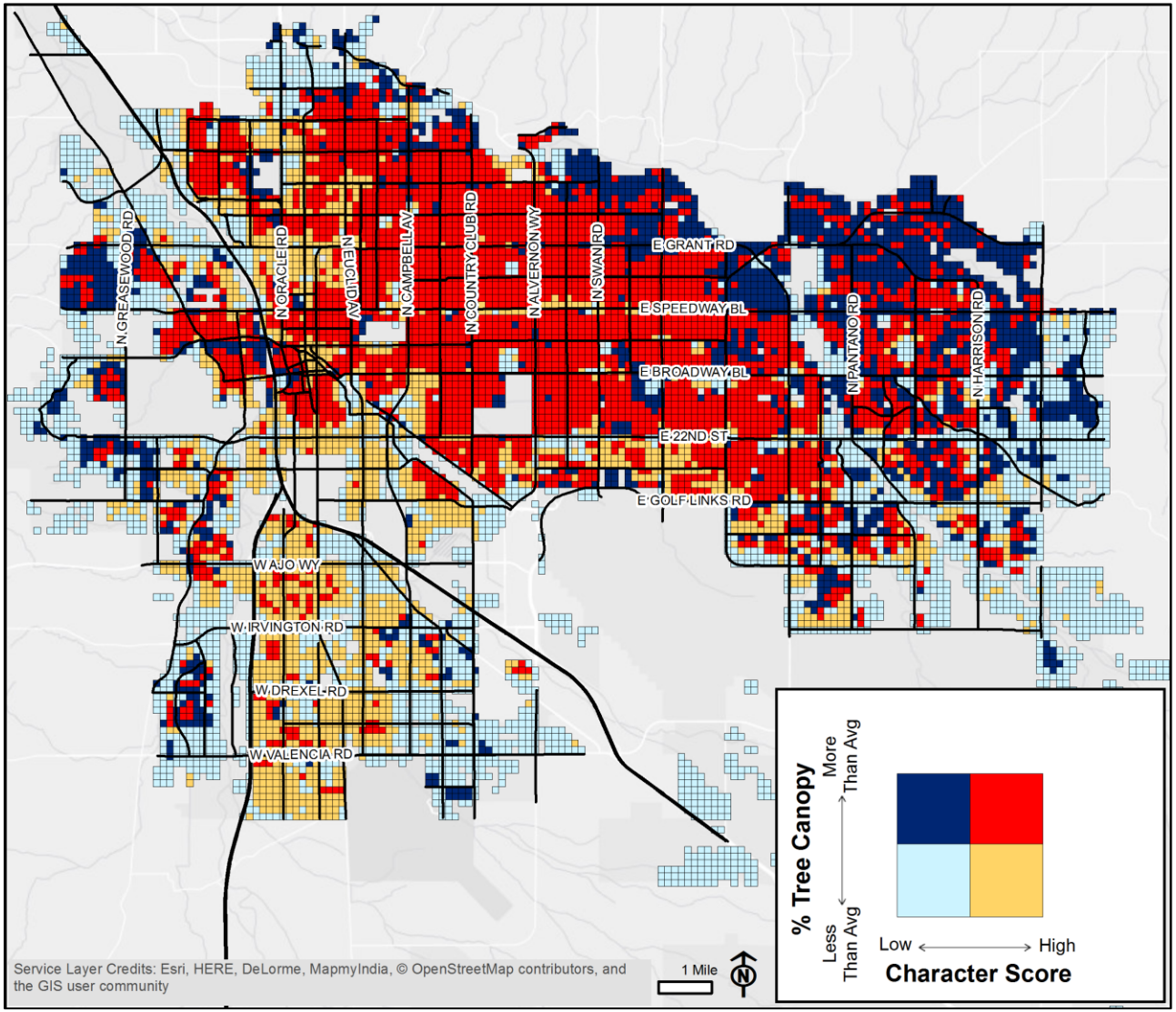
Opposite: High granularity commercial fabric on North 4th Avenue includes small, locally-owned businesses. Right: Low granularity commercial fabric on E Broadway Blvd. includes chain restaurants. Street level images credit: Google, Inc., 2016.

Findings: Tucson's Older, Smaller Buildings Support Greater Vitality

This research shows that Tucson's older, smaller buildings and mixed-vintage blocks support greater neighborhood livability, economic vitality, and residential density and diversity. Areas of the city with older and historic buildings are more walkable, have more top-rated restaurants and non-chain businesses, have greater density of jobs in new businesses and small businesses, and have greater residential density. Small-scale buildings and parcels allow more diverse ownership, support small business development, and facilitate mixed uses. Neighborhoods and cities made up of multiple, smaller parts are more resilient and adaptable to change. Furthermore, analysis of trends in construction and demolition reveal that retrofits and repairs to existing buildings take place across larger swaths of the city's geography and continue with less volatility through difficult economic times, compared to new construction.

The following pages contain further explication of these findings, beginning with results related to neighborhood livability and economic vitality, then moving to results related to residential density and diversity, and concluding with construction and demolition trends. Many pages in the findings section of the report illustrate high-performing areas with darker reds and blues and low-performing areas with light orange and blue coloration. On these maps, warmer colors indicate areas with older, smaller buildings and mixed-vintage blocks, and cooler colors indicate areas that primarily have large, new buildings. These maps thus show the relative performance of the city's older and newer neighborhoods. The maps also enable the reader to understand at a glance where the city has older and mixed-vintage building stock that may be leveraged to greater effect.

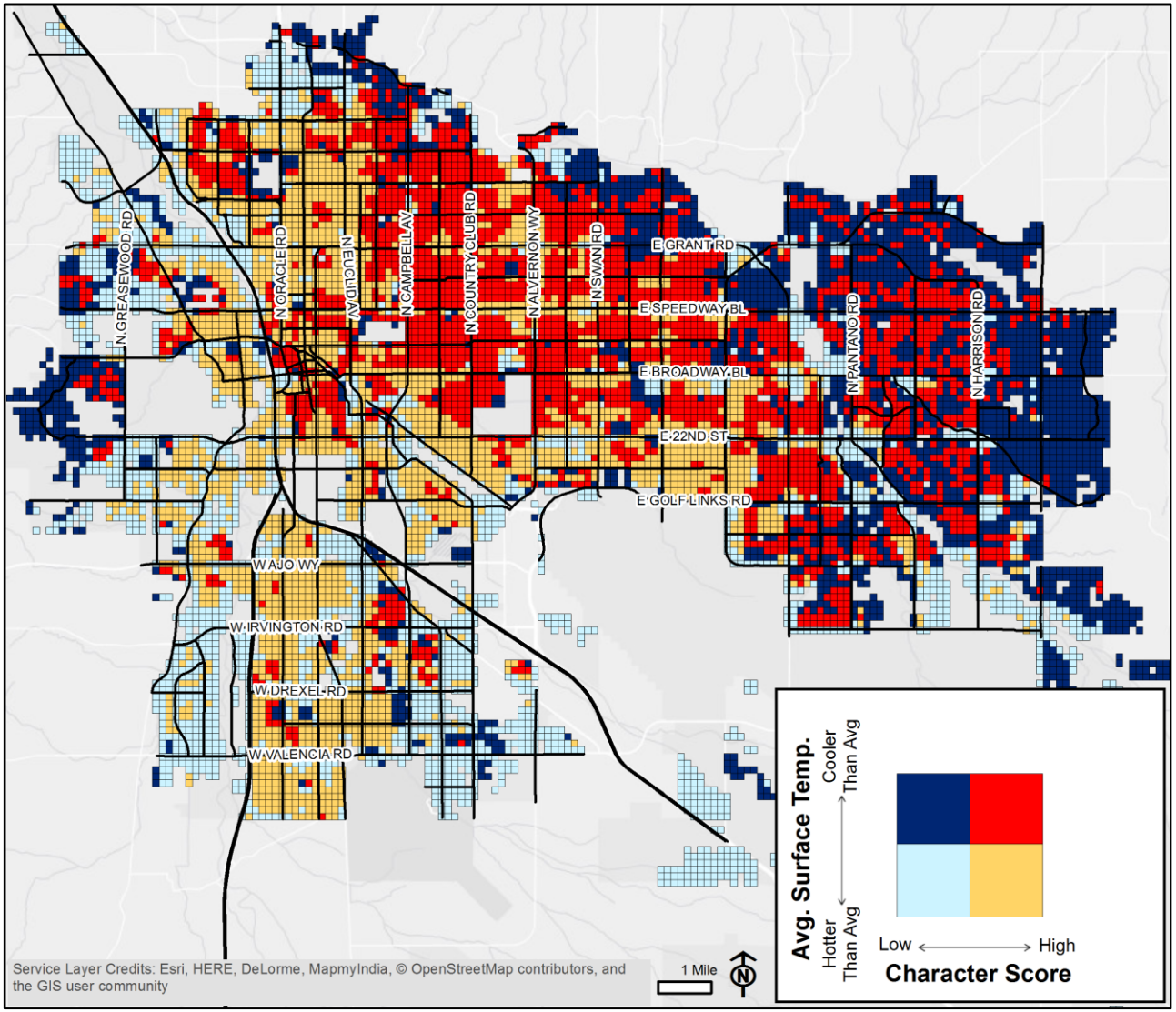
Mesquite and Palo Verde trees provide relief from the sun in old neighborhoods like Armory Park, a historic district south of Tucson's downtown. Photo Credit: Mike Powe, National Trust for Historic Preservation.



Map combines Character Score data and tree canopy data. Darker colors indicate greater than citywide average percent tree canopy coverage. Red and orange squares have high Character Scores, indicating the presence of older, smaller buildings and mixed-vintage blocks. Blue squares have low Character Scores, indicating that the building stock is composed of relatively large, new buildings constructed at around the same time period.

It's Easier to Find Shade in Areas with Older, Smaller Buildings

In this part of the U.S., shade is a key livability factor. Using tree canopy data constructed from high-resolution aerial 3D-laser scanning (LIDAR) data provided by the Pima Association of Governments, the Preservation Green Lab research team analyzed the relationship between Tucson's tree canopy and its built environment. We find clear evidence that areas with older, smaller buildings and a fine-grained mix of old and new buildings have significantly greater shade from tree canopy. On average, about 11 percent of high Character Score areas are shielded from the sun by trees, compared to nearly eight percent in low Character Score areas. Older and historic buildings are often on shadier blocks. In the oldest quarter of the city, the average percent tree canopy is more than double what's found on the newest quarter of the city by the median building age metric.

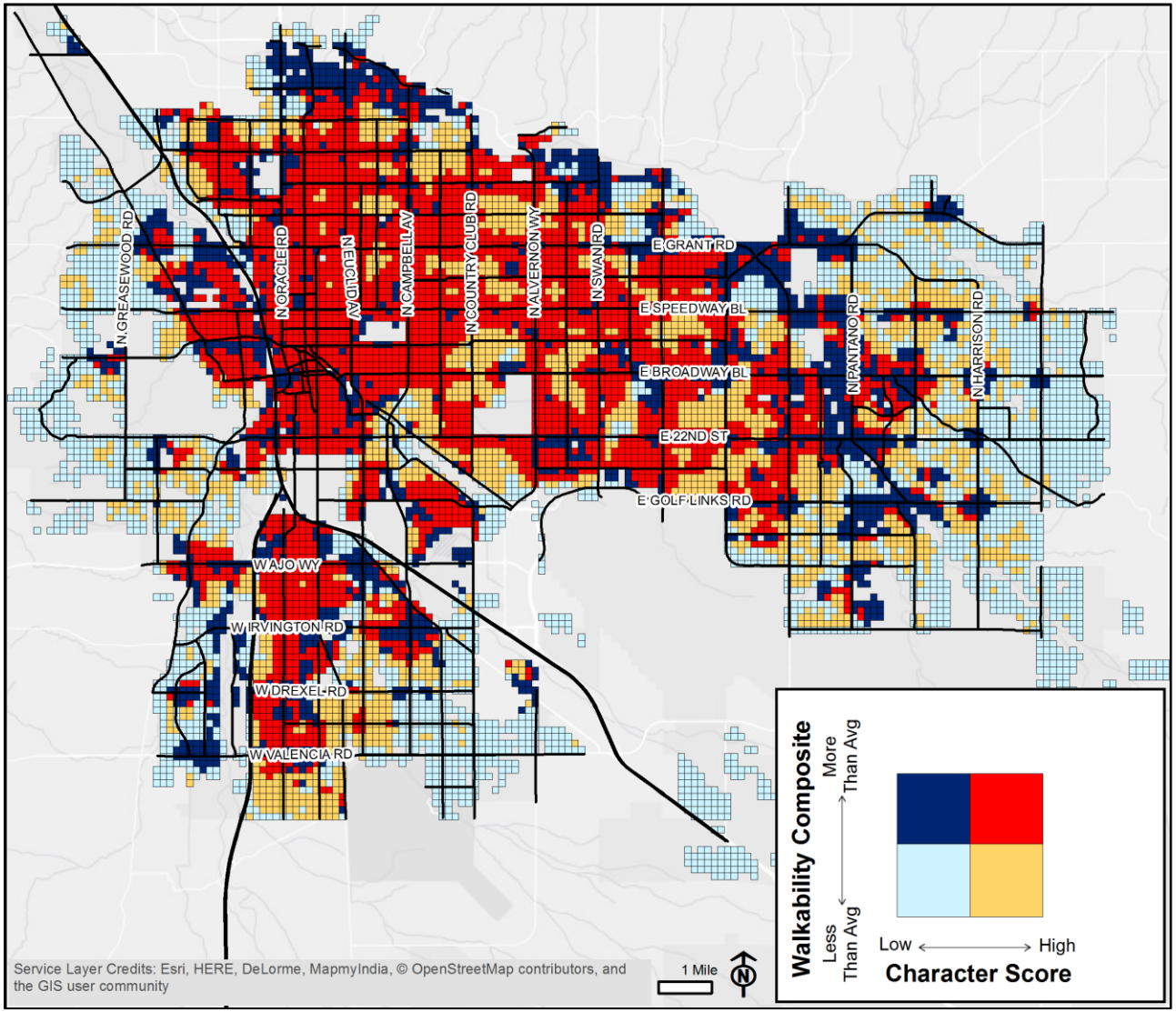


Map combines Character Score data and average surface temperature data. Darker colors indicate cooler than average surface temperatures and lighter colors indicate warmer than average surface temperatures. Red and orange squares have high Character Scores, indicating the presence of older, smaller buildings and mixed-vintage blocks. Blue squares have low Character Scores, indicating that the building stock is composed of relatively large, new buildings constructed at around the same time period.

Older Parts of Tucson are Cooler

Using surface temperature data developed from infrared satellite imagery in a study by Halper, Scott, and Yool* we assessed Tucson's average surface temperatures according to the median building age, diversity of building age, granularity, and Character Score. There is a significant statistical link between cooler surface temperatures and older, smaller buildings. The surface temperatures of grid squares with median building age below the citywide median were nearly a full degree cooler (0.9 degrees Fahrenheit) on average than the half of the city with comparatively new buildings. On average, parts of Tucson where at least 20 percent of the structures were built before 1945 have surface temperatures that are a half degree cooler than parts of the city with less than 20 percent of prewar buildings.

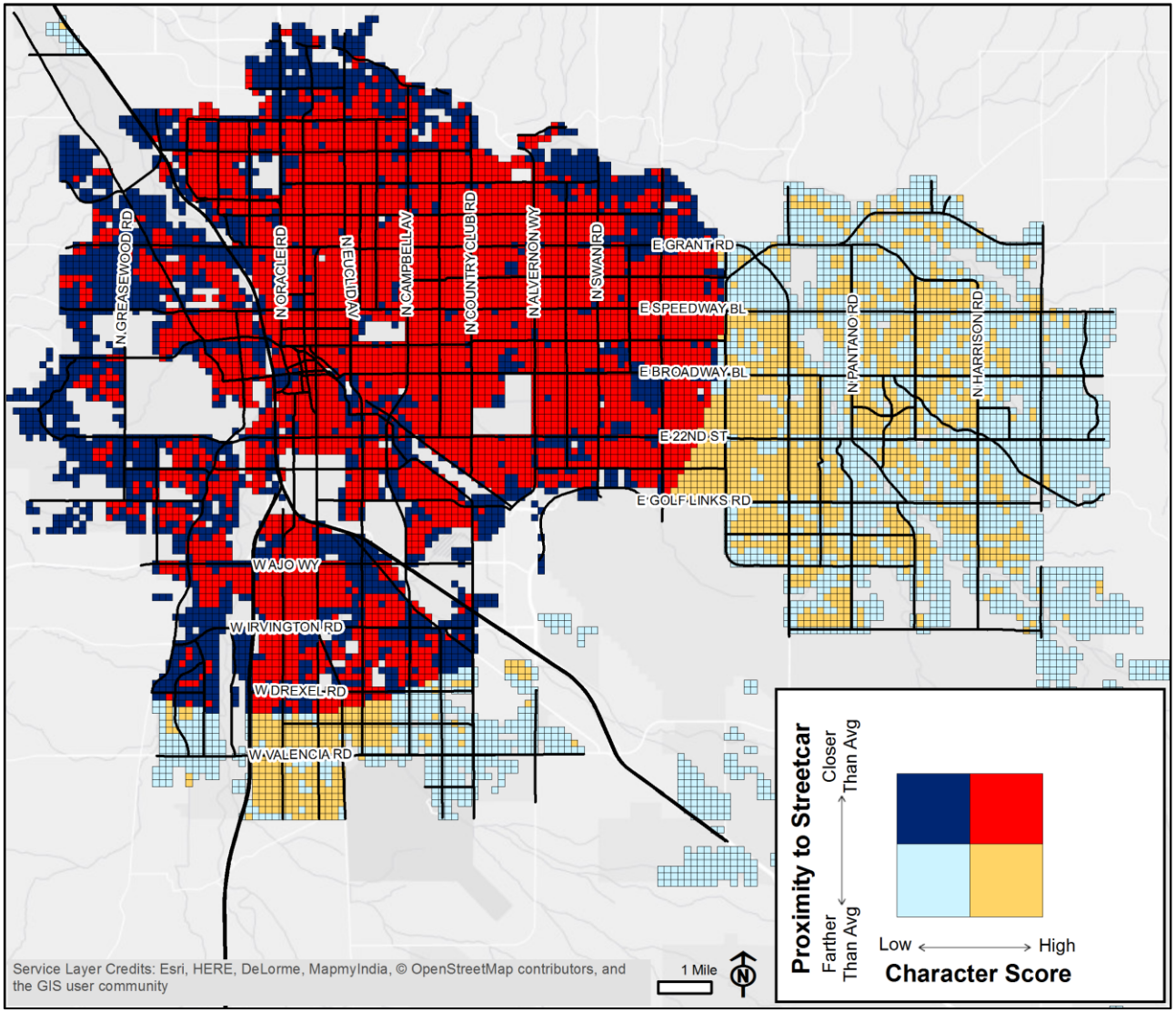
** Correlating vegetation, water use and surface temperatures in a semi-arid city: A multi-scale analysis of the impacts of irrigation by single-family residences. Eve B. Halper, Christopher A. Scott, Stephen R. Yool, Geographical Analysis (2012) 44, 235-257.*



Map combines Character Score data and walkability data. Darker colors indicate greater than citywide average scores on a locally-developed walkability composite metric. Red and orange squares have high Character Scores, indicating the presence of older, smaller buildings and mixed-vintage blocks. Blue squares have low Character Scores, indicating that the building stock is composed of relatively large, new buildings constructed at around the same time period.

Areas with Older Buildings are More Walkable

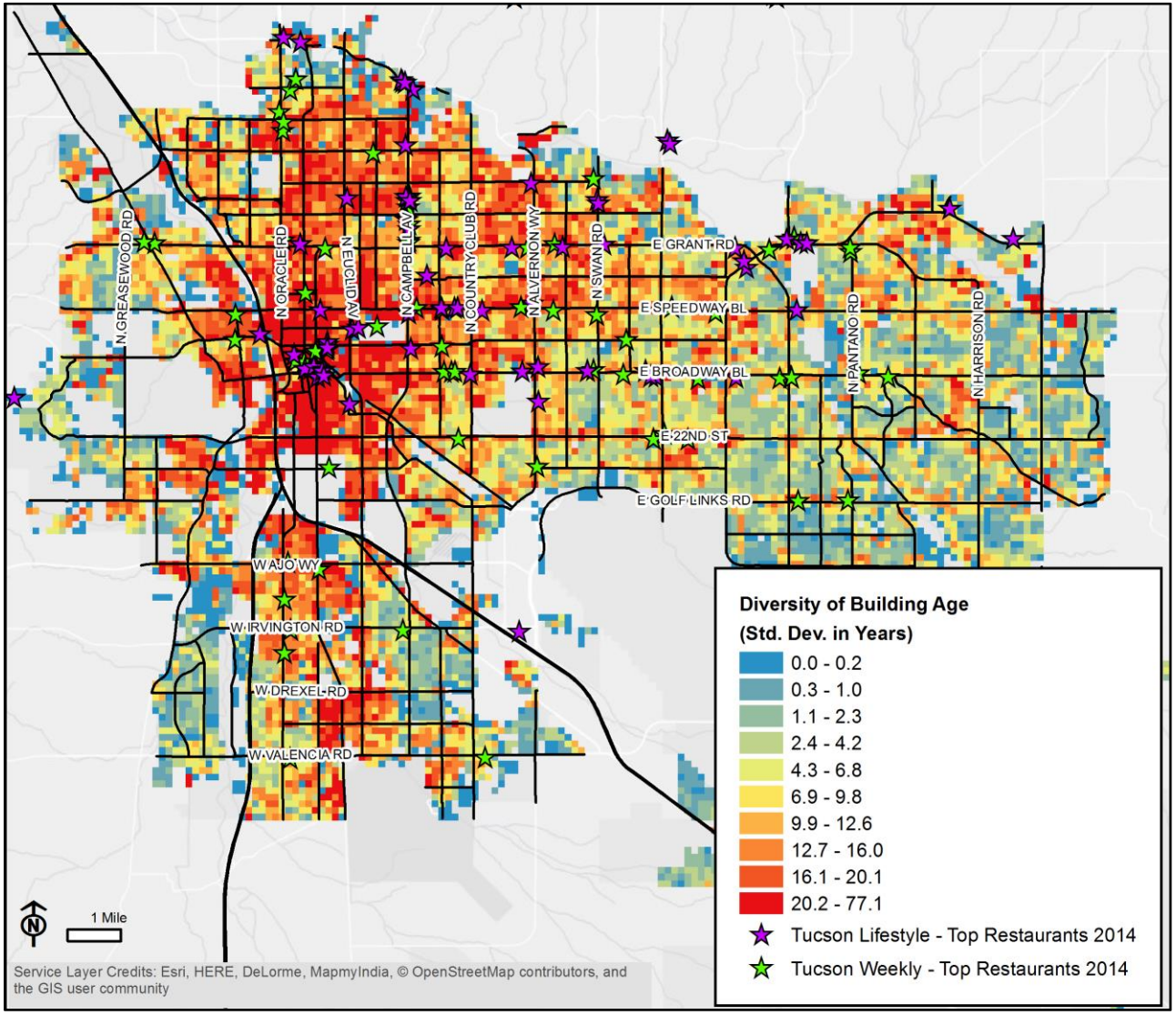
The Green Lab research team compared the walkability of areas with older, smaller buildings and mixed-vintage blocks to areas with mostly large, new buildings constructed at approximately the same time. Using a walkability composite index developed by the Pima Association of Governments, we find that areas with older median building age, greater diversity of building age, and higher percentages of buildings constructed before 1945 and before 1920 are significantly more walkable. Sixty-two percent of high Character Score grid squares have above average walkability composite scores. Just 34 percent of low Character Scores have above average walkability composite scores. Ninety-four percent of grid squares with at least one building constructed before 1920 have higher than the citywide average walkability composite score.



Map combines Character Score data and the distance to the closest streetcar stop. Darker colors indicate greater than average proximity. Red and yellow squares are high Character Score areas with older, smaller buildings and mixed-vintage blocks. Blue squares have larger, newer buildings.

Areas with Older Buildings are More Streetcar Accessible

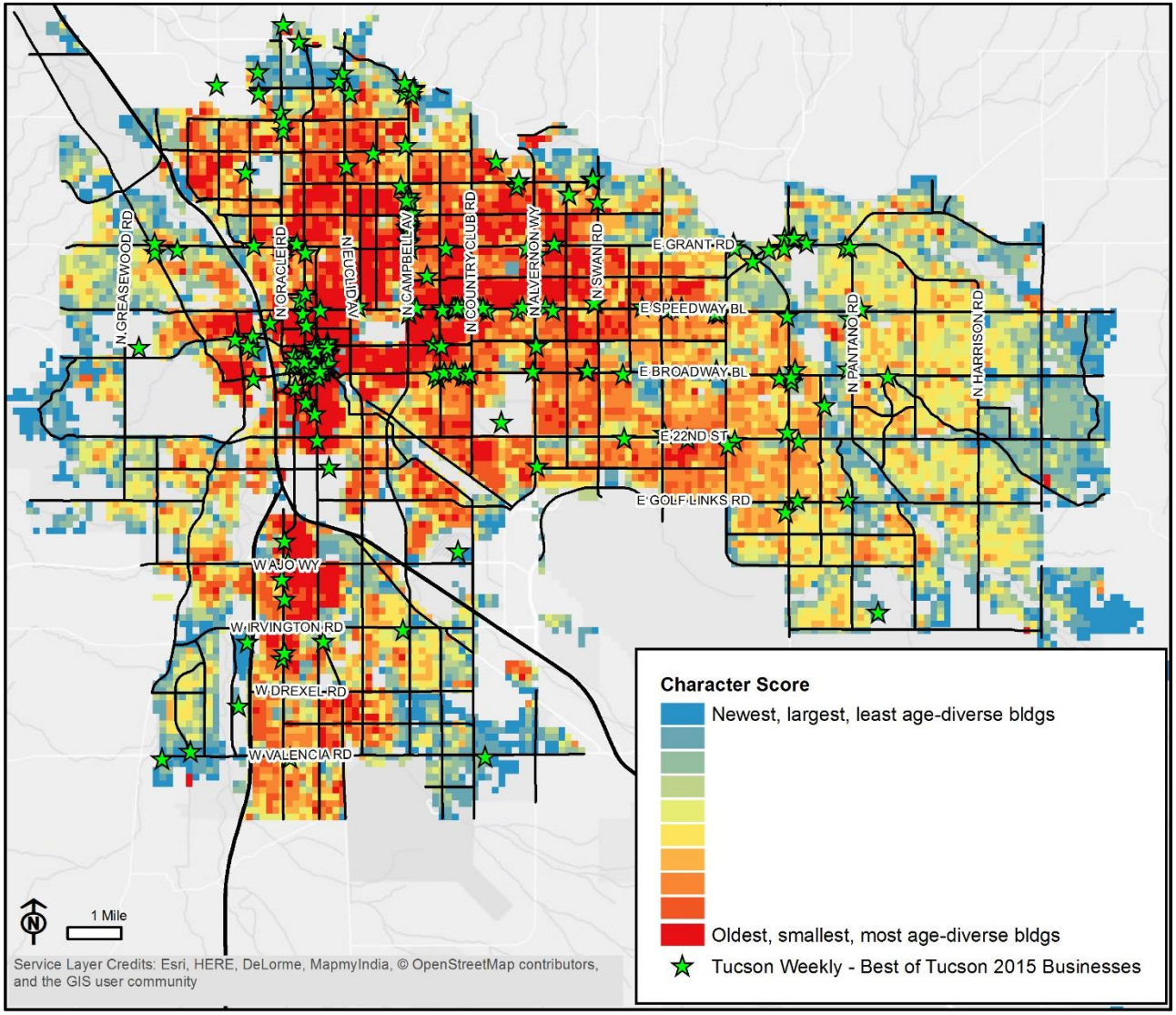
Sun Link, Tucson's streetcar system, opened in July 2014, connecting the University of Arizona, North 4th Avenue business district, downtown, and neighborhoods on the west side of downtown. Older median building age, greater diversity of building age, greater granularity, and higher percentages of buildings constructed before 1945 all significantly predict lower distances to streetcar stops. This comes as no surprise. Areas within walking distance of Sun Link stops generally have older and historic buildings and fine-grained blocks. Whereas the median building age in the average grid square in Tucson is 1975, the average median building age in grid squares within ¼-mile of a streetcar stop is 1955. On average, 38 percent of buildings were built before 1945 in grid squares within ¼ mile walk of a streetcar stop, compared to an average of four percent of buildings in the average grid square citywide.



Map includes grid squares colored according to their diversity of building age, as well as pink and green colored stars indicating the locations of top-rated bars and restaurants included on lists assembled by Tucson Lifestyle and Tucson Weekly.

Tucson's Best Restaurants are on Blocks with Old Buildings

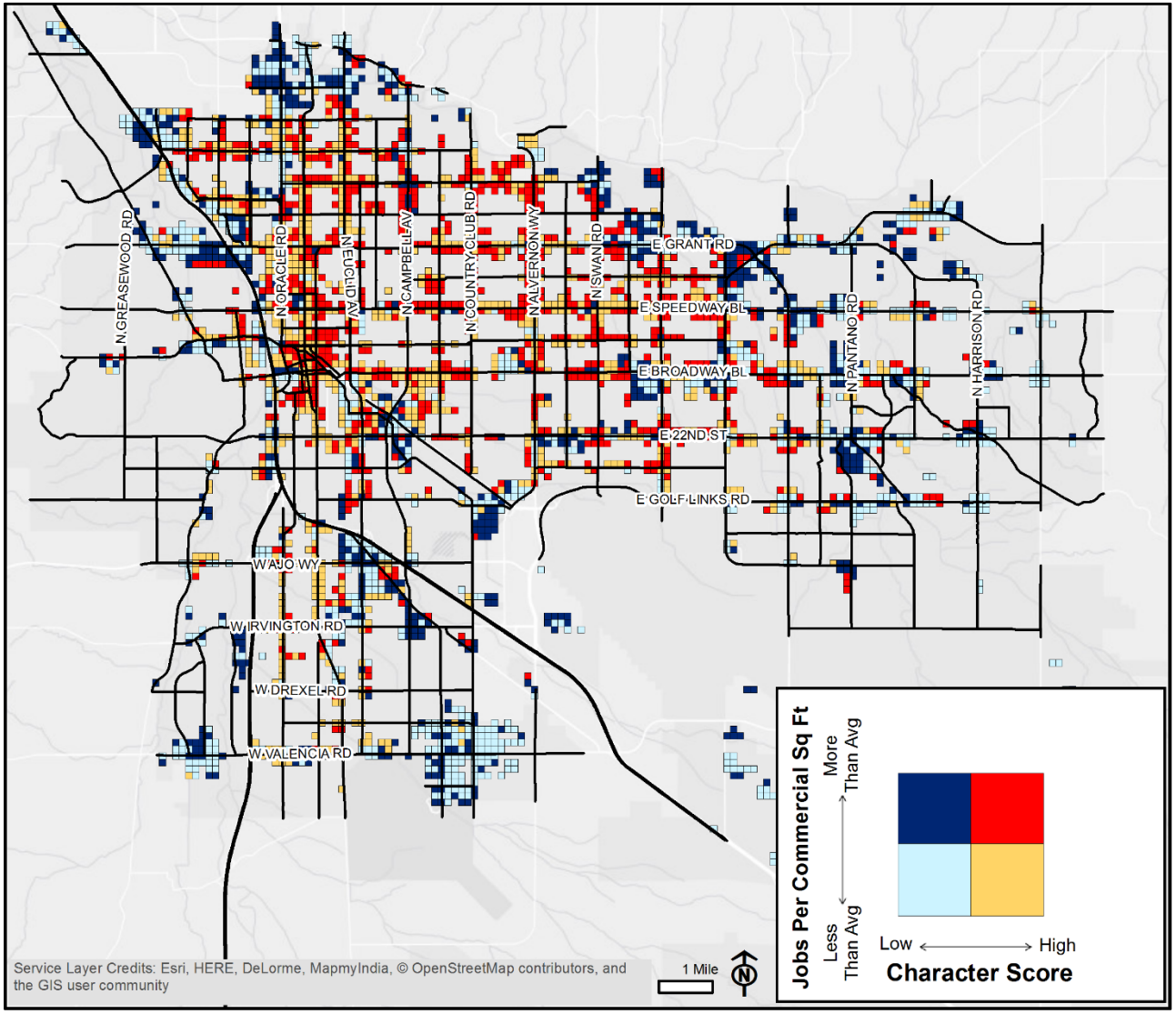
In 2015, Tucson became the first city in the United States to receive designation as an international City of Gastronomy by the United Nations Educational, Scientific, and Cultural Organization (UNESCO). We analyzed the locations of the city's best restaurants and bars, as listed on two recent "Best of Tucson" lists assembled by the local publications *Tucson Weekly* and *Tucson Lifestyle* based on readers' votes. We find that greater diversity of building age and greater percentages of buildings constructed before 1945 are predictors of the presence of top-rated restaurants and bars. The average standard deviation of building age in grid squares with a top-rated restaurant or bar is 14.7 years, far more than the citywide average of 8.8 years. In grid squares with top-rated establishments, an average of 10 percent of the buildings was constructed before 1945, compared to four percent citywide.



Map combines Character Score data and the locations of places included on Tucson's Weekly "Best of Tucson 2015" list. Red and orange squares on the map indicate areas with older, smaller buildings and mixed-vintage blocks, and blue and green squares indicate areas with mostly large, new buildings. Top-rated places are clustered in high Character Score areas.

The "Best of Tucson" is Found in the Oldest Areas of the City

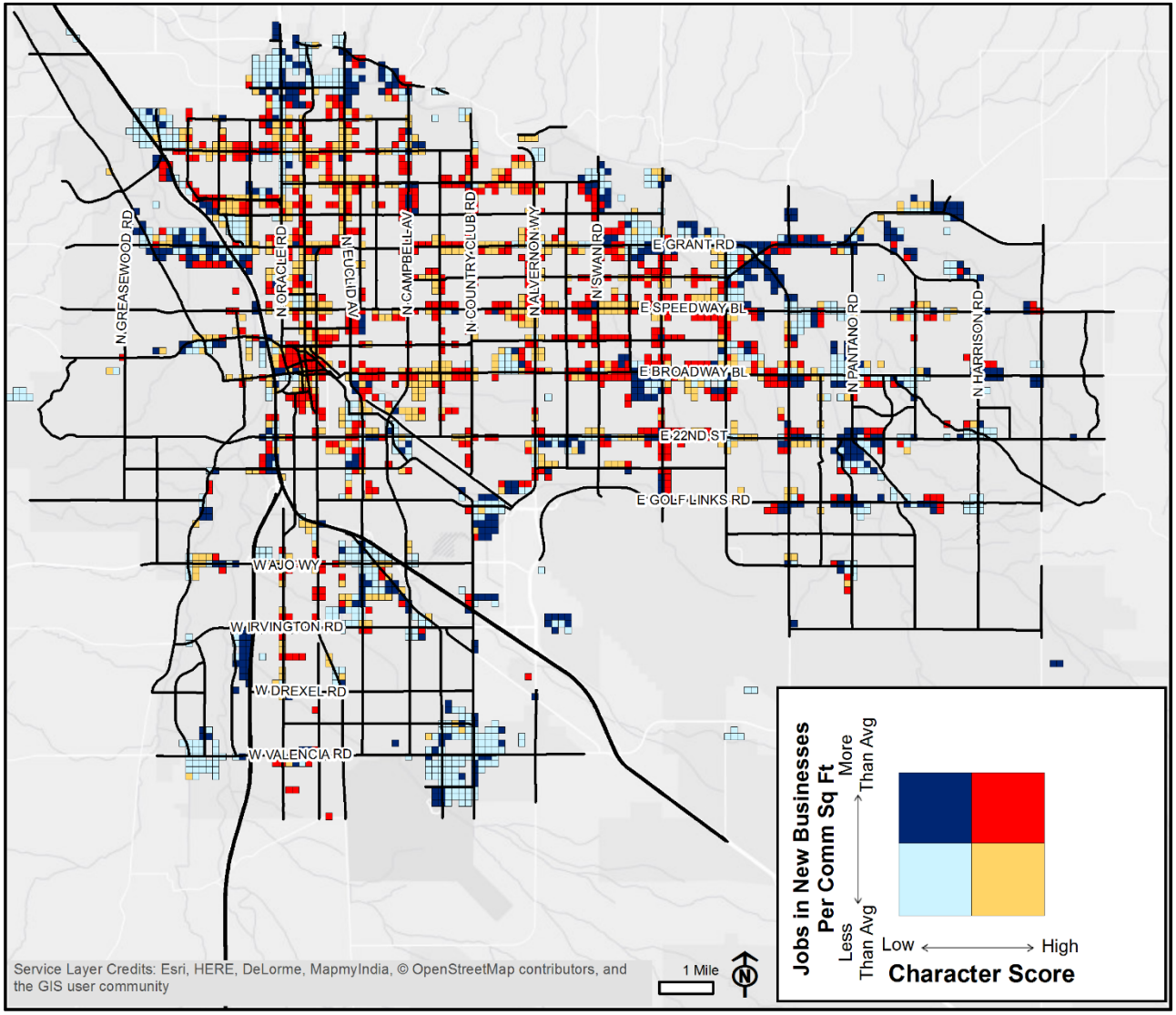
Using *Tucson Weekly*'s 2015 "Best Of Tucson" list, we extended the "Best Restaurants and Bars" analysis and included all the businesses and places with discrete locations recognized in 2015. This list includes art galleries and movie theatres; farmers markets, auto repair, shops, and yoga studios. It includes beloved places ranging from the best playground to the best tattoo parlor. We find that older median building age, higher Character Scores, and higher percentages of buildings constructed before 1945 and 1920 act as significant predictors of the locations of these top-rated businesses and places. In grid squares with "Best of" locations, an average of 12 percent of buildings was constructed before 1945, compared to four percent citywide. Half of the buildings in grid squares with these businesses, parks, and other places were constructed before 1967, compared to a median year built of 1974 citywide.



Map combines Character Score data and data on the number of private sector jobs per commercial square foot of space. Darker colors indicate greater job density than citywide average. Red and yellow squares are high Character Score areas with older, smaller buildings and mixed-vintage blocks. Blue squares have larger, newer buildings.

Areas with Older, Smaller Buildings are Packed with Jobs

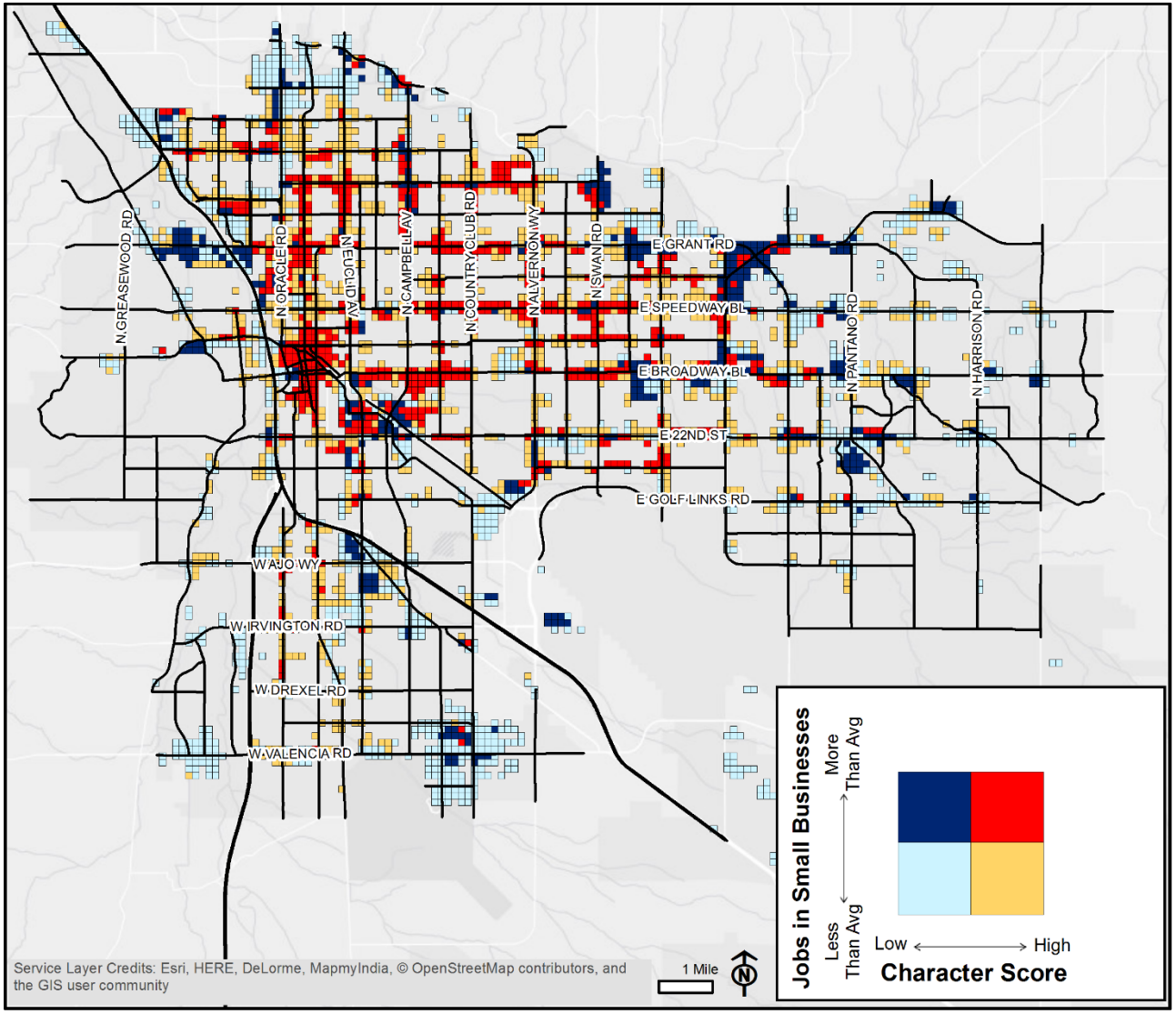
Consistent with past Preservation Green Lab research on Seattle, San Francisco, and Washington, D.C., Tucson's Character Score composite index predicts significantly greater concentrations of jobs per square foot of commercial space. Forty-one percent of high Character Score areas have greater than the citywide average number of jobs per commercial square foot, compared to 26 percent of areas with mostly large, new buildings. We also analyzed the change in the count of jobs between 2009 and 2013, both as an aggregate count and on a commercial-square-foot basis. We find that areas with high diversity of building age and high percentages of buildings constructed before 1920 saw significantly greater increases in their counts of jobs over that time period.



Map combines Character Score data and data on the number of jobs in new businesses per commercial square foot of space. Darker colors indicate greater density of jobs in new businesses than citywide average. Red and yellow squares are high Character Score areas with older, smaller buildings and mixed-vintage blocks. Blue squares have larger, newer buildings.

Jobs in New Businesses are Concentrated in Tucson's Older and Historic Areas

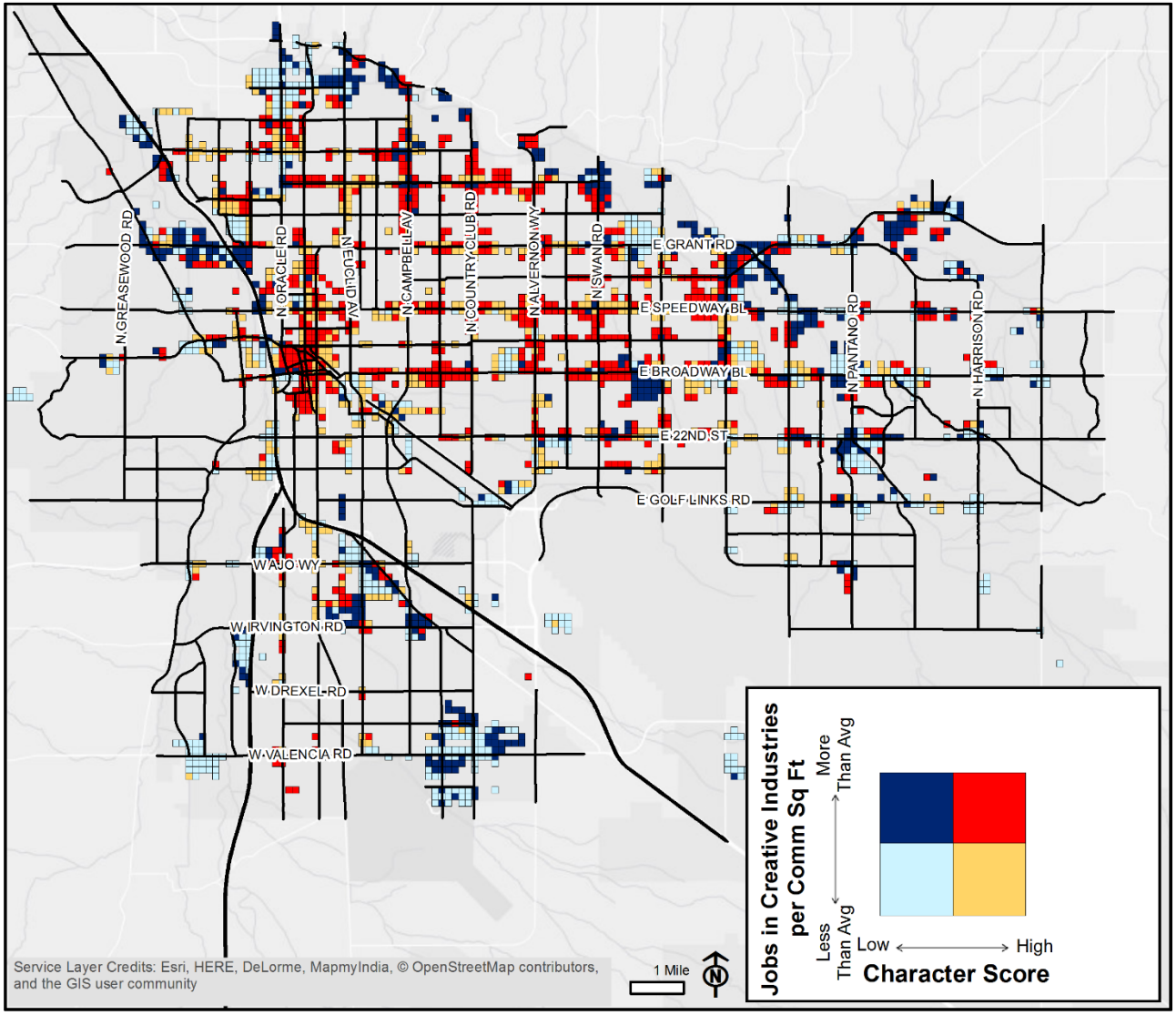
This research finds clear evidence supporting the hypothesis that areas with older, smaller buildings act as fertile ground for incubating new businesses. We find significantly greater counts of jobs in new businesses per square foot of commercial space in areas with older median building, greater granularity of built fabric, higher Character Scores, and higher percentages of buildings constructed before 1945 or 1920. Areas with at least one building constructed before 1920 have an average of 5.6 jobs in new businesses, compared to an average of 2.5 jobs in new businesses citywide. The granularity of the built fabric also has a particularly strong statistical link to the density of jobs per commercial square foot. More than twice as many areas with high granularity had at least one job in a new business per 1,000 square feet of commercial space compared to areas with low granularity and larger buildings.



Map combines Character Score data and data on the number of jobs in small businesses. Darker colors indicate more jobs in small businesses than citywide average. Red and yellow squares are high Character Score areas with older, smaller buildings and mixed-vintage blocks. Blue squares have larger, newer buildings.

High Character Score Areas Provide Opportunities for Tucson's Small Businesses

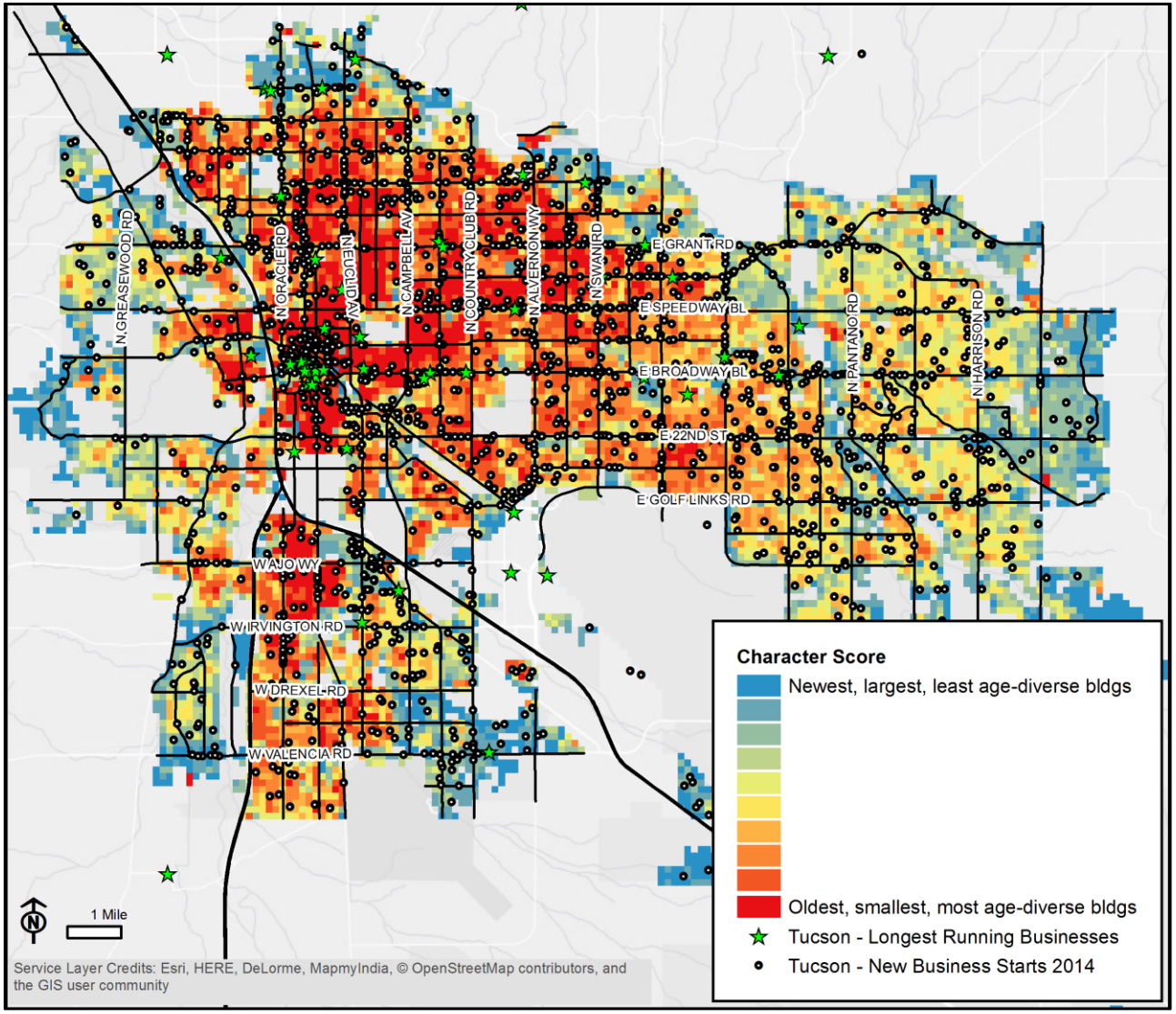
Areas of Tucson with older, smaller buildings and mixed-vintage blocks play a critical role in supporting the city's small businesses and the jobs they provide. We find that older building age, greater diversity of building age, and smaller building size are significant predictors of the number of jobs in small businesses. Areas of the city with predominantly smaller, older buildings or mixed-vintage blocks have an average of 20 percent more jobs in small businesses than areas with mostly larger, newer buildings. On average, high Character Score grid squares have 8.5 jobs in small businesses, and 42 percent of the jobs in these areas are in small businesses. In comparison, areas with low Character Scores—indicating larger, newer buildings--have an average of 5.7 jobs in small businesses, and 22 percent of the jobs in these areas are in small businesses.



Map combines Character Score data and data on the number of jobs in creative industries per square foot of commercial space. Darker colors indicate greater than average density of jobs in creative industries per commercial square foot. Red and yellow squares are high Character Score areas with older, smaller buildings and mixed-vintage blocks. Blue squares have larger, newer buildings.

Creative Industries are Concentrated in Areas with Older, Smaller Buildings

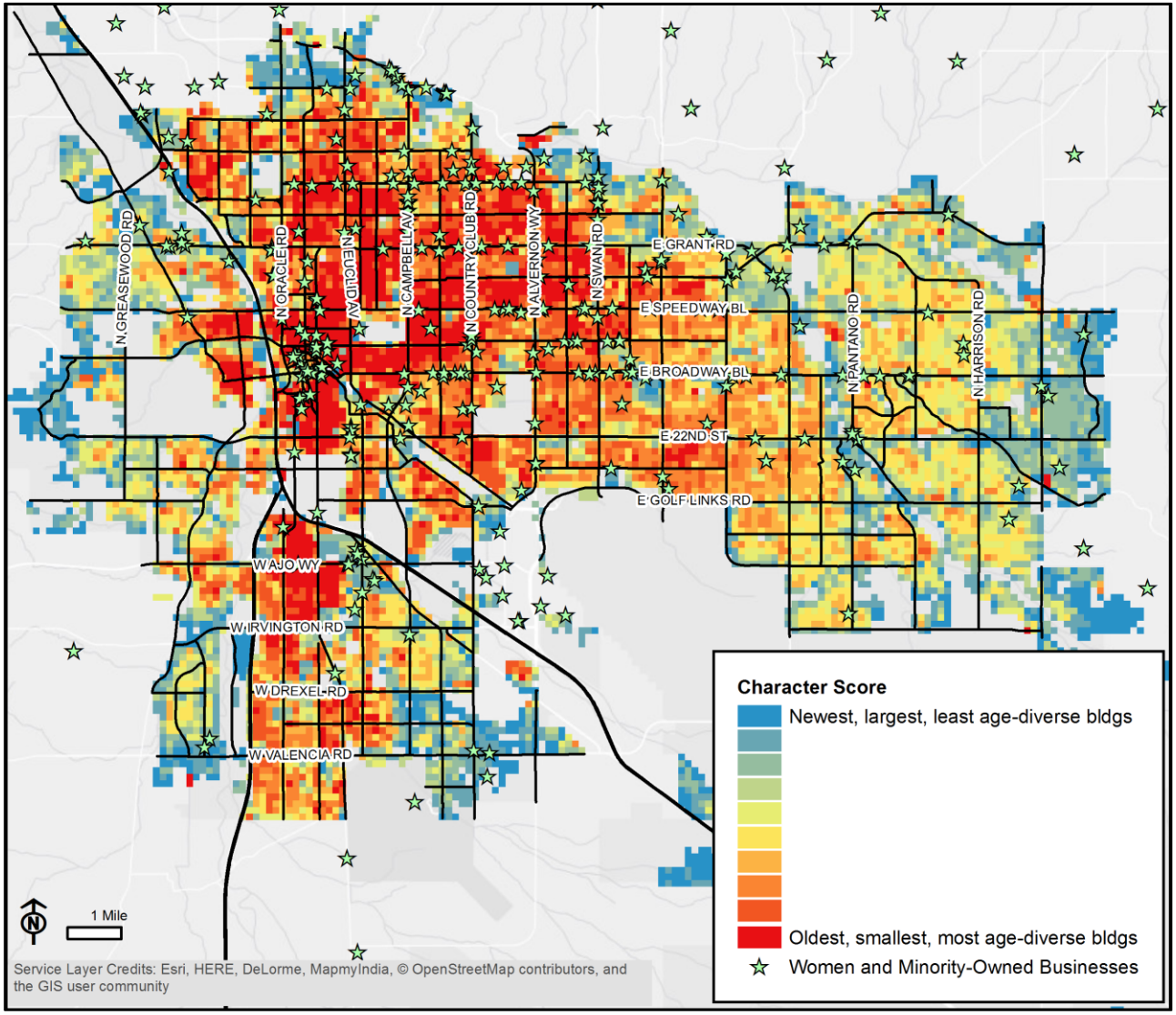
Jobs in creative industries tend to cluster in areas of Tucson with older, smaller buildings and higher percentages of buildings constructed before 1945 and 1920. About five percent of Tucson's grid squares in commercial areas have at least one building constructed before 1920, but this small portion of the city's total area houses over 10 percent of the city's total number of jobs in creative industries. High Character Score areas have 20 percent more jobs in creative industries than areas with larger, newer buildings. There are an average six jobs in creative industries in areas with older, smaller buildings and mixed-vintage blocks and an average of 4.8 jobs in creative industries in areas with mostly large, new buildings. Thirty-five percent more high Character Score areas than low Character Score areas have at least one job in creative industries per 1,000 commercial square feet.



Map combines Character Score data and the locations of Tucson's longest-running businesses and businesses newly licensed in 2014. Red and orange squares indicate areas with older, smaller buildings and mixed-vintage blocks, and blue and green color indicates mostly large, new buildings. Both old and new businesses concentrate in high Character Score areas.

A Mix of Old and New Buildings Fosters a Mix of Tucson's Oldest and Newest Businesses

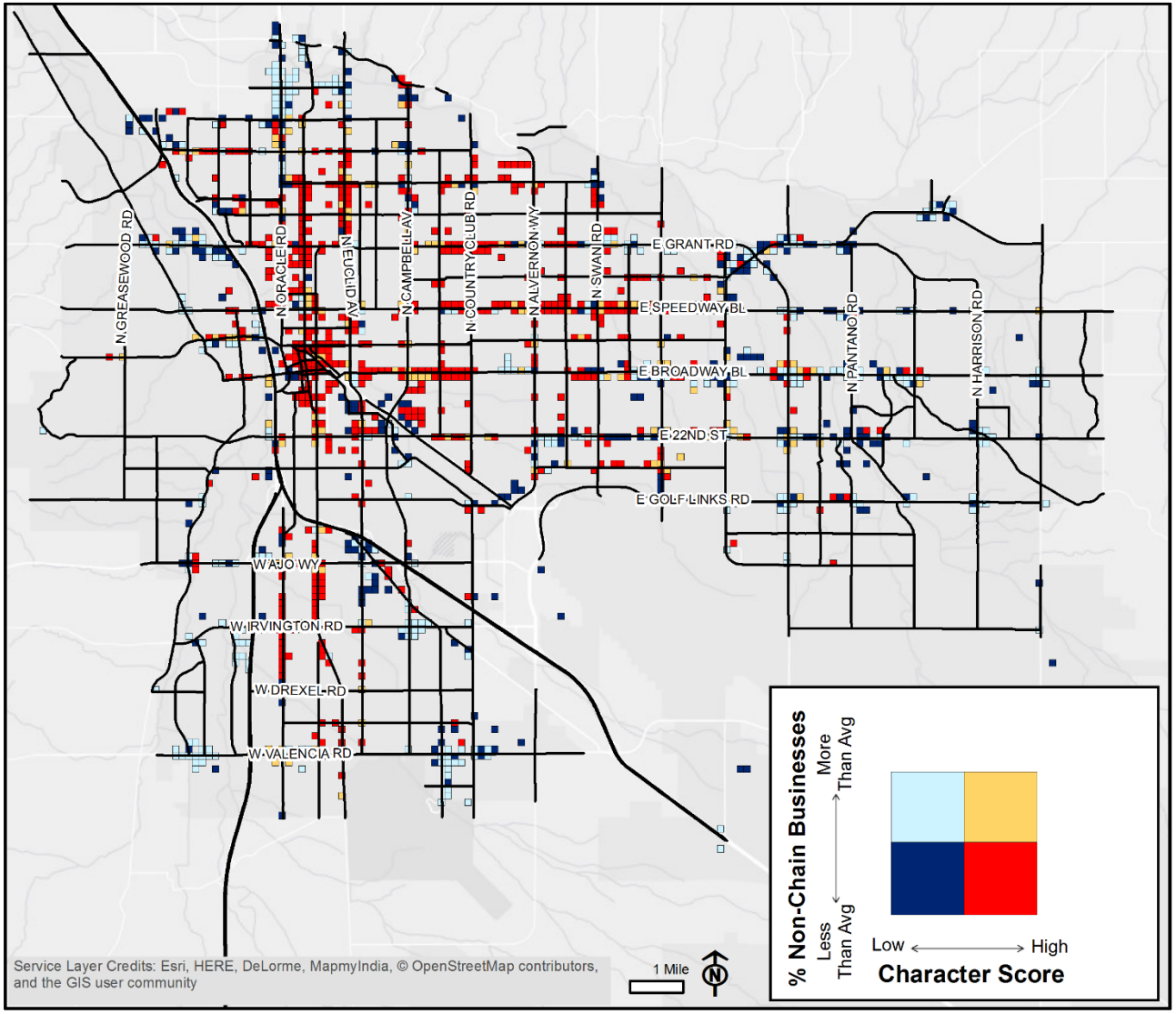
Areas with older, smaller buildings and mixed-vintage blocks have many of Tucson's newest businesses as well as many of the city's longest-running businesses. Our analysis shows that older median building age is a significant predictor of the density of new business licenses. Meanwhile, greater diversity of building age and higher percentages of buildings constructed before 1920 and 1945 are significant predictors of the locations of Tucson's oldest businesses. Fifteen percent of grid squares with older median building age than the citywide median had at least two *new* business starts in 2014, compared to 13 percent of grid squares with newer buildings. Old buildings in Tucson also house the city's *oldest* businesses. While about 25 percent of the city's grid squares in commercial areas have at least one pre-1945 building, these areas house 47 percent of the city's oldest businesses.



Map combines Character Score data and the locations of Tucson's women and minority-owned businesses. Red and orange squares indicate areas with older, smaller buildings and mixed-vintage blocks, and blue and green color indicates mostly large, new buildings. Women and minority-owned businesses are clustered in areas with high diversity of building age.

Women and Minority-Owned Businesses Locate in Tucson's Oldest Areas

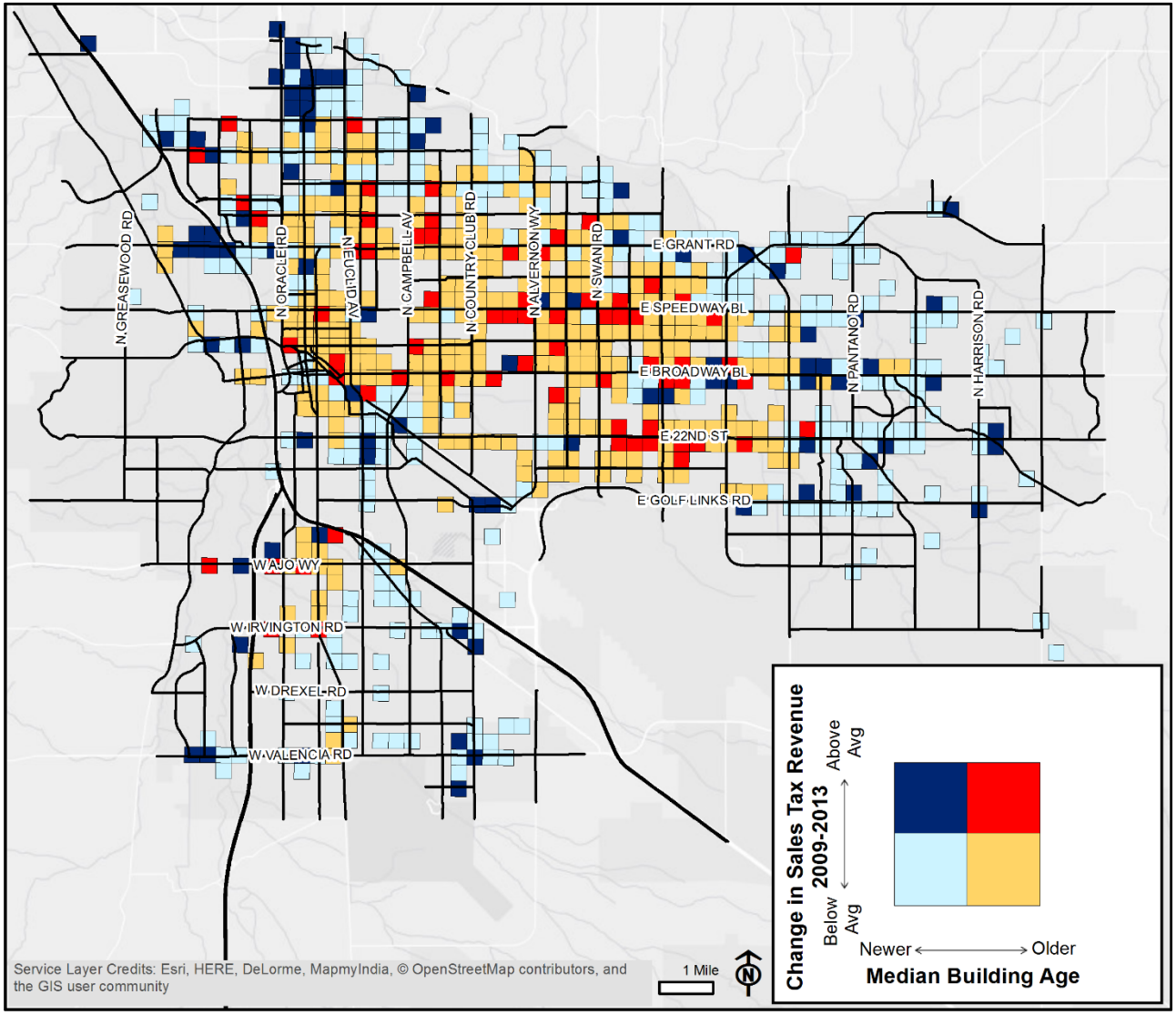
This research finds a significant statistical links between the presence of women and minority-owned businesses, diversity of building age, and percentage of buildings constructed before 1920. Areas with the greatest density of women and minority-owned businesses have a standard deviation of building age of 17.1 years, far more than the average of 12.9 years found in commercial areas citywide. Areas with greater than median diversity of building age account for 60 percent of the city's total number of women and minority-owned businesses in 50 percent of the city's commercial areas. Likewise, though only six percent of grid squares that have at least one business and one employee have at least one building constructed before 1920, 14 percent of the city's women and minority-owned businesses are located in these areas.



Map combines Character Score data and data on the percent of restaurants and retailers that are not chain establishments. Darker colors indicate greater than average percent non-chain businesses. Orange and red coloration indicates that the grid square has older, smaller buildings and mixed-vintage blocks. Blue coloration indicates mostly large new buildings.

Older, Smaller Buildings Provide Spaces for Tucson's Independent Restaurants and Retailers

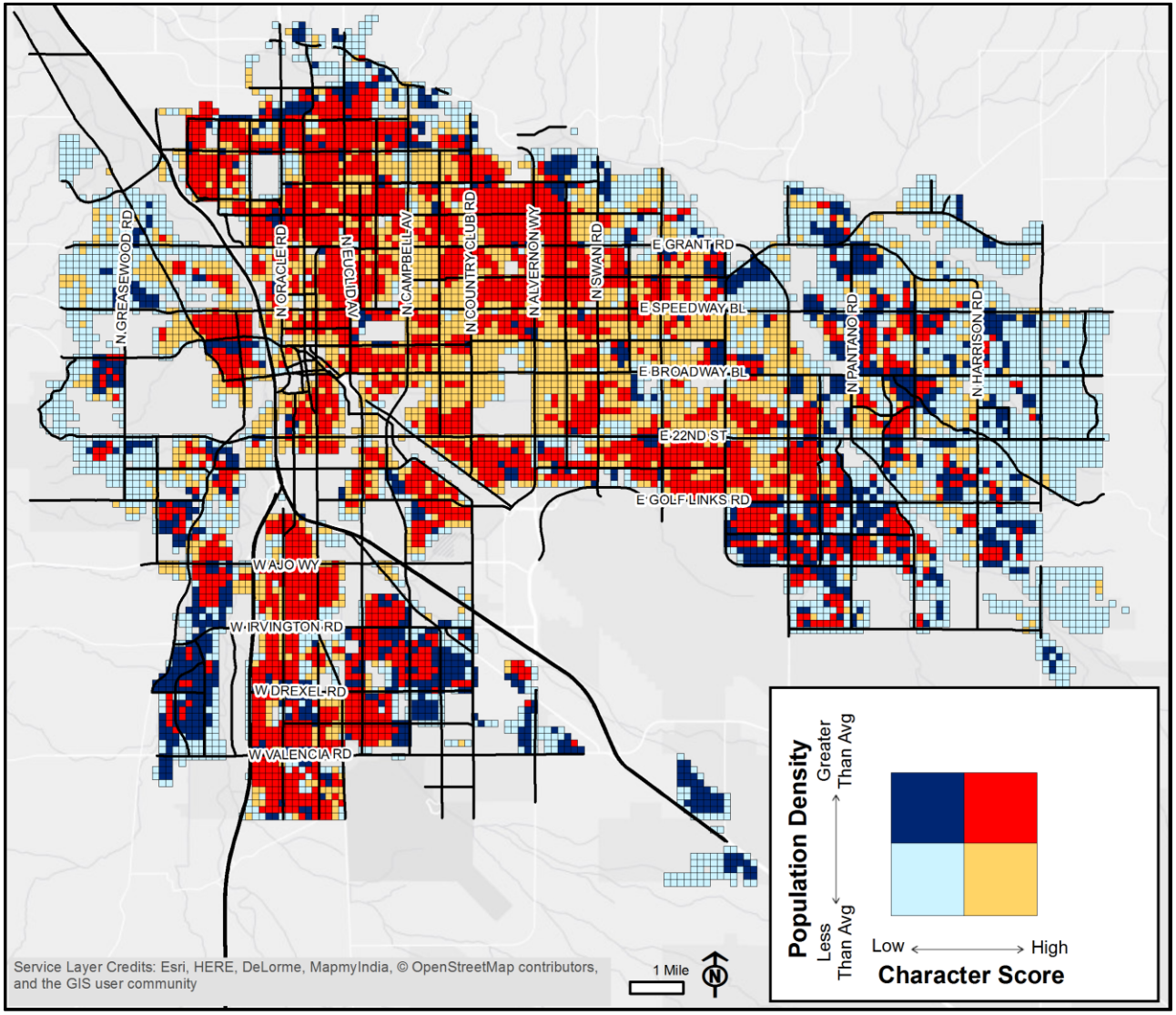
This research finds a connection between older, character-rich areas and higher percentages of non-chain, independent restaurants and retailers. Every measure we hypothesized would have a statistical link to these non-chain businesses was supported in our statistical models: older median building age, greater diversity of building age, greater granularity, higher Character Scores, and higher percentages of buildings constructed before 1945 and 1920. High Character Score commercial areas have an average of 80 percent non-chain restaurants and retailers per grid square, compared to a citywide average of 66 percent in commercial areas with at least one restaurant or retailer. On average, in areas with at least one building constructed before 1920, 90 percent of restaurants and retailers are non-chain establishments.



Map combines median building age information and data on the change in sales tax revenue between 2009 and 2013. Darker colors indicate areas that outperformed the citywide average in the difference in sales tax revenue over this time period. Red and orange coloration indicates areas that have relatively old buildings. Blue squares indicate areas with relatively new buildings.

Businesses in Older Areas of Tucson Stayed Strong during the Great Recession, and Recovered Faster

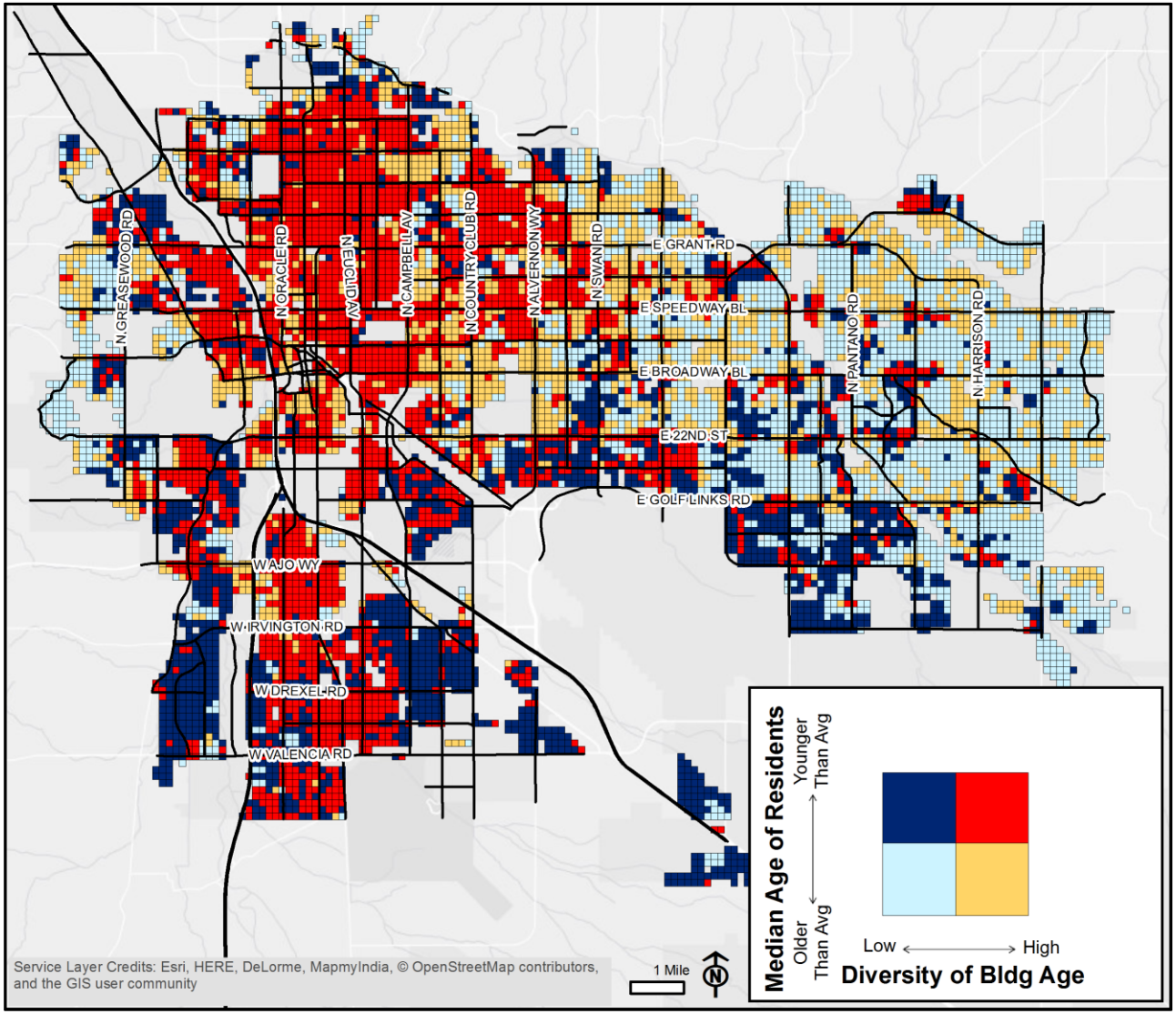
Tucson offered the Green Lab a unique opportunity to analyze sales tax revenue data over time. To ensure that the data would be private and not traceable to any small set of businesses, this dataset was constructed by city officials at a 400-meter-by-400-meter scale. We find no significant differences in 2013 sales tax revenue per commercial square foot across the median age of buildings, diversity of building age, and granularity. However, areas with older median building age outperformed newer areas when comparing sales tax revenue between 2009 and 2013, suggesting that areas with older buildings may have fared better during the Great Recession, and recovered faster. Comparing 2013 and 2009 data, areas with median building age older the citywide median had an average increase in sales tax revenue of about $19,900, compared to an increase of about $13,100 in areas with newer buildings.



Map combines Character Score data and data on the number of residents living in a grid square boundaries. Darker colors indicate areas that outperformed the citywide average population density. Red and orange squares indicate areas with older, smaller buildings and mixed-vintage blocks. Squares colored in shades of blue have mostly large, new buildings.

Tucson's Fine-Grained Blocks Have Greater Residential Densities

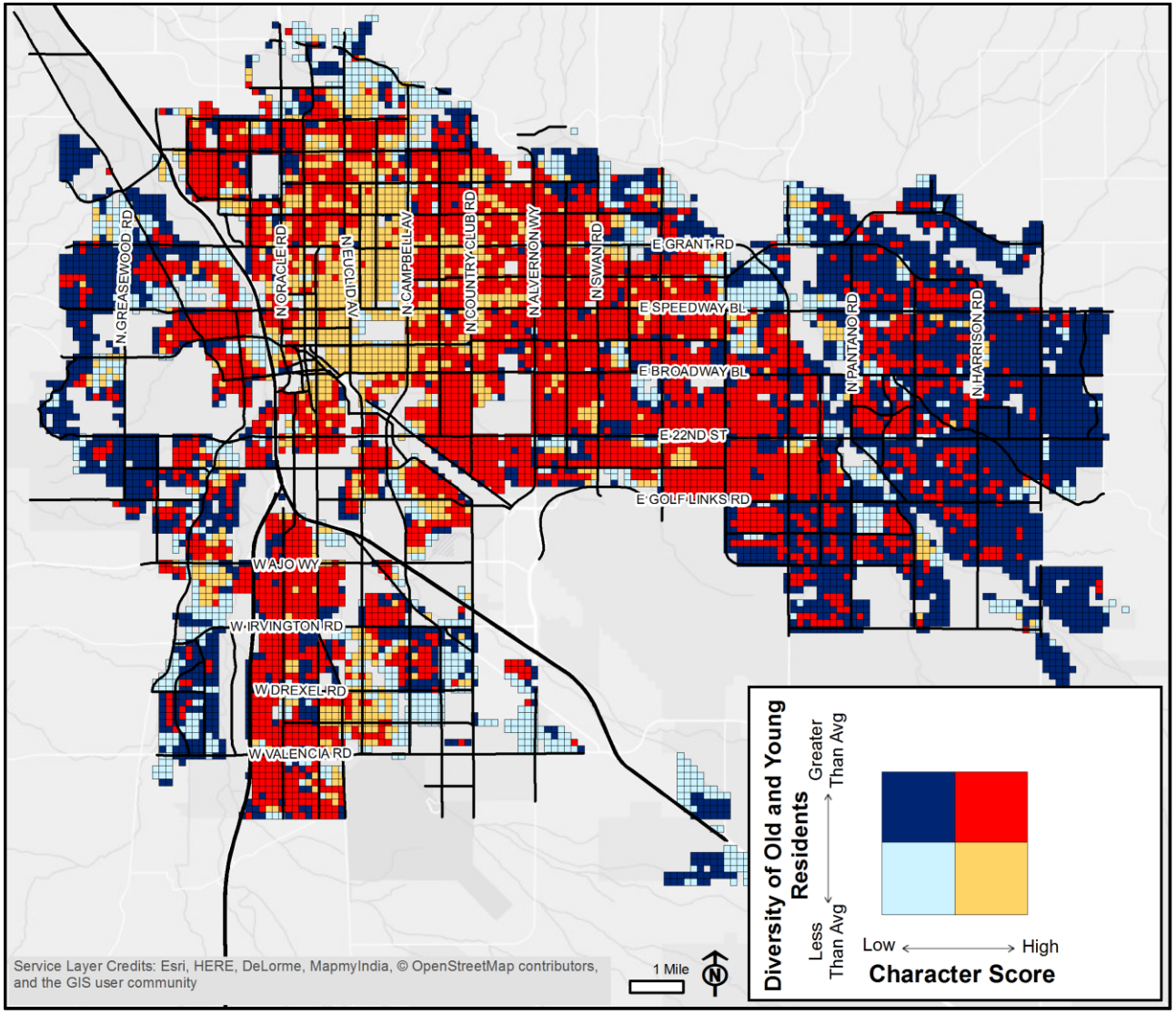
Areas of Tucson with especially fine-grained blocks of smaller structures have significantly greater population density and density of housing units. On average, high Character Score areas of the city have 62.8 residents and 29.3 housing units, compared to 45.1 residents and 25.3 housing units in areas with mostly large, new buildings. While 56 percent of high Character Score areas have greater than the citywide average number of residents, only 30 percent of low Character Score areas meet this threshold. While this finding may at first seem counterintuitive, it can likely be explained in part by the degree to which older neighborhoods mix multiple housing types into single blocks. Fine-grained blocks also often lack the large amounts of parking, large bedroom size, and large lot sizes of newer, more coarse-grained development.



Map combines Character Score data and data on the median age of residents living in each grid square. Darker colors indicate areas that have younger median age of residents than the citywide average. Red and orange squares indicate areas with a mix of old and new buildings. Squares colored in shades of blue have buildings that were constructed at around the same time.

Young Tucsonans Love Areas with a Mix of Old and New Buildings

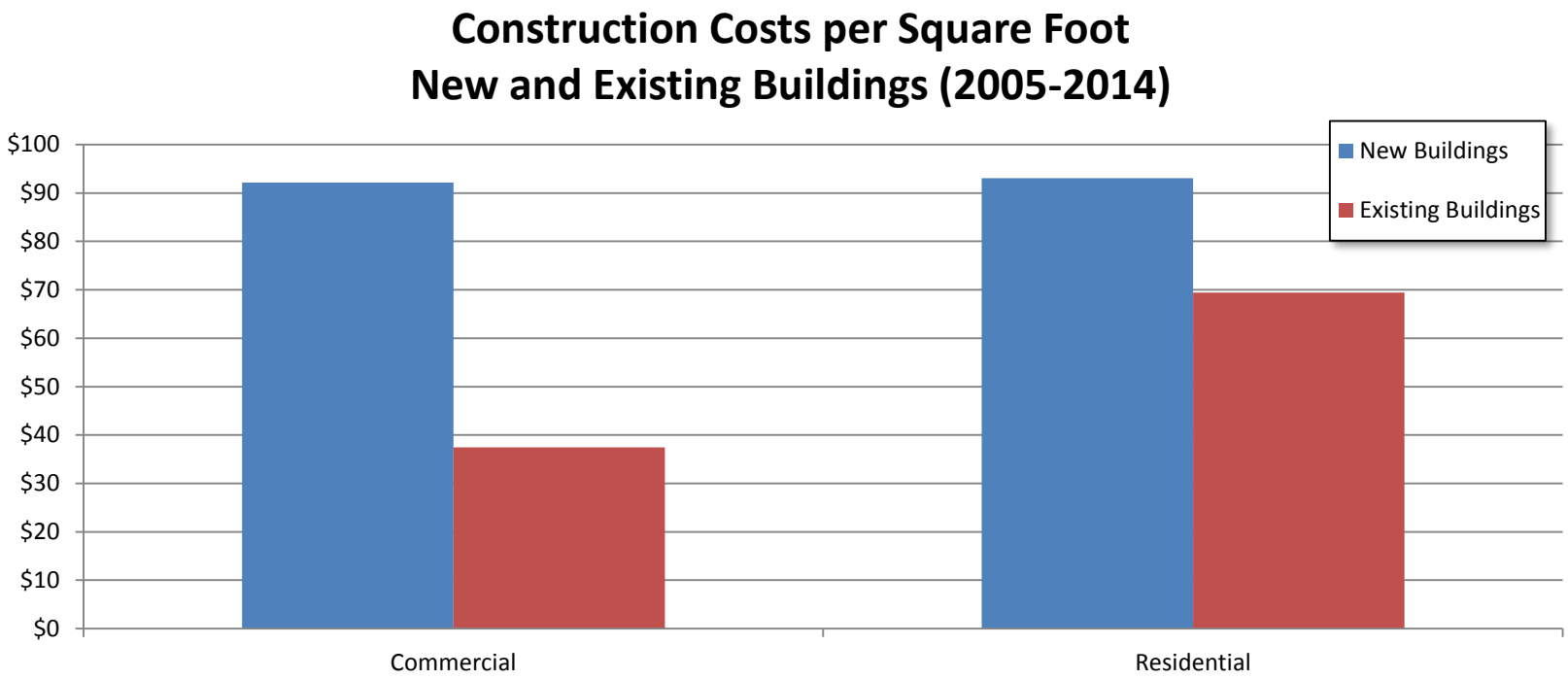
This research finds a significant statistical link between younger median age of residents and greater diversity of building age and granularity. The median age of residents in areas with high diversity of building age is an average of 37.0 years, compared to 39.3 years in areas with low diversity of building age. We also find that there are significantly higher percentages of the population in the 18-34 "Millennials" age group in areas that have greater diversity of building age and higher percentages of buildings constructed before 1945 and 1920. On average, in areas with at least one building constructed before 1920, 35 percent of the resident population is between the ages of 18 and 34, much higher than the citywide average of 26 percent.



Map combines Character Score data and data on the diversity of resident age for people living in each grid square. Darker colors indicate areas that have greater diversity of resident age than the citywide average. Red and orange squares indicate areas with older, smaller buildings and mixed-vintage blocks. Squares colored in shades of blue have mostly large, new buildings.

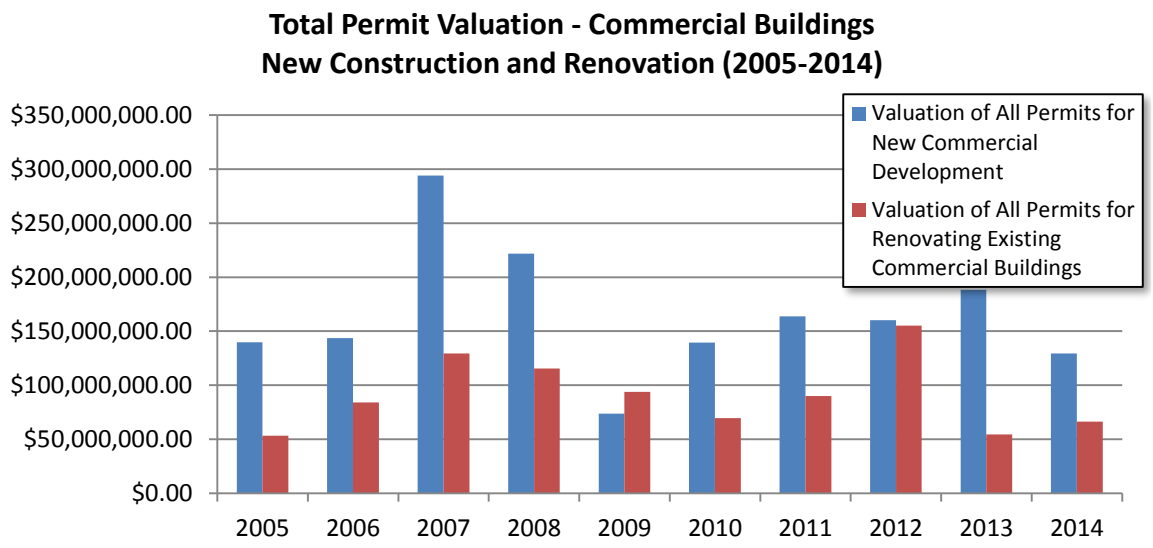
High Character Score Areas are Home to Young and Old Tucsonans Alike

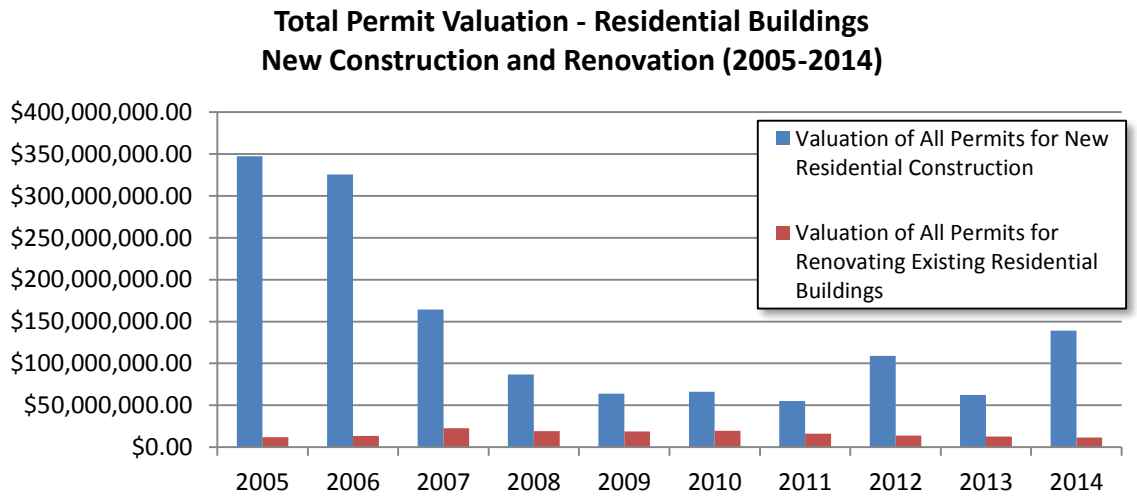
To assess whether areas with older, smaller buildings have a greater mix of residents from different age groups, the Preservation Green Lab research team developed a Resident Age Diversity Index (RADI). Higher scores on the RADI index indicate areas where there is an equal representation of residents from five different age groups: 0-17; 18-34; 35-49; 50-64; and 65+. We find that areas with older, smaller buildings and high Character Scores have significantly greater diversity of residents from different age groups. 75 percent of high Character Score areas had greater than the citywide average diversity of resident age, compared to 71 percent of low Character Score areas.



New Construction Costs More than Rehabilitation of Existing Buildings

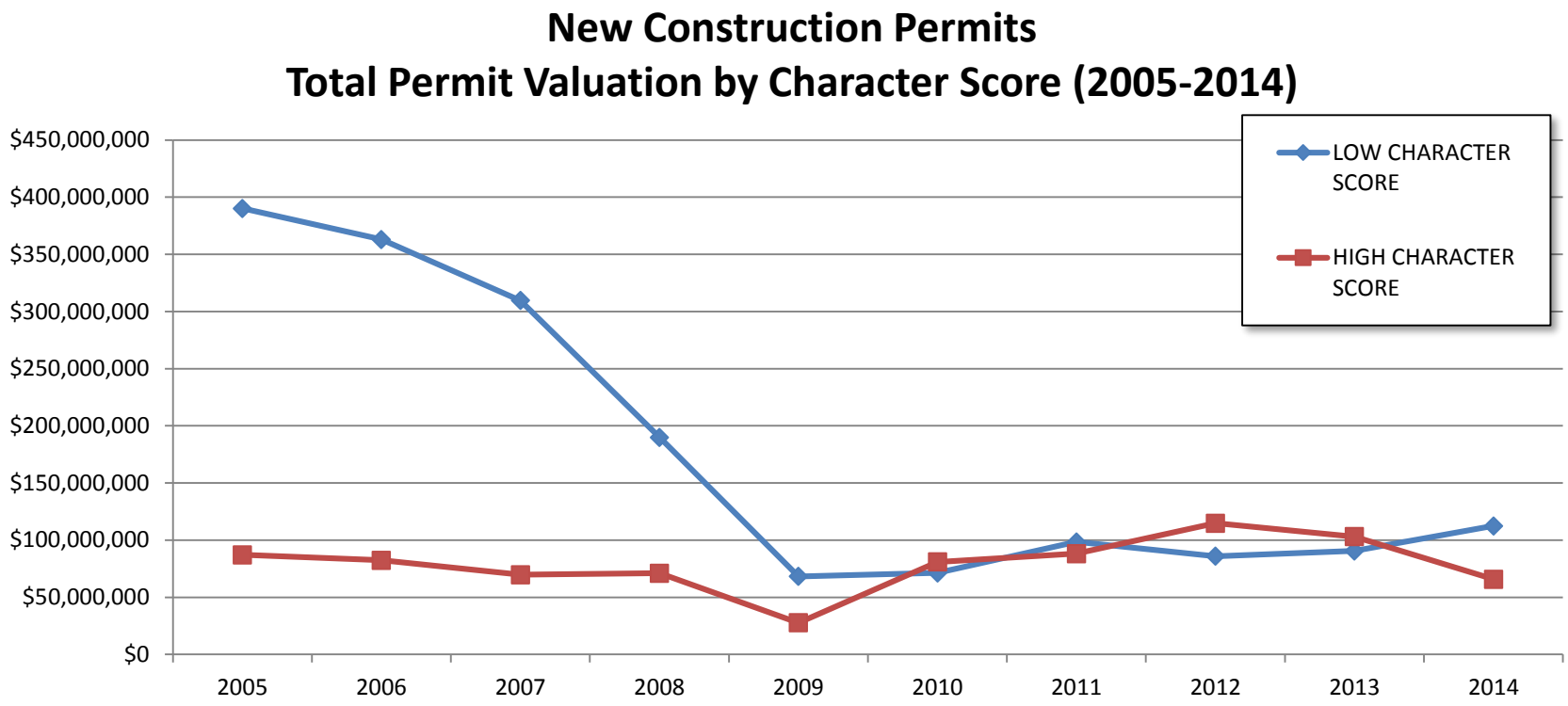
On an average, per-square-foot basis, new construction costs far more than rehabilitation of an existing building. Between 2005 and 2014, new construction had an average cost of about $92 per square foot for commercial buildings and about $93 per square foot for residential buildings. Additions, alterations, and repairs of existing buildings, meanwhile, had an average cost of about $37 per square foot for commercial buildings and about $69 per square foot for residential buildings. Where older, smaller buildings can be reused, it is often cost effective to repair and lengthen their lives.





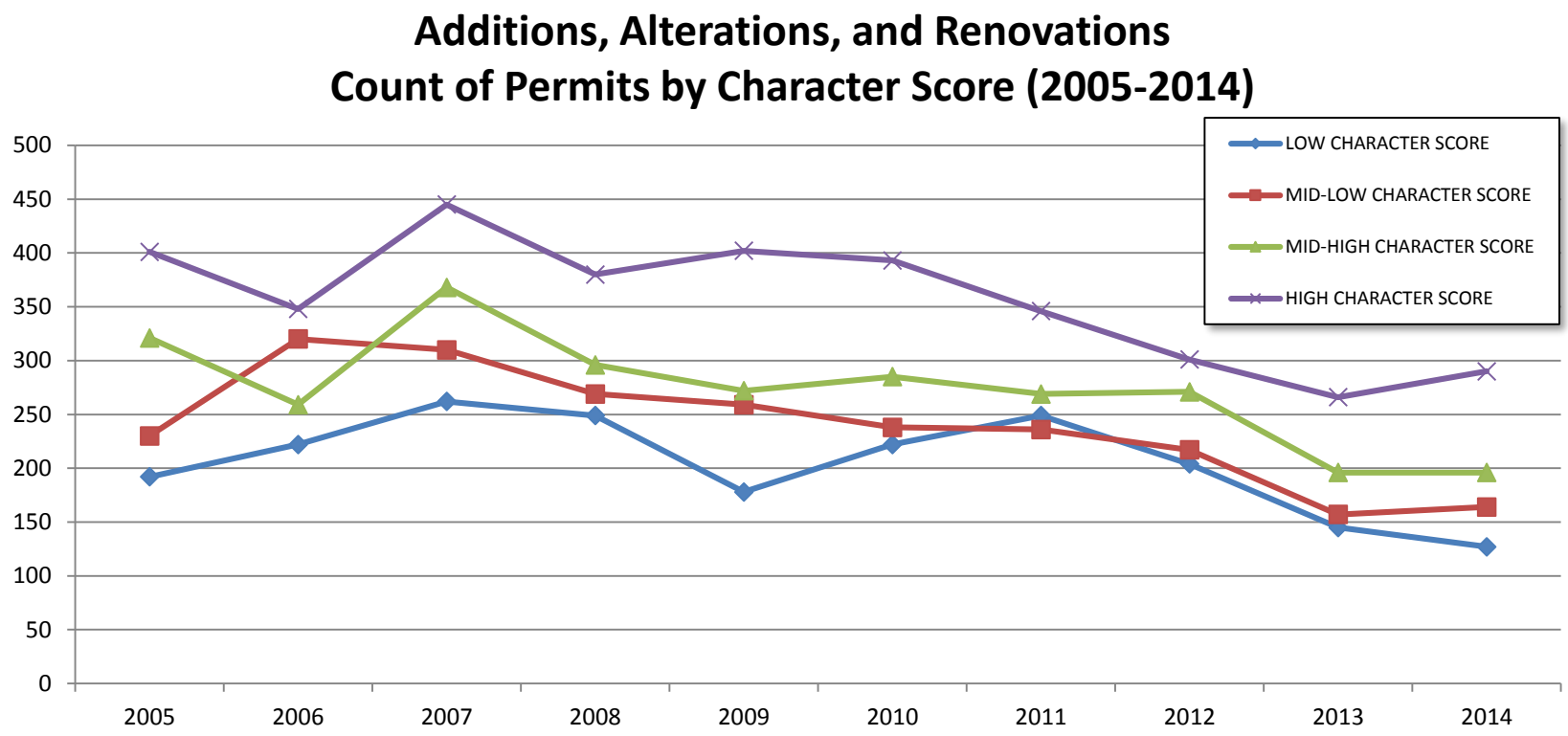
Investment Levels Are Generally Lower in Existing Buildings, but Renovation Activity is More Stable

While new construction generally outpaces renovation work to existing buildings in terms of total dollars invested and total permits pulled, we find that renovation work stayed relatively stable throughout the recession while new construction came to a virtual halt. This suggests that investments in existing buildings run counter to economic downturns, helping insulate the local economy from broad volatility.



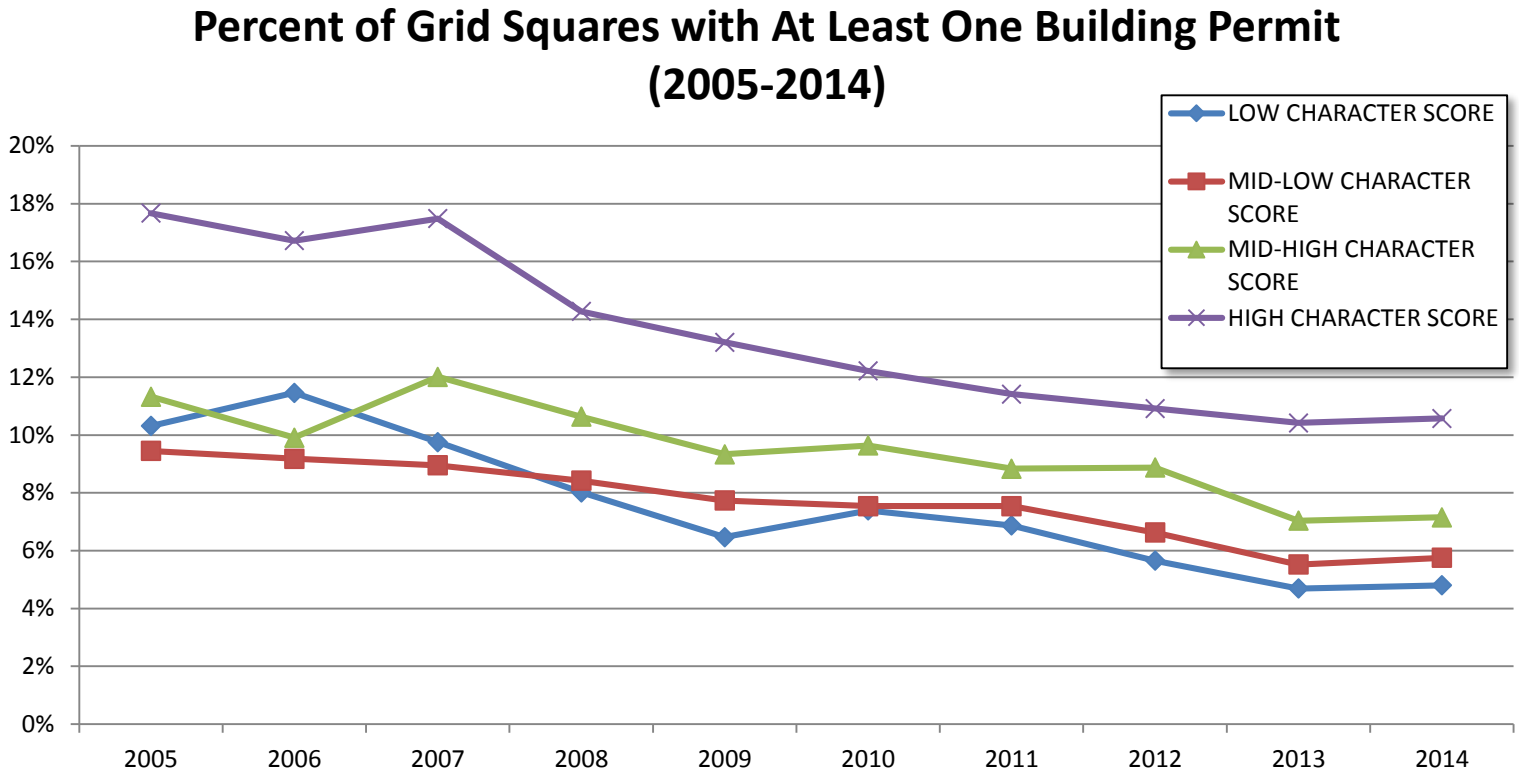
Investment in New Construction in Older Areas of Tucson Surpassed Investment in New Areas during the Economy's Recovery

Areas with low Character Scores—areas with relatively large, new buildings constructed at around the same time—had plummeting levels of investment in new construction building between 2007 and 2009. After 2009, dollars invested in new construction was roughly equivalent in areas with older, smaller buildings and mixed-vintage blocks and in areas with larger, newer structures. This fits a nationwide trend toward investment in infill development and redevelopment in cities' older neighborhoods that are more proximate to downtowns.



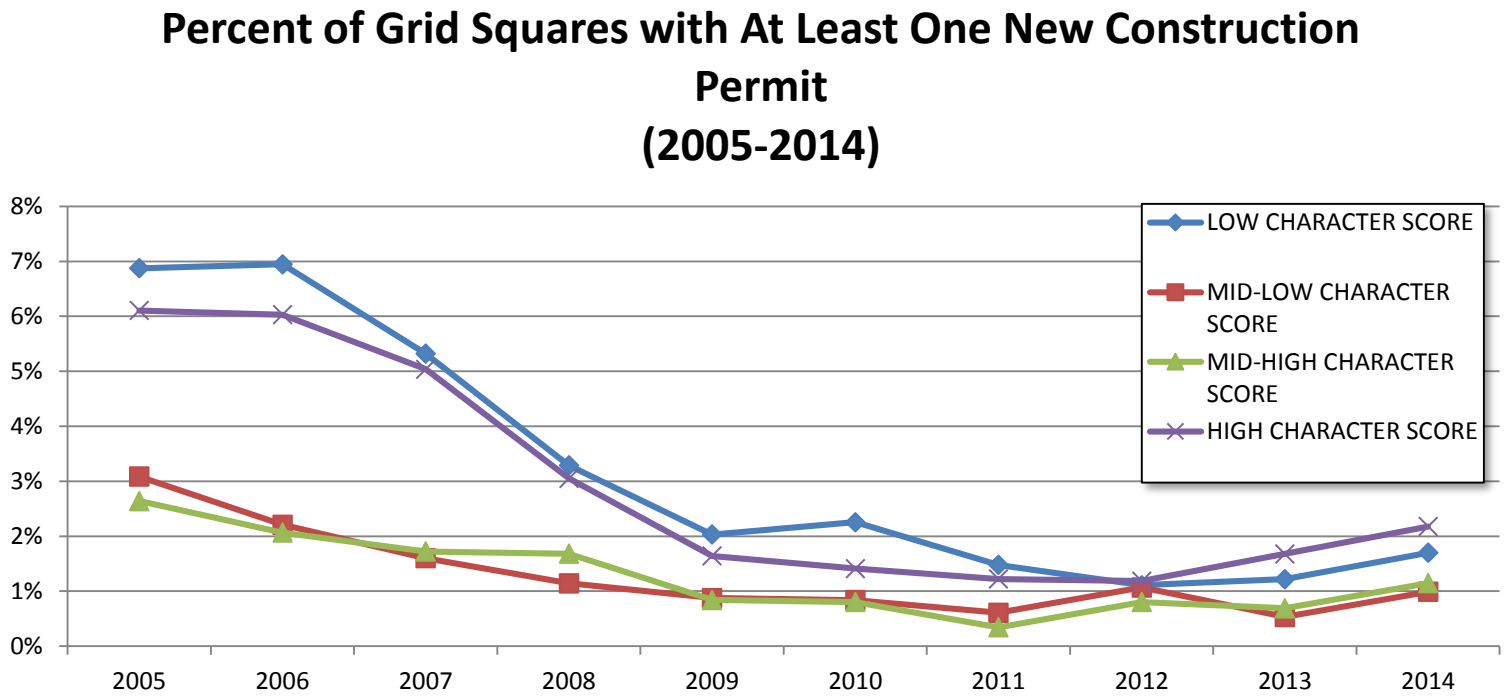
High Character Score Areas Have More Rehabilitation Activity

Rehabilitations of existing buildings occur at higher levels in areas with older, smaller buildings and mixed-vintage blocks. This trend was very consistent during the period explored through this research. The higher the Character Score of an area, the greater the number of permits pulled annually for investment in existing buildings.



Building Activity Is More Widespread in Areas with Older, Smaller Buildings

Building activity—whether new construction or renovation—is much more widespread in areas with older, smaller buildings and mixed-vintage blocks. At peak levels in 2005, building permits were pulled in nearly 18% of high Character Score areas. Meanwhile, building permits in areas with larger, newer buildings peaked in 2006 at a much lower level of about 12%. This data indicates that there are more widespread construction projects and construction jobs in areas with older and historic fabric.



New Construction Is Far Less Widespread across the City Now than It Was Before the Great Recession

While new construction peaked at 6-7% of high and low Character Score areas in 2005 and 2006, it is far more localized in recent years. This could reflect more focused investment in central neighborhoods and a trend away from sprawling developments on the edges of the city.

Recommendations

This research shows what differences older and historic buildings make in supporting Tucson's economic and social vitality and neighborhood livability. It shows why the character of the built environment matters. So how can Tucson's older, smaller buildings be leveraged and supported further to benefit the community? What can be done to make building reuse more likely? While much of Tucson's older and historic fabric performs exceptionally well according to the metrics analyzed in this study, there are sections of the city where older, smaller buildings could benefit from reinvestment, and from attention from policymakers. Additional older and historic buildings and blocks would benefit from implementing the following recommendations:

Recommendation: Conduct Outreach to Developers Interested in Building Reuse

City of Tucson officials could benefit from holding facilitated conversations with developers and building owners who are interested in reusing older and historic buildings in the city. These "user focus group" conversations could identify barriers to building reuse which may not be familiar or obvious to non-practitioners. Attention could be focused on barriers that could be addressed by streamlining the permitting and plan review processes, providing more flexibility in the building and zoning codes, adopting new incentives, and encouraging use of existing financial incentive programs such as Federal and State Historic Tax Credits. The Preservation Green Lab's "Partnership for Building Reuse," developed in collaboration with the Urban Land Institute, may serve as a model for this process. The Small Scale Developer Boot Camp led by the Incremental Development Alliance may also be a useful model to explore.

Recommendation: Create an Adaptive Reuse Program in Tucson.

The City of Tucson should consider creating an adaptive reuse program that supports and streamlines the permitting and plan review for building reuse projects, reduces or waives additional parking requirements following major investment in an existing building, and reduces or waives permitting fees for building reuse projects. City officials could look to the best practices of two successful programs established in other cities. The City of Los Angeles's 1999 Adaptive Reuse Ordinance was initially crafted as a strategy for activating vacant and underutilized buildings in the city's historic core. By waiving parking requirements, streamlining permitting and plan review, and thoughtfully removing select additional barriers, Downtown Los Angeles has added more than 14,000 new residential units and more than 30,000 new residents without the number of demolition and new construction projects seen elsewhere. A closer model is the City of Phoenix's award-winning Adaptive Reuse Program. Started in 2008 in a pilot area and now available citywide, it applies the International Existing Building Code to renovations of existing buildings that have difficulties complying with regular codes and standards; uses a special fund to help cover permit fees; provides city-funded architectural design services and tailored guidance from city officials with expertise in building reuse; analyzes how projects meet standards by balancing qualitative and quantitative compliance at the level of the building envelope and allows offsets for existing elements and materials;

"This research shows what a difference older and historic buildings make in supporting Tucson's economic and social vitality and neighborhood livability."

and reduces parking requirements for reuse projects. This program has significantly reduced timeframes and costs for adaptive reuse of older buildings for new business uses. Tucson officials could consider piloting an adaptive reuse program in targeted sections of the city with many older, smaller buildings to test its impact.

Recommendation: Encourage building reuse in struggling areas with older buildings.

Building reuse need not be a purely market-driven and market-based development strategy. In areas facing shortages of affordable housing and other community development challenges, building reuse could serve as a means of keeping structures in use while improving the lives of current residents in challenged neighborhoods. For instance, with funding from the federal Department of Housing and Urban Development (HUD), and low-income housing tax credits from the Arizona Department of Housing, vacant and abandoned buildings could be stabilized and used as community centers and for affordable housing. More private investors could be made aware of Federal and State Historic Tax Credits for renovations of historic commercial buildings for new uses. National organizations such as Artspace, the Local Initiatives Support Corporation (LISC), NeighborWorks America, and Habitat for Humanity offer an array of successful models that could be adopted in Tucson to provide neighborhood anchors while strengthening the existing built fabric of the city. Challenged areas with older and historic buildings could be identified using GIS mapping and modeling of publicly accessible data. “Reuse Opportunity Modeling,” developed by the Preservation Green Lab and applied in Baltimore, Philadelphia, Chicago, and Detroit, could provide a framework for approaching this task.

Two popular local restaurants occupy an older building at the Five Points intersection south of downtown. New businesses and developments have begun sprouting up in this area in recent years This study points to additional opportunities to strengthen building reuse through policy, research, incentives, and outreach. Photo Credit: Mike Powe, National Trust for Historic Preservation.

Opportunities for Future Research

In addition to shedding light on the current performance of Tucson's older and historic buildings and blocks, this research identified additional questions that could be considered through further research and analysis that builds on these findings.

Research Opportunity: Analyze the current performance and future potential of Tucson's major transportation corridors in terms of a combination of urban design characteristics and multimodal transportation levels of service.

How can Tucson best strike a balance between reusing older and historic buildings and promoting efficient, multimodal transportation infrastructure? Multimodal transportation refers to multiple modes (types) of transportation, such as walking, cycling, driving, transit, and freight. Assessments and projections of traffic flow involve various metrics, such as Levels of Service for these various modes. In future studies, mapping and assessing transportation corridors could include measuring the social and economic performance of different areas in relation to building granularity, street widths, building-height to street-width ratios, spatial characteristics of parking, and other urban design elements, to explore opportunities to strengthen connections between high-performing urban design and efficient, multimodal transportation infrastructure.

Research Opportunity: Refine the methodology for measuring granularity of the built environment.

For the granularity measure used in this study, the research team utilized a building polygon shapefile provided by the Pima Association of Governments and based on 2008 LIDAR data. While this building polygon file was determined to be a better fit for this project than the parcel shapefile available from the City of Tucson, it has clear limits. For instance, in some of Tucson's older commercial corridors, buildings are built so tightly up against one another that, in some instances, the building polygon shapefile misrecognized multiple continuous buildings as a single structure. This type of error results in some commercial corridors scoring lower on the granularity measure than their actual building size would warrant. In future research projects, researchers should consider developing a new granularity measure that is integrates pedestrian level details. For instance, an alternate granularity measure could focus on the number of doors on buildings on a given street. This alternate measure would account for multiple businesses or a greater mix of residents and businesses at the street level.

Research Opportunity: Assess the environmental performance of Tucson's older and historic buildings.

This study focused on the relationship between characteristics of buildings and blocks and measures related to economic vitality, livability, and residential density and diversity. Future research could focus on the relative energy efficiency of older buildings and blocks and assess how older buildings constructed with passive heating and cooling features and other manifestations of so-called "original design intelligence" compare with newer buildings that were designed and built with modern construction techniques and heating, ventilation, and air conditioning (HVAC) systems. Research conducted on large structures in other cities suggests that, in many instances, older buildings operate more efficiently than new buildings. Future such research could explore how preservation and building reuse fit into Tucson's sustainability and resilience planning.

Research Opportunity: Conduct further assessment of the economic impact of older and historic buildings.

This research used a variety of measures related to job density, business licenses, sales tax revenue, and types of businesses. Future research could extend this analysis by calculating the relative economic performance of older and historic buildings and new buildings in terms of local versus non-local building ownership, local versus non-local business ownership, vacancy rates within buildings, business stability, employment characteristics, and tax revenue generated. This research could test hypotheses developed from research conducted in other cities by Joe Minicozzi and Urban3, which explored the full costs and revenues associated with different types of developments. For instance, Minicozzi has found that that small, Main Street-style, mixed-use developments generate much more positive net tax benefits than large, big box-style retail developments. Research methodologies that blend the Preservation Green Lab approach with full public cost and revenue accounting could test the applicability of those conclusions and yield new, useful insights for Tucson.

Older, smaller commercial buildings house small local businesses on North 4th Avenue. Future research could dig more deeply into the full economic impact of these businesses, including the degree to which dollars spent in non-chain local businesses are recirculated in the local economy . Photo Credit: Mike Powe, National Trust for Historic Preservation.

Conclusions

This research found that Tucson's urban fabric with mostly older, smaller buildings and mixed-vintage blocks plays a unique and valuable role in supporting livable neighborhoods, economic vitality, and dense and diverse residential environments. These areas support beloved parks and award-winning restaurants. They are home to startups, creative companies, and dense concentrations of small, locally-owned businesses. They attract investments in building renovation projects and new businesses even during economic downturns, making the local economy more resilient. To keep these valuable assets in use, Tucsonans will need to continue to develop and refine innovative, creative policies that acknowledge the economic and social value of existing buildings and encourage new infill that is compatible with high-performing existing urban fabric and applies the urban design and economic development lessons from this study. By bringing together new and old in a thoughtful way, Tucson will remain on a sustainable path of continued livability and prosperity.

The historic Hotel Congress and Rialto Theatre anchor the eastern terminus of Congress Street in Downtown Tucson and demonstrate the real potential for leveraging historic assets. This study reveals the powerful and unique role these older buildings play in Tucson and points to additional opportunities to bring vitality to other parts of the city with older and historic structures. Photo Credit: Paul Sableman (Flickr) under CC-by-2.0 License.

APPENDIX A: DETAILS ON THE METHODOLOGICAL APPROACH

This project involved bringing together datasets from many different sources, "fitting" that data into a custom grid geography, and running spatial regression models to test the relationships between characteristics of the built fabric and social, cultural, and economic vitality at the grid square level. This appendix provides a more detailed accounting of the methodological approach taken in this work.

Data Collection

The bulk of the data used in this project came from governmental sources, though some select data was obtained from non-governmental entities. The research team collected data through a combination of simple web searches of publicly accessible open data platforms (e.g., the U.S. Census Bureau, cities' open data portals, county assessor websites, etc.), requests to city and county departments and intergovernmental agencies, and targeted collection from non-governmental websites and publications such as DataJoe, *Tucson Weekly*, and *Tucson Lifestyle*. Some preliminary analysis was conducted by the Green Lab's partners at the City of Tucson and shared in a processed form. For example, to protect the privacy and confidentiality of individual business's taxable retail sales data, City of Tucson officials aggregated sales tax revenue data to a custom 400-meter-by-400-meter grid.

The native geographies of the data in this project varied from spatial points (e.g., latitudinal and longitudinal coordinates and street addresses for businesses, etc.) to Census block groups. (For a detailed accounting of the data used in this project, including information on data sources and native geographies, please refer to the Data Catalog in Appendix B).

Data Aggregation and Development of Metrics

Given that the data used in this project uses a variety of native geographies, the research team opted to "fit" the data to a custom 200-meter-by-200 meter grid. This builds on the research methodology established in the Preservation Green Lab's 2014 *Older, Smaller, Better* research report, which was published in the peer-reviewed *Journal of the American Planning Association* in early 2016.

After overlaying the geometric grid over the city geographies, data was aggregated and distilled from native geometric units into the grid squares. Point-based data was mapped and spatially joined to the grid. U.S. Census block and block group geographies were overlaid over the grid, and values associated with each block or block group were distributed into grid squares according to the proportion of the census geography that lay in each grid square. For instance, if 40% of a census block was in a given grid square, the research team multiplied the values associated with that census block by 0.40 and added the adjusted values into appropriate grid square data fields. This approach operates on the assumption that the spatial distribution of data was perfectly consistent across the geographic spatial units. Though the assumption may not hold in all cases, this approach to distributing data into the grid geography was ultimately the best available option. The business listing data used in this project came from a variety of sources, and this diversity poses some threat to the validity of the study's results. For instance, the overall count of businesses was distilled from business license data, but the count of women and minority-owned businesses was taken a data source assembled by a non-governmental third party. For the "density of businesses" and "density of jobs" measures, the research team divided the number of businesses, jobs, etc., in each grid square by the total commercial square footage located in that grid square, as listed in county assessor tables. Combining these disparate data sources may have resulted in some inaccuracies, but the resultant distortions were likely marginal in size and did not influence the results.

As this research aimed to test the role that older, smaller buildings play in fostering community vitality, the research team developed key measures of the building fabric. The project's measure of building age focused on the median year of construction of all buildings in each grid square. Age diversity was measured by calculating the standard deviation of the years of construction of all buildings in each grid square, and the measure of granularity is equal to the count of the number of buildings that lay in each square. In order to place the relative age, age diversity, and granularity in context with the complete set of buildings in Tucson, these measures were normalized according to Tucson's total building stock. This involved transforming the units for each measure into *z* values, which point to each grid square's number of standard deviations above or below that square's respective city average for these key measures.

Finally, to test the overall effect of building age, age diversity, and granularity, the research team created a composite "Character Score" measure that combined the *z* values for each measure in each grid square. Various options for weighting the three component measures were considered, but ultimately, each measure was seen as equally important to the overall character of the block's fabric. Given this, the research team opted to simply add up the *z*-scores for building age, age diversity, and granularity to create the Character Score.

Spatial Regression Analysis

In preparation for statistical analysis, select grid squares were excluded from the regression models, depending on the specific research question. For all analyses, a first step involved excluding grid squares that did not have data for each independent variable. For instance, grid squares that did not have data for building age or a count of buildings or parcels were excluded.

For analyses of most livability metrics, all grid squares with at least one complete building record were included. The Walkability Composite represents one exception: In this analysis, grid squares without Walkability data were excluded as well.

For analyses of economic vitality, grid squares without commercial activity were excluded in an effort to strengthen the performance of the statistical models. For instance, analyses of job density included only grid squares with at least one private sector job and at least 50 commercial square feet. For analyses focused on the density of particular subsets of jobs (e.g., jobs in creative industries) per commercial square foot, grid squares without the specific job type in question were excluded. For analyses focused on the density of businesses, only grid squares with at least one business record, one employee, and 50 commercial square feet were included. Analyses of sales tax revenue included only grid squares with non-zero records of sales tax revenue generated. Finally, analyses of non-chain restaurants and retailers included only grid squares with at least one record for a restaurant or retail business.

For analyses of residential density and population characteristics, grid squares without at least five residents or five housing units were excluded. In order to account for spatial dependence in the study's statistical models, the research team employed spatial regression models in GeoDa and R. In addition to measures of the character of the grid square's built fabric, control measures for private investment in the grid square's buildings and median income were included. The measure of private investment was equal to the sum of all dollars spent on development projects in a grid square between 2010 and 2014. A log transformation was used on the permit dollar value to limit its range and to improve its use in statistical models.

Medan income was measured using the U.S. Census Bureau records for median income that corresponded to each grid square. The research team developed and ran one model that used the composite "Character Score" alongside these control measures. A second model was used that included the *z*-scores for each component measure alongside the control variables. In each of the spatial regression models, the research team employed a spatial weight matrix based on first-order Queen contiguity. Additional models were used to test the relative role of buildings constructed before 1945 and before 1920.

Using the statistical packages included in R and GeoDa, the research team ran OLS regression models and Moran's I diagnostic tests for spatial autocorrelation. In most instances, the Moran's I test showed significant spatial autocorrelation, which posed a significant threat to the validity of the OLS model, so Lagrange-Multiplier diagnostic tests were also run to test for residual spatial dependence. Based on the results of the Lagrange tests, the research team opted to use either spatial lag or spatial error models, depending on whether the tests to point to the presence of "lag" across neighboring grid squares or statistical "error" in measures that vary across space. In this study, a mix of spatial lag and spatial error models were ultimately used. In a few instances, spatial autocorrelation was not an issue and a simple OLS regression model was sufficient.

As suggested by Luc Anselin and his colleagues at Arizona State University's GeoDa Center for Geospatial Analysis and Computation, the research team tested the relative performance of the spatial lag and spatial error models against the performance of the original OLS regression model by comparing the respective Wald statistics, likelihood ratios, and Lagrange multiplier scores. In many cases, these tests did not fall in the expected order ($LM \leq LR \leq W$), indicating possible misspecification of the model. Given the large size of the project's dataset and some underlying non-normality and heteroskedasticity in the metrics data, the research team was confident that the models are reliable, though this could warrant further exploration. Future research may include additional spatial variables to strengthen the models further.

Anselin, L. (2005). *Exploring spatial data with GeoDa: A workbook.* Urbana, IL: Center for Spatially Integrated Social Science.

Vitality Metric = a(Character Score) + b(median income) + c(construction dollars) + d(weighted spatial lag or spatial error term) + error

Vitality Metric = a(z-standardized building age) + b(z-standardized diversity of building age) + c(z-standardized granularity of built fabric) + d(median income) + e(construction dollars) + f(weighted spatial lag or spatial error term) + error

Vitality Metric = a(percent of buildings constructed before 1945) + b(median income) + c(construction dollars) + d(weighted spatial lag or spatial error term) + error

Vitality Metric = a(percent of buildings constructed before 1920) + b(median income) + c(construction dollars) + d(weighted spatial lag or spatial error term) + error

APPENDIX B: DATA SOURCES

Building Characteristics Metrics and Other Independent Variables	Units	Data Source and Vintage	Native Geography of Data	Notes
Median Year Built	Median calculated from age of properties in parcel file	Pima County Assessor (2015)	Parcel	
Diversity of Building Age	Standard deviation calculated from age of properties in parcel file	Pima County Assessor (2015)	Parcel	
Granularity	Number of buildings and partial buildings per grid square	Pima Association of Governments (2008)	Building	
Character Score	Combined *z*-standardized median building age, diversity of building age, and granularity values	Pima County Assessor (2015) and Pima Association of Governments (2014)	Grid square	Custom measure developed by Preservation Green Lab
Commercial square feet	Sum of built square feet for all commercial properties (excluding multifamily housing)	Pima County Assessor (2015)	Parcel	
Investment in new construction and AAR to existing buildings	Sum of permit valuation data for all permits pulled between 2010 and 2014 within each grid square	City of Tucson (2010-2014)	Point	
Median household income	Median household income	U.S. Census Bureau / American Community Survey (2013)	Census tract	

Livability Metrics	Units	Data Source and Vintage	Native Geography of Data	Notes
Percent tree canopy	Percent of block shaded by tree canopy	Pima Association of Governments (2007)	Census block	
Average surface temperature		Eve Halper and Pima Association of Governments (2008)	Census block	
PAG Walkability	Custom walkability composite	Pima Association of Governments (2014)	Raster	Raster converted to points then average values computed for grid squares
Access to bike infrastructure (distance to bike route)	Proximity (meters) to bike routes, bike boulevard/shared land markings, bike routes with striped shoulders, bus/bike lanes, shared-use paths, and shared lane markings	City of Tucson (2015)		
Access to streetcar (distance to streetcar stop)	Minimum distance from grid square to streetcar stop (meters)	City of Tucson (2015)	GIS calculated	
Top Tucson Weekly restaurants	Addresses of top-rated restaurants	Tucson Weekly (2014)	Address point	Geocoded by research team
Top Tucson Lifestyle restaurants	Addresses of top-rated restaurants	Tucson Lifestyle (2014)	Address point	Geocoded by research team
Top restaurants – 2014 (combined lists)	Addresses of top-rated restaurants	Tucson Weekly + Tucson Lifestyle (2014)	Address point	Geocoded by research team
Best Of Tucson 2015 places	Addresses of top-rated restaurants, retailers, and other places	Tucson Weekly (2015)	Address point	Geocoded by research team

Metrics - Investment in Buildings	Units	Data Source and Vintage	Native Geography of Data	Notes
Investment in alterations, additions, and repairs to existing buildings	Sum of permit valuation data for all addition, alteration, and repair permits pulled between 2010 and 2014 within each grid square	City of Tucson (2010-2014)	Point	
Investment in new construction	Sum of permit valuation data for all new construction permits pulled between 2010 and 2014 within each grid square	City of Tucson (2010-2014)	Point	
Metrics - Private Sector Jobs	**Units**	**Data Source and Vintage**	**Native Geography of Data**	**Notes**
Density of private jobs (2013)	Count of private sector jobs	U.S. Census Bureau –LEHD Data (2013)	Census block	
Density of private jobs per 1K comm. sq. ft.	Logged count of private sector jobs divided by commercial square feet measure	U.S. Census Bureau – LEHD Data (2013) + Pima County Assessor (2015)	Census block / Parcel	
Change in density of jobs (2009-2013)	Change in count of private sector jobs	U.S. Census Bureau – LEHD Data (2011; 2013)	Census block	
Change in density of jobs per 1K comm. sq. ft. (2009-2013)	Logged count of private sector jobs divided by commercial square feet measure	U.S. Census Bureau –LEHD Data (2013) + Pima County Assessor (2015)	Census block / Parcel	

Metrics - Jobs in New Businesses	Units	Data Source and Vintage	Native Geography of Data	Notes
Density of jobs in new businesses (2013)	Count of private sector jobs in businesses launched in the previous three years	U.S. Census Bureau –LEHD Data (2013)	Census block	
Density of jobs in new businesses per 1K comm. sq. ft. (2013)	Count of private sector jobs in businesses launched in the previous three years divided by commercial square feet measure (logged)	U.S. Census Bureau – LEHD Data (2013) + Pima County Assessor (2015)	Census block / Parcel	Includes only grid squares with non-zero count of jobs in new businesses
Percent of private sector jobs in new businesses (2013)	Count of private sector jobs in businesses launched in the previous three years divided by total count of private sector jobs	U.S. Census Bureau –LEHD Data (2013)	Census block	
Change in density of jobs in new businesses (2011-2013)	Change in count of private sector jobs in businesses launched in the previous three years, 2011 to 2013	U.S. Census Bureau – LEHD Data (2011; 2013)	Census block	
Change in density of jobs in new businesses per 1K comm. sq. ft. (2011-2013)	Change in count of private sector jobs in businesses launched in the previous three years (2011 – 2013), divided by commercial square feet measure, 2011 to 2013	U.S. Census Bureau – LEHD Data (2011; 2013) + Pima County Assessor (2015)	Census block / Parcel	
Change in percent of private sector jobs that are in new businesses (2011-2013)	Change in count of private sector jobs in businesses launched in the previous three years divided by total count of private sector jobs, 2011 to 2013	U.S. Census Bureau – LEHD Data (2011; 2013)	Census block	

Metrics - Jobs in Small Businesses	Units	Data Source and Vintage	Native Geography of Data	Notes
Density of jobs in small businesses	Count of private sector jobs in businesses with less than 20 employees	U.S. Census Bureau –LEHD Data (2013)	Census block	
Density of jobs in small businesses per 1K comm. sq. ft.	Count of private sector jobs in businesses with less than 20 employees, divided by commercial square feet measure (logged)	U.S. Census Bureau – LEHD Data (2013) + Pima County Assessor (2015)	Census block / Parcel	Includes only grid squares with non-zero count of jobs in new businesses
Percent of private sector jobs in small businesses	Count of private sector jobs in businesses with less than 20 employees divided by total count of private sector jobs	U.S. Census Bureau –LEHD Data (2013)	Census block	
Change in density of jobs in small businesses (2011-2013)	Change in count of private sector jobs in businesses with less than 20 employees (2011 – 2013)	U.S. Census Bureau –LEHD Data (2011; 2013)	Census block	
Change in density of jobs in small businesses per 1K comm. sq. ft. (2011-2013)	Change in count of private sector jobs in businesses with less than 20 employees (2011 – 2013), divided by commercial square feet measure	U.S. Census Bureau –LEHD Data (2013) + Pima County Assessor (2015)	Census block / Parcel	
Change in percent of private sector jobs that are in small businesses (2011-2013)	Change in count of private sector jobs in businesses with less than 20 employees divided by total count of private sector jobs, 2011 to 2013	U.S. Census Bureau –LEHD Data (2011; 2013)	Census block	
Metrics - Jobs in Creative Industries	**Units**	**Data Source and Vintage**	**Native Geography of Data**	**Notes**
Density of jobs in creative industries	Count of private sector jobs in arts, entertainment, and recreation (NAICS sector 71); information (NAICS sector 51); and professional, scientific, and technical services (NAICS sector 54) industries	U.S. Census Bureau –LEHD Data (2013)	Census block	

Metrics - Jobs in Creative Industries	Units	Data Source and Vintage	Native Geography of Data	Notes
Density of jobs in creative industries per 1K comm. sq. ft. (2013)	Count of private sector jobs in arts, entertainment, and recreation (NAICS sector 71); information (NAICS sector 51); and professional, scientific, and technical services (NAICS sector 54) industries, divided by commercial square feet measure (logged)	U.S. Census Bureau – LEHD Data (2013) + Pima County Assessor (2015)	Census block / Parcel	Includes only grid squares with non-zero count of jobs in new businesses
Percent of jobs that are in creative industries (2013)	Count of private sector jobs in arts, entertainment, and recreation (NAICS sector 71); information (NAICS sector 51); and professional, scientific, and technical services (NAICS sector 54) industries, divided by total count of private sector jobs	U.S. Census Bureau – LEHD Data (2013)	Census block	
Change in density of jobs in creative industries (2009-2013)	Change in count of private sector jobs in arts, entertainment, and recreation (NAICS sector 71); information (NAICS sector 51); and professional, scientific, and technical services (NAICS sector 54) industries between 2009 and 2013	U.S. Census Bureau – LEHD Data (2009; 2013)	Census block	
Change in density of jobs in creative industries per 1K comm. sq. ft. (2009-2013)	Change in count of private sector jobs in arts, entertainment, and recreation (NAICS sector 71); information (NAICS sector 51); and professional, scientific, and technical services (NAICS sector 54) industries between 2009 and 2013, divided by commercial square feet measure	U.S. Census Bureau – LEHD Data (2009; 2013) + Pima County Assessor (2015)	Census block / Parcel	

Metrics - Jobs in Creative Industries	Units	Data Source and Vintage	Native Geography of Data	Notes
Change in percent of jobs that are in creative industries (2009-2013)	Change in count of private sector jobs in arts, entertainment, and recreation (NAICS sector 71); information (NAICS sector 51); and professional, scientific, and technical services (NAICS sector 54) industries divided by total count of private sector jobs, 2009 to 2013	U.S. Census Bureau – LEHD Data (2009; 2013)	Census block	
Metrics – Jobs in Food and Accommodation Industries	**Units**	**Data Source and Vintage**	**Native Geography of Data**	**Notes**
Density of jobs in food/accommodation industries (2013)	Count of private sector jobs in accommodation and food services (NAICS sector 72) industries	U.S. Census Bureau –LEHD Data (2013)	Census block	
Density of jobs in food/accommodation industries per 1K comm. sq. ft.	Count of private sector jobs in accommodation and food services (NAICS sector 72) industries, divided by commercial square feet measure (logged)	U.S. Census Bureau – LEHD Data (2013) + Pima County Assessor (2015)	Census block	Includes only grid squares with non-zero count of jobs in new businesses
Percent of jobs that are in food/accommodation industries	Count of private sector jobs in accommodation and food services (NAICS sector 72) industries divided by total count of private sector jobs	U.S. Census Bureau –LEHD Data (2013)	Census block	
Change in density of jobs in food/accommodation industries	Change in count of private sector jobs in accommodation and food services (NAICS sector 72) between 2009 and 2013	U.S. Census Bureau – LEHD Data (2009; 2013)	Census block / Parcel	

Metrics – Jobs in Food and Accommodation Industries	Units	Data Source and Vintage	Native Geography of Data	Notes
Change in density of jobs in food/accommodation industries per 1K comm. sq. ft.	Change in count of private sector jobs in accommodation and food services (NAICS sector 72) between 2009 and 2013, divided by commercial square feet measure	U.S. Census Bureau – LEHD Data (2009; 2013) + Pima County Assessor (2015)	Census block	
Change in percent of jobs that are in food/accommodation industries (2009-2013)	Change in count of private sector jobs in accommodation and food services (NAICS sector 72) industries divided by total count of private sector jobs, 2009 to 2013	U.S. Census Bureau –LEHD Data (2013)	Census block	
Density of Businesses and Employees	**Units**	**Data Source and Vintage**	**Native Geography of Data**	**Notes**
Density of businesses	Count of businesses located in each grid square	Pima Association of Governments (2013)	Point	
Density of businesses per 1K comm. sq. ft.	Count of businesses located in each grid square, divided by commercial square feet measure	Pima Association of Governments (2013) + Pima County Assessor (2015)	Point / Parcel	
Change in density of businesses	Change in count of business licenses based in each grid square, 2008 to 2014	City of Tucson (2008-2014)	Point	
Change in density of businesses per 1K comm. sq. ft.	Change in count of business licenses based in each grid square, divided by commercial square feet measure, 2008 to 2014 (logged)	City of Tucson (2008-2014) + Pima County Assessor (2015)	Point / Parcel	

Density of Businesses and Employees	Units	Data Source and Vintage	Native Geography of Data	Notes
Density of employees	Count of employees located in each grid square	Pima Association of Governments (2013)	Point	
Density of employees per 1K comm. sq. ft. (2013) (logged)	Count of employees located in each grid square, divided by commercial square feet measure	Pima Association of Governments (2013) + Pima County Assessor (2015)	Point / Parcel	
Business Characteristics Metrics	**Units**	**Data Source and Vintage**	**Native Geography of Data**	**Notes**
Density of new business licenses	Count of business license with 2014 start dates	City of Tucson (2014)	Point	
Density of new business licenses per 1K comm sq ft.	Count of business license with 2014 start dates, divided by commercial square feet measure (logged)	City of Tucson (2014) + Pima County Assessor (2015)	Point / Parcel	
Density of Tucson's longest-running businesses (2013)	Count of Tucson's oldest businesses	DataJoe, LLC (2013)	Point	
Density of women-and-minority owned businesses (2013)	Count of Tucson's women and minority-owned businesses	DataJoe, LLC (2013)	Point	
Percent of businesses with women-and-minority ownership (2013)	Count of Tucson's women and minority-owned businesses, divided by count of 2013 business licenses per grid square	DataJoe, LLC (2013) + City of Tucson (2013	Point	

Business Characteristics Metrics	Units	Data Source and Vintage	Native Geography of Data	Notes
Density of non-chain restaurants and retailers	Count of restaurants and retailers that are not branch locations	Pima Association of Governments (2013)	Point	
Percent of restaurants and retailers that are not chains	Count of restaurants and retailers that are not branch locations, divided by total count of restaurants and retailers	Pima Association of Governments (2013)	Point	
Sales Tax Revenue Metrics	**Units**	**Data Source and Vintage**	**Native Geography of Data**	**Notes**
Sales tax revenue (2013)	Aggregate sales tax revenue generated in 2013 per 400-meter-by-400-meter grid square	City of Tucson (2013)	400-meter-by-400-meter grid square	Data processed and assembled by City of Tucson officials
Sales tax revenue per comm. sq. ft. (2013)	Aggregate sales tax revenue generated in 2013 per 400-meter-by-400-meter grid square, divided by commercial square feet measure	City of Tucson (2013) + Pima County Assessor (2015)	400-meter-by-400-meter grid square	Data processed and assembled by City of Tucson officials
Change in sales tax revenue (2009-2013)	Change in aggregate sales tax revenue generated in 2013 per 400-meter-by-400-meter grid square, 2009 to 2013	City of Tucson (2009; 2013)	400-meter-by-400-meter grid square	Data processed and assembled by City of Tucson officials
Change in sales tax revenue per comm. sq. ft. (2009-2013) (log)	Change in aggregate sales tax revenue generated in 2013 per 400-meter-by-400-meter grid square, divided by commercial square feet measure, 2009 to 2013	City of Tucson (2009; 2013) + Pima County Assessor (2015)	400-meter-by-400-meter grid square	Data processed and assembled by City of Tucson officials

Residential Density Metrics	Units	Data Source and Vintage	Native Geography of Data	Notes
Population density - Residents	Total population per grid square	U.S. Census Bureau (2010)	Census block	
Population density - Housing units	Total count of housing units per grid square	U.S. Census Bureau (2010)	Census block	
Vacancy rate	Count of vacant housing units divided by total count of housing units per grid square	U.S. Census Bureau (2010)	Census block	
Change in population density - Residents	Change in total population per grid square	U.S. Census Bureau (2000; 2010)	Census block	
Change in population density - Housing units	Change in total count of housing units per grid square, 2000 to 2010	U.S. Census Bureau (2000; 2010)	Census block	
Change in vacancy rate	Change in count of vacant housing units divided by total count of housing units per grid square, 2000 to 2010	U.S. Census Bureau (2000; 2010)	Census block	

Residential Diversity Metrics	Units	Data Source and Vintage	Native Geography of Data	Notes
Median age of residents	Median age of residents	U.S. Census Bureau (2010)	Census block	
Percent of the population age 18-34	Count of residents age 18-34 divided by total population per grid square	U.S. Census Bureau (2010)	Census block	
Diversity of age of residents	Index calculated on a 0-100 scale using proportions of population from the following age groups: 0-17, 18-34, 35-49, 50-64, 65+. An equal distribution of all groups is equal to 100. Presence of only one group is equal to 0.	U.S. Census Bureau (2010)	Census block	Calculated by the Preservation Green Lab using census data
Racial and ethnic diversity	Index calculated on a 0-100 scale using proportions of population from the following racial and ethnic groups: Non-Hispanic white, non-Hispanic African-American, non-Hispanic Asian, Hispanic, and all other races and ethnicities. An equal distribution of all groups is equal to 100. Presence of only one group is equal to 0.	U.S. Census Bureau (2010)	Census block	Calculated by the Preservation Green Lab using census data
Percent of the population that is Hispanic or non-white	Count of all Hispanic or non-White residents divided by the total population per grid square	U.S. Census Bureau (2010)	Census block	
Change in median age of residents (2000-2010)	Change in the median age of residents, 2000 to 2010	U.S. Census Bureau (2000; 2010)	Census block	
Change in the percent of the population age 18-34 (2000-2010)	Change in the count of residents age 18-34 divided by total population per grid square, 2000 to 2010	U.S. Census Bureau (2000; 2010)	Census block	

Residential Diversity Metrics	Units	Data Source and Vintage	Native Geography of Data	Notes
Change in the diversity of age of residents (2000-2010)	Change in index calculated on a 0-100 scale using proportions of population from the following age groups: 0-17, 18-34, 35-49, 50-64, 65+, 2000 to 2010	U.S. Census Bureau (2000; 2010)	Census block	Calculated by the Preservation Green Lab using census data
Change in racial and ethnic diversity (2000-2010)	Index calculated on a 0-100 scale using proportions of population from the following racial and ethnic groups: Non-Hispanic white, non-Hispanic African-American, non-Hispanic Asian, Hispanic, and all other races and ethnicities, 2000 to 2010	U.S. Census Bureau (2000; 2010)	Census block	Calculated by the Preservation Green Lab using census data
Change in the percent of the population that is Hispanic or non-white (2000-2010)	Change in the count of all Hispanic or non-White residents divided by the total population per grid square, 2000 to 2010	U.S. Census Bureau (2000; 2010)	Census block	

APPENDIX C: COMPLETE FINDINGS

Findings: Livability Measures

Livability	Median Bldg Age	Diversity Bldg Age	Granularity	Character Score	% Pre-1945	% Pre-1920
Percent tree canopy	0.657	0.084	0.543	0.447	2.770	3.992
Average surface temperature	-0.305	-0.026	-0.094	-0.124	-0.834	-0.700
PAG Walkability	1.929	1.294	-2.747	0.106	16.859	38.255
Access to bike infrastructure (distance to bike route)	-0.362	0.276	3.564	1.282	13.991	36.015
Access to streetcar (distance to streetcar stop)	-268.624	-372.807	-39.242	-26.601	-323.44	-110.580
Top Tucson Weekly restaurants	0.010	0.008	-0.008	0.003	0.094	0.090
Top Tucson Lifestyle restaurants	0.000	0.028	-0.009	0.005	0.145	0.201
Top restaurants (combined lists)	0.010	0.036	-0.018	0.008	0.239	0.292
Best Of Tucson 2015 places (TW)	0.064	0.017	-0.046	0.012	0.361	0.499

Cells highlighted in green show support the hypothesis that areas with older, smaller buildings and greater diversity of building age support positive livability findings. Findings highlighted in red counter this hypothesis with a significant result in the opposite direction. Findings highlighted in yellow indicate that no significant link was found between that predictor variable and the specific livability measure.

The findings from this research show a clear, statistically significant link between key measures of livability and the presence of older, smaller buildings and mixed-vintage blocks. Areas with older, smaller buildings and a fine-grained mix of old and new buildings have significantly greater tree canopy and significantly cooler average surface temperatures. Areas with older buildings and mix of old and new buildings are also significantly more walkable and have significantly more accessibility via the new streetcar. Contrary to our expectations, this analysis shows some evidence that coarse-grained areas with relatively large buildings are more walkable and bikeable. This may be an artifact of the fact that Tucson's bicycle and pedestrian infrastructure follows major traffic corridors, where there larger buildings than in other parts of the city.

We also analyzed the relationship between Tucson's most beloved restaurants and retailers and characteristics of the built environment. Using lists of top restaurants and retailers from *Tucson Weekly* and *Tucson Lifestyle* (as rated by readers' votes), and the list of other top-ranked places in the *Best of Tucson 2015* list from *Tucson Weekly,* we collected and geocoded the locations of all listed establishments. We find that areas of Tucson that have a greater mix of old and new buildings and a higher percentage of buildings constructed before 1945 are significantly more likely to have top-ranked restaurants, retailers, and other favorite places.

Findings: Economic Vitality Measures

We analyzed a wide range of measures of economic vitality in this study, including data on the total number of private-sector jobs, as well as counts of jobs in small businesses, new businesses, creative industries, and food and accommodation industries. Using a non-governmental dataset, we also analyzed the count of businesses and reported count of employees. We measured each variable in multiple forms: the latest count of jobs, businesses, or employees per grid square; the count of jobs, businesses, and employees per 1,000 commercial square feet; the change in count of jobs or businesses over time; and the change in jobs or businesses over time per 1,000 commercial square feet. (Data on the count of employees was only available for one point in time and was not included in the change over time analysis.) We also analyzed the percent of all jobs represented by jobs in small businesses, new businesses, creative industries, and food and accommodation industries, and the change in the proportion of these job types across two points in time. This research also included a focused look at the count and percentage of women and minority-owned businesses, new businesses, long-running businesses, and non-chain restaurants and retailers. Finally, we analyzed sales tax revenue generated by businesses across two points in time, both as an aggregate sum and on a per-commercial-square-foot basis.

We analyze the count of jobs, employees, and businesses, employees per commercial square foot in order to control for the height of buildings and support an "apples to apples" comparison of job density across different types of buildings. It is fair to assume that taller, mid- and high-rise buildings will have a greater aggregate count of jobs, employees, and businesses than older, one-to-three floor commercial and mixed-use buildings. Stacking businesses and jobs is, of course, an efficient use of land, but "per-commercial-square-foot" measures illuminate the relative intensity of use of the building overall.

The findings of this analysis suggest that areas of Tucson with older, smaller buildings and mixed-vintage blocks perform as well as areas with larger, newer buildings, and in many instances, the older and historic sections of the city outperform areas with relatively large, new commercial buildings.

Private Sector Jobs (Overall)

As an aggregate count, areas with smaller buildings and high Character Scores have significantly fewer private sector jobs than areas with larger mixed-use and commercial buildings. However, areas with older, smaller buildings have more jobs on a per-commercial-square-foot basis. Contrary to our expectations, we find that areas with a mix of old and new buildings have significantly lower counts of private sector jobs per commercial square foot. Between 2009 and 2013, however, areas with a mix of old and new buildings have had a significant increase in the count of private sector jobs, compared to the change in private sector jobs in areas that are more homogenous in their era of construction. Areas of Tucson with larger proportions of buildings constructed before 1920 had a substantial and statistically significant increase in their count of private sector jobs. Finally, on a per-commercial-square-foot basis, areas of Tucson with older buildings gained significantly more jobs between 2009 and 2013 than areas with newer buildings.

Economic Vitality – Private Sector Jobs	Median Building Age	Diversity Building Age	Granularity	Character Score	% Pre-1945	% Pre-1920
Density of private jobs (2013)	0.393	-0.711	-7.031	-2.455	-4.101	24.740
Density of private jobs per 1K comm. sq. ft. (2013) (log)	0.041	-0.151	0.296	0.071	0.179	0.429
Change in density of jobs (2009-2013)	-4.025	11.508	2.132	2.75	29.046	200.45
Change in density of jobs per 1K comm. sq. ft. (2009-2013)	1.097	0.456	-0.859	0.238	5.452	4.671

Green highlighting indicates findings that supported the hypothesis that areas with older, smaller buildings and mixed-vintage blocks had significantly greater counts of private sector jobs than areas with predominately newer, larger buildings. Red highlighting indicates statistically significant findings that countered this hypothesis, and yellow highlighting indicates findings without a statistically significant difference.

Jobs in New Businesses

As an aggregate count, areas with smaller buildings have significantly fewer jobs in new businesses. However, areas with older, smaller buildings and high proportions of buildings constructed before 1945 and 1920 have significantly more jobs in new businesses per commercial square foot. Areas with high Character Scores and smaller buildings have significantly higher percentages of jobs in new businesses, compared to areas with larger buildings and low Character Scores. Between 2011 and 2013, areas with older buildings have had significantly less growth in the aggregate count of jobs in new businesses than areas with newer buildings, though this analysis found no significant difference in the change in density of jobs in new businesses per commercial square foot over the same time period. Finally, between 2011 and 2013, areas with smaller buildings and high Character Scores had a significantly greater increase in the proportion of jobs in new businesses, compared to areas with larger buildings and low Character Scores.

Economic Vitality – Jobs in New Businesses	Median Building Age	Diversity Building Age	Granularity	Character Score	% Pre-1945	% Pre-1920
Density of jobs in new businesses (2013)	-0.027	0.068	-0.324	-0.100	0.332	4.260
Density of jobs in new businesses per 1K comm. sq. ft. (2013) (log of non-zero values)	0.094	-0.134	0.496	0.167	1.111	1.552
Percent of private sector jobs in new businesses (2013)	0.000	-0.002	0.010	0.003	0.025	-0.037
Change in density of jobs in new businesses (2011-2013)	-0.694	-0.132	0.558	-0.101	-5.516	-37.038
Change in density of jobs in new businesses per 1K comm. sq. ft. (2011-2013)	0.144	0.009	0.057	0.074	0.256	-0.575
Change in percent of private sector jobs that are in new businesses (2011-2013)	0.000	0.002	0.009	0.004	0.004	-0.075

Green highlighting indicates findings that supported the hypothesis that areas with older, smaller buildings and mixed-vintage blocks had significantly greater counts of jobs in new businesses than areas with predominately newer, larger buildings. Red highlighting indicates statistically significant findings that countered this hypothesis, and yellow highlighting indicates findings without a statistically significant difference.

Jobs in Small Businesses

This research strongly supports the hypothesis that areas with older, smaller buildings and a mix of old and new buildings foster small businesses. Whether measured as aggregate counts of jobs or as counts of jobs per commercial square foot, high Character Score areas outperform areas of Tucson with larger, newer buildings in their density of jobs in small businesses. Measured as change over time, this research identified no significant differences between different areas of Tucson according to median building age, diversity of age, granularity, or Character Score.

Economic Vitality – Jobs in Small Businesses	Median Building Age	Diversity Building Age	Granularity	Character Score	% Pre-1945	% Pre-1920
Density of jobs in small businesses (2013)	0.350	0.820	-0.173	0.310	3.439	10.390
Density of jobs in small businesses per 1K comm. sq. ft. (2013) (log of non-zero values)	0.218	-0.004	0.522	0.282	1.286	2.089
Percent of private sector jobs in small businesses (2013)	0.038	0.024	0.053	0.039	0.310	0.404
Change in density of jobs in small businesses (2011-2013)	-0.081	0.07	0.048	0.008	0.209	-0.483
Change in density of jobs in small businesses per 1K comm. sq. ft. (2011-2013)	-0.01	0.033	-0.055	0.008	0.209	-0.483
Change in percent of private sector jobs that are in small businesses (2011-2013)	0.003	0.003	-0.004	0.001	0.035	-0.001

Green highlighting indicates findings that supported the hypothesis that areas with older, smaller buildings and mixed-vintage blocks had significantly greater counts of jobs in small businesses than areas with predominately newer, larger buildings. Red highlighting indicates statistically significant findings that countered this hypothesis, and yellow highlighting indicates findings without a statistically significant difference.

Jobs in Creative Industries

This research finds some support for the hypothesis that areas with older, smaller buildings and a mix of old and new buildings act as hubs of jobs in creative industries. As an aggregate count, areas with smaller buildings and high Character Scores have significantly fewer jobs in creative industries, though this is tempered by significantly greater aggregate counts of jobs in creative industries in areas with high diversity of building age and high concentrations of buildings constructed before 1920. On a per-commercial-square-foot basis, areas with older, smaller buildings, high Character Scores, and high percentages of buildings constructed before 1920 and 1945 have significantly more jobs in creative industries. There are also significantly higher proportions of these jobs (as a percentage of all private-sector jobs) in areas with high Character Scores and buildings constructed pre-1920 and pre-1945. Finally, areas with smaller buildings saw a significantly greater rise in the proportion of jobs in creative industries between 2009 and 2013, compared to areas with larger buildings.

Economic Vitality – Jobs in Creative Industries	Median Building Age	Diversity Building Age	Granularity	Character Score	% Pre-1945	% Pre-1920
Density of jobs in creative industries (2013)	-0.349	0.423	-0.537	-0.184	1.059	7.096
Density of jobs in creative industries per 1K comm. sq. ft. (2013) (log of non-zero values)	0.103	-0.054	0.461	0.182	1.577	2.24
Percent of jobs that are in creative industries (2013)	0.007	0.004	0.002	0.004	0.097	0.232
Change in density of jobs in creative industries (2009-2013)	-0.207	-0.165	0.167	-0.067	0.490	5.091
Change in density of jobs in creative industries per 1K comm. sq. ft. (2009-2013)	-0.049	0.328	-0.396	-0.039	1.202	1.900
Change in percent of jobs that are in creative industries (2009-2013)	-0.004	0.001	0.006	0.001	0.027	-0.012

Green highlighting indicates findings that supported the hypothesis that areas with older, smaller buildings and mixed-vintage blocks had significantly greater counts of jobs in creative industries than areas with predominately newer, larger buildings. Red highlighting indicates statistically significant findings that countered this hypothesis, and yellow highlighting indicates findings without a statistically significant difference.

Counts of Businesses and Employees

Access to a proprietary business database allowed us to compare our findings from datasets collected by government agencies to analysis of non-governmental data. This included counts of businesses as identified through telephone surveys and counts of employees as reported by those businesses.

As with our analysis of the density of jobs, we find significantly lower aggregate counts of businesses and employees in areas with small, fine-grained building stock, and significantly greater counts of businesses and employees per commercial square foot in areas with older, smaller buildings and mixed-vintage blocks. Areas of Tucson with high percentages of buildings constructed before 1920 and 1945 have greater density of businesses per commercial square foot, compared to areas with little or no stock of buildings constructed before those dates.

Using business license data from the City of Tucson, we also analyzed the change in counts of businesses between 2008 and 2014, both as an aggregate count and on a per-commercial-square-foot basis. We were surprised to find a significantly greater decrease in the count of active business licenses between 2008 and 2014 in areas that have older median building age. On a per-commercial-square-foot basis, we found a significantly greater decrease in the count of active business licenses over this time period in areas with high Character Scores. However, over this span there was a significant increase in the density of businesses in areas with mostly smaller buildings, showing the growing importance of small buildings for housing businesses in Tucson.

Economic Vitality – Density of Businesses and Employees	Median Bldg Age	Diversity Bldg Age	Granularity	Character Score	% Pre-1945	% Pre-1920
Density of businesses (2013)	0.148	0.277	-0.859	-0.158	-0.122	2.733
Density of employees (2013)	-2.236	0.694	-14.897	-5.677	-25.436	-7.470
Density of businesses per 1K comm. sq. ft. (2013) (logged)	0.074	-0.023	0.429	0.168	0.898	1.402
Density of employees per 1K comm. sq. ft. (2013) (logged)	0.020	-0.037	0.112	0.035	0.204	0.852
Change in density of businesses (2008-2014)	-0.383	-0.079	0.478	0.001	0.300	1.168
Change in density of businesses per 1K comm. sq. ft. (2008-2014) (log)	-0.148	-0.167	0.010	-0.100	-0.760	-1.161

Green highlighting indicates findings that supported the hypothesis that areas with older, smaller buildings and mixed-vintage blocks had significantly greater counts of businesses and employees than areas with predominately newer, larger buildings. Red highlighting indicates statistically significant findings that countered this hypothesis, and yellow highlighting indicates findings without a statistically significant difference.

Business Characteristics

Newest and Oldest Businesses
Areas of Tucson with older median building age had significantly more new business licenses in 2014, but areas with smaller buildings had significantly fewer new business licenses that year. On a per-commercial-square-foot basis, however, areas with smaller buildings actually had significantly more new business licenses in 2014. Meanwhile, Tucson's longest-running businesses are significantly more likely to be located in areas of the city with a mix of old and new buildings and a high percentage of buildings constructed before 1920 or 1945. Contrary to our expectations, these legacy businesses were significantly more likely to be in areas with larger buildings or in areas with fewer buildings sitting side by side.

Women- and Minority-Owned Businesses
We find a similar pattern in the analysis for the locations of women- and minority-owned businesses: these businesses are concentrated in areas with a diverse mix of fairly large old and new buildings and in areas with high percentages of buildings constructed before 1920.

Non-Chain Businesses
We find strong support for the hypothesis that areas with older, smaller buildings, mixed-vintage blocks, and high proportions of buildings constructed before 1920 and 1945 have higher counts and percentages of distinctive non-chain restaurants and retailers. Older median building age, higher Character Scores, and higher percentages of buildings constructed before 1920 and 1945 predict higher counts of non-chain restaurants and retailers. Lower granularity scores—indicating fewer buildings per grid square—were the one significant predictor of counts of non-chain restaurants and retailers that ran counter to our hypothesis. We found that there are significantly higher counts of non-chain restaurants and retailers in areas with large buildings. However, this might be due to the presence of large shopping malls and strip malls that include many businesses in large, single buildings. Finally, all six of our predictor variables were significantly associated with higher percentages of non-chain restaurants and retailers in the expected direction. That is, there are significantly higher proportions of non-chain restaurants and retailers in areas of Tucson where there are older, smaller buildings and mixed-vintage blocks.

Economic Vitality – Business Characteristics	Median Bldg Age	Diversity Bldg Age	Granularity	Character Score	% Pre-1945	% Pre-1920
Density of new business licenses (2014)	0.057	0.039	-0.109	-0.005	0.048	0.063
Density of new business licenses per 1K comm sq ft. (2014) (logged)	-0.012	-0.029	0.073	0.012	-0.032	-0.052
Density of Tucson's longest-running businesses (2013)	0.005	0.007	-0.010	0.000	0.034	0.151
Density of women-and-minority owned businesses (2013)	0.018	0.018	-0.029	0.002	0.100	0.241
Percent of businesses with women-and-minority ownership (2013)	0.000	0.003	-0.003	0.000	-0.002	-0.021
Density of non-chain restaurants and retailers	0.394	0.084	-0.207	0.095	1.609	3.593
Percent of restaurants and retailers that are not chains	0.071	0.033	0.077	0.061	0.398	0.543

Green highlighting indicates findings that supported the hypothesis that areas with older, smaller buildings and mixed-vintage blocks had significantly greater counts of new businesses, longest-running businesses, women and minority-owned businesses, and non-chain restaurants and retailers. Red highlighting indicates statistically significant findings that countered this hypothesis, and yellow highlighting indicates findings without a statistically significant difference.

Sales Tax Revenue

This research finds very limited support for the hypothesis that areas with older, smaller buildings and mixed-vintage blocks and commercial uses produce significantly more sales tax revenue than areas with larger, newer buildings. Areas with larger buildings constructed at around the same time produced significantly greater sales tax revenue in 2013, as did areas with low Character Scores. However, on a per-commercial-square-foot basis, no significant differences were found across the six predictor variables analyzed in this study. That is, areas of Tucson with older, smaller buildings produce roughly the same levels of sales tax revenue per commercial square foot as areas with large, new buildings. Finally, it should be noted that areas with older buildings had a significantly greater increase in sales tax revenue coming out of the Great Recession. This faster recovery compared to areas with relatively new buildings supports the hypothesis that areas with older buildings have greater economic resilience during large cycles in general prosperity.

Economic Vitality – Sales Tax Revenue	Median Bldg Age	Diversity Bldg Age	Granularity	Character Score	% Pre-1945	% Pre-1920
Sales tax revenue (2013)	-5931.57	-34799.77	-62500.19	-33227.40	-135471.9	-3989.98
Sales tax revenue per comm. sq. ft. (2013)	-0.12	-0.87	1.60	0.29	-3.75	-1.30
Change in sales tax revenue (2009-2013)	13095.87	-9739.45	-6997.09	-6.81	-29199.67	39756.94
Change in sales tax revenue per comm. sq. ft. (2009-2013) (log)	0.10	-0.52	0.93	0.23	-1.67	-1.28

Green highlighting indicates findings that supported the hypothesis that areas with older, smaller buildings and mixed-vintage blocks had significantly greater sales tax revenue. Red highlighting indicates statistically significant findings that countered this hypothesis, and yellow highlighting indicates findings without a statistically significant difference.

Findings: Residential Density and Diversity Measures

Finally, we analyzed links between data on residential density and demographic diversity from the decennial census and key characteristics of the built environment. We compared the population characteristics of areas of Tucson with older, smaller buildings and mixed-vintage blocks to areas with predominantly large, new buildings.

Population Density and Vacancy Rates

Our findings relating residential density and vacancy rates to building age, diversity of building age, and granularity are mixed. Though areas of Tucson with older buildings had significantly lower vacancy rates in 2010, these areas had lower population density in terms of both count of residents and count of housing units. They also saw significantly greater declines in population density between 2000 and 2010, relative to areas with newer buildings. High granularity scores—indicating that there are higher counts of smaller buildings in the area—were associated with significantly greater density in 2010 and significantly greater increases in density between 2000 and 2010, as well as lower vacancy rates in 2010 and greater drops in vacancy rates between 2000 and 2010. The composite Character Score metric was a significant predictor of greater population density and housing unit density in 2010, as well as significantly lower vacancy rates. However, areas with high Character Scores also had significantly less population growth between 2000 and 2010 and significantly greater increase in vacancy rates over that period.

Population Density and Vacancy Rates	Median Bldg Age	Diversity Bldg Age	Granularity	Character Score	% Pre-1945	% Pre-1920
Population density - Residents (2010)	-5.449	-1.419	15.960	4.103	-5.517	-6.664
Population density - Housing units (2010)	-1.912	-0.310	5.320	1.516	-1.814	6.781
Vacancy rate (2010)	-0.002	0.003	-0.007	-0.002	0.020	-0.006
Change in population density - Residents (2000-2010)	-3.472	0.780	1.856	-0.427	2.461	8.743
Change in population density - Housing units (2000-2010)	-1.13	0.263	0.656	-0.116	-0.647	1.595
Change in vacancy rate (2000-2010)	0.005	0	-0.002	0.001	0.002	-0.019

Green highlighting indicates findings that supported the hypothesis that areas with older, smaller buildings and mixed-vintage blocks had significantly greater population density and lower vacancy rates. Red highlighting indicates statistically significant findings that countered this hypothesis, and yellow highlighting indicates findings without a statistically significant difference.

Population Diversity

As with measures related to population density, our findings related to population diversity are mixed. In 2010, areas of Tucson with high diversity of building age had significantly younger residents, greater proportions of residents between the age of 18 and 34, and greater racial and ethnic diversity. However, areas of Tucson with older median building age have significantly older residents, lower proportions of residents between the age of 18 and 34, less racial and ethnic diversity, and lower percentages of Hispanic or nonwhite residents. Furthermore, between 2000 and 2010, older areas of the city grew significantly less diverse in terms of the population makeup by age group, grew significantly older in terms of the median age of residents, and had significantly greater decreases in proportions of Hispanic or nonwhite residents, compared to areas of the city with newer developments.

In 2010, areas with high Character Scores had significantly greater diversity of residents in terms of the population makeup by age group, and these areas gained significantly higher percentages of the population age 18-34 between 2000 and 2010. However, high-Character-Score areas were also significantly less diverse in terms of racial and ethnic diversity and percent Hispanic or nonwhite in 2010, and had significantly greater decreases in the diversity of the age of residents, and greater decreases in the percent of the population that is Hispanic or nonwhite, between 2000 and 2010.

Areas of Tucson with high percentages of buildings constructed before 1945 and 1920 had significantly higher percentages of residents age 18-34 and significantly greater age of residents in 2010. Areas with high percentages of buildings constructed before 1945 also had a significantly greater increase in the proportion of the population age 18-34 between 2000 and 2010.

Residential Density and Diversity	Median Bldg Age	Diversity Bldg Age	Granularity	Character Score	% Pre-1945	% Pre-1920
Median age of residents (2010)	1.053	-0.346	-0.163	0.116	-0.056	4.451
Percent of the population age 18-34 (2010)	-0.008	0.011	-0.001	-0.002	0.072	0.098
Diversity of age of residents (2010)	1.300	-0.317	0.368	0.418	1.647	11.177
Racial and ethnic diversity (2010)	-1.134	0.327	-0.393	-0.375	-2.500	-6.110
Percent of the population that is Hispanic or non-white (2010)	-0.016	0.000	-0.001	-0.003	-0.030	-0.028
Change in median age of residents (2000-2010)	0.143	-0.072	-0.148	-0.018	-0.687	1.028
Change in the percent of the population age 18-34 (2000-2010)	0.006	0.001	0	0.002	0.025	0.016
Change in the diversity of age of residents (2000-2010)	-0.489	-0.335	0.028	-0.265	-3.346	-3.870
Change in racial and ethnic diversity (2000-2010)	-0.020	0.433	-0.382	-0.032	1.101	-11.102
Change in the percent of the population that is Hispanic or non-white (2000-2010)	-0.005	-0.005	0.001	-0.003	-0.041	-0.086

Green highlighting indicates findings that supported the hypothesis that areas with older, smaller buildings and mixed-vintage blocks had significantly greater population diversity. Red highlighting indicates statistically significant findings that countered this hypothesis, and yellow highlighting indicates findings without a statistically significant difference.

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