



Growing Greener

**The Environmental Benefits of a
Compact and Connected Austin**

TexPIRG
Education Fund

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Written by:

Katherine Eshel, Frontier Group

Luke Metzger and Brian Zabcik, Environment Texas Research & Policy Center

Bay Scoggin, TexPIRG Education Fund

October 2017

Acknowledgments

The authors thank Drs. Kara M. Kockelman, John M. Sharp and Jacob A. Wegmann of The University of Texas at Austin, and Dr. John Jacob of Texas A&M University, for their review of drafts of this document, as well as their insights and suggestions. Thanks also to Tony Dutzik and Elizabeth Berg of Frontier Group for editorial support.

Environment Texas Research & Policy Center and TexPIRG Education Fund thank the Meadows Foundation for making this report possible. The authors bear responsibility for any factual errors. The recommendations are those of Environment Texas Research & Policy Center and TexPIRG Education Fund. The views expressed in this report are those of the authors and do not necessarily reflect the views of our funders or those who provided review.

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Growing Greener is also the name of grant program in the Commonwealth of Pennsylvania that funds watershed restoration and protection, abandoned mine reclamation and abandoned oil and gas well plugging projects.

Layout: To the Point Publications, tothepoint@imagina.com

Cover photo: Brian Zabcik

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Executive Summary

Austin is one of America's fastest-growing cities. This growth has brought dynamism to the city, but has also created environmental problems. Because much of Austin's growth has taken place at the urban fringe, the addition of new residents and businesses has caused persistent and worsening problems with traffic congestion, air pollution and water quality, as more undeveloped land is converted into new development.

To accommodate the continued influx of new people to the city, Austin is currently revising its land development code in a process called CodeNEXT. This revision seeks to house a growing population in ways that minimize the increase of developed land.

Compact development can deliver tangible benefits for the environment – reducing energy use and greenhouse gas emissions, curbing the flow of polluted runoff into streams and lakes, and protecting natural areas and agricultural lands. By adopting strong policies to mitigate the local impacts of greater density, such as green infrastructure to manage stormwater, Austin can develop in a way that will bring lasting environmental benefits.

Compact development benefits the environment in numerous ways.

- **Energy use and greenhouse gas emissions:** Compact development uses less energy for construction, building operation and transportation, which results in lower greenhouse gas emissions.
- In Austin, a suburban neighborhood with detached single-family homes can consume up to three times more energy in construction and materials, and up to 50 percent more energy in daily operation than a densely developed neighborhood with duplexes and low-rise apartments.¹
- Shared walls in attached buildings result in direct energy savings as housing units share and save heat, with less leakage.²
- Energy used for transportation currently generates 35 percent of greenhouse gas emissions in Travis County.³ The 2007 study *Growing Cooler* and other studies have found that people living in compact neighborhoods drive 20 to 40 percent less than those living in sprawling neighborhoods, using less energy and producing fewer emissions.⁴
- **Water quality:** Compact development reduces land conversion, which has a significant impact on water pollution.⁵ Compact development also produces less runoff and affects less of a given watershed than lower-density development, resulting in healthier waterways and aquifers for the same amount of housing capacity.⁶
- A Houston-area study suggests that doubling density in that city would result in less overall pollution in the area's bays and bayous, and would do more to curb pollution than many traditional tools for managing stormwater.⁷

- Urban sprawl also affects aquifer recharge. The amount of clean rainwater that can infiltrate into the soil where it falls is reduced by sprawl, while the amount of dirty runoff polluted with pesticides and pathogens is increased.⁸ This can result in poor water quality in some areas where polluted water enters Austin’s waterways, threatening surface and groundwater quality.⁹
 - **Flood risk:** Compact urban development can help minimize the total amount of paved land in the metropolitan area, which contributes to less total runoff and reduced flood risks.¹⁰
 - The U.S. Geological Survey studied 25 years of streamflow and rainfall data along Waller Creek and found that converting land along the creek for development increased the scale and frequency of flooding.¹¹
 - A 2003 study published in the *Journal of Water Resources and Planning* found that high- and medium-density development increased impervious cover 72 percent less than low-density development.¹² As a result, high- and medium-density developments had less than half the effect of low-density development on runoff volume and peak flow.¹³
 - **Water consumption:** Compact development can result in lower water use than sprawling development.¹⁴ Building more compactly on smaller lots can decrease water demand for landscaping and minimize overall water demand.¹⁵
 - A 2007 study found that water use in single-family units in the Phoenix metro area increased by 1.8 percent for each 1,000-square foot increase in average lot size, and by 1.7 percent for every 1°F rise in the average daily temperature low due to the urban heat island.¹⁶
 - In Austin, outdoor uses, like residential lawn watering and commercial landscape irrigation, account for more than a fifth of total water use, with a summertime peak.¹⁷ Austin also has the highest percentage of big-lot homes among the four major metro areas of Texas, with 6.6 percent of single-family homes on 5-acre lots or more.¹⁸ Smaller lot sizes could help to lower water demand and reduce pressure on Austin’s water resources.
 - **Land consumption:** Population growth, suburbanization and urban development drive land conversion in Texas.¹⁹
 - The Texas A&M Institute of Renewable Natural Resources estimates that between 1997 and 2012, Texas lost more than 1.1 million acres of farms, ranches and forests to urban and suburban development, 87 percent of which lie within the state’s 25 fastest-growing counties.²⁰
 - **Air quality:** Compact development forms can reduce traffic over a metropolitan area, which results in lower levels of ozone, a ground-level pollutant that can cause adverse health effects.²¹ Compact development can also reduce urban heat island effects, which contribute to ozone pollution; as a result, compact cities have relatively fewer heat waves, and improved regional air quality.²²
 - Sprawling cities have been found to experience up to 62 percent more high ozone days than compact cities.²³
 - Particulate pollution causes approximately 8,700 premature deaths in Texas each year, and ozone pollution causes approximately 2,100 more.²⁴
- Compact forms of development deliver environmental benefits at the regional level, but may create local environmental and public health impacts. Through smart public policy, Austin can mitigate many of the local impacts of compact development.**
- Green stormwater infrastructure (GSI) can help compensate for the increase of impervious cover in densely developed areas. By using natural drain-

age processes to capture and cleanse rainwater on-site, GSI features can reduce water pollution and flooding severity. GSI features are especially effective at filtering surface pollutants out of stormwater, and can generally retain enough water to reduce or even eliminate flooding from small to mid-size storms.²⁵

- Limiting the overall amount of impervious cover helps ensure the preservation of undeveloped land where rainwater may naturally infiltrate the soil or be stored, which enhances flood resiliency. But impervious cover limits, like the Save Our Springs Ordinance that limits impervious surface to 15 percent of the total site area in the Barton Springs Zones, must be implemented with care to ensure that they do not increase incentives for sprawl.
- The localized increases in vehicular traffic and air pollution that may result from increased density can be reduced through improvements in public transportation, vehicle electrification, mobility as a service (e.g. ride-hailing), and improved infrastructure for walking and biking. Today, Austin ranks only 21st in job accessibility via transit out of the 50 metro areas with the largest populations.²⁶ Compact, mixed-use

neighborhoods built around high-capacity transit can help decrease energy use and greenhouse gas emissions.

- Street and building designs that maximize vegetation and reflectivity can reduce urban heat island effects. One study focused on development in Houston found that placing shade trees near buildings and using light-colored roofing and paving materials that reflect sunlight could save \$82 million on energy, decrease peak power demand, and cut carbon emissions by an amount equivalent to taking more than 199,000 passenger vehicles off the road.²⁷

The current revision of Austin's land development code, last overhauled in the 1980s, gives the city a golden opportunity to reshape how it develops for coming generations. Expanding the areas within Austin where compact and walkable neighborhoods can be built would reduce the pressure for further sprawl, protect our environment, and enhance our quality of life. Austin should adopt a new development code that increases neighborhood walkability, provides "missing middle" housing (a wide range of residential forms between single-family homes and high-rise apartment buildings), and reduces the considerable environmental damage caused by sprawl.

Introduction

Austin is experiencing among the fastest population and economic growth in the country. Austin's growth has brought benefits to many – a 2017 Brookings Institution report found that Austin's growth since 2010 has reduced unemployment and poverty rates and made the city an attractive destination for workers and employers.²⁸

But Austin's dynamism also brings challenges – such as conversion of undeveloped land into development, persistent and worsening problems with traffic congestion, and growing concerns about the impact of development on water quality. The health of Austin's reservoirs has declined in recent years, while urban floods like the deadly 2015 Memorial Day flood have caused millions of dollars in damage.²⁹

Looking to the future, Austin faces a choice – continue to grow mainly through new development at the region's fringe, or find ways to accommodate more people and businesses within the city's existing neighborhoods.

Focusing new growth in compact, walkable neighborhoods can address many of Austin's growing pains. Done right, compact development can benefit the environment and provide access to types of housing – such as housing in the “missing middle” between high-rises and single-family homes – that can meet Austin's emerging housing needs. Building quality compact single-family and multi-family housing close to transit can create viable housing options close to the city center as Austin continues to grow.

Credit: © 2015 Opticos Design, Inc.



Figure 1. The “Missing Middle” Refers to Residential Forms Ranging from Duplexes to Small Apartment Buildings

In this unique moment of growth and prosperity, the city has a rare opportunity to implement its vision for a “compact and connected Austin,” originally laid out in the *Imagine Austin* comprehensive plan, by enshrining compact development in its new Land Development Code, current being revised through the CodeNEXT process.

As CodeNEXT is finalized and debated through early 2018, it will be crucial to ensure that the new code’s provisions lay the foundation for a more compact, livable and environmentally sustainable Austin. This

paper reviews the existing literature produced by academic and government researchers on the environmental effects of different urban densities, with a particular emphasis on studies carried out in Austin and Texas, and describes the considerable environmental benefits of compact development. By building for a compact and connected future, Austin can meet its growth challenges, while protecting our environment, as well as setting an example of leadership for other rapidly growing cities to follow.

Austin Is Experiencing Explosive Population Growth

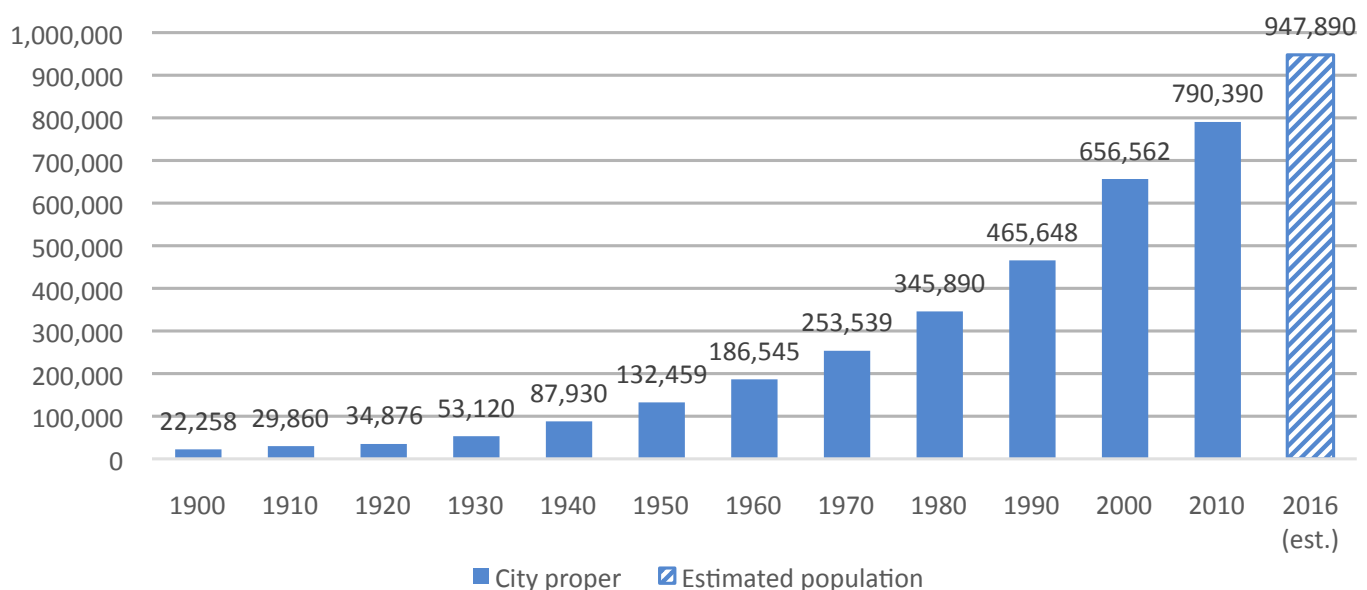
Austin is one of the fastest-growing large metro areas in America, with the second highest population growth rate since 2010.³⁰ The population of the Austin area has increased by nearly 20 percent since 2010, adding more than 340,000 new residents, or approximately 149 new residents per day, more than any other decade since the beginning of the 20th century.³¹

Austin is not the only Texas city experiencing rapid growth. Although the population of the Austin area has soared in recent decades, the fastest growth is taking place in suburbs.³³ Whereas neighborhoods around the central business district and the Capitol lost residents between 2010 and 2015 according to the American Community Survey, some suburbs have even doubled in size over the same period, such as

Buda and Hutto.³⁴ Two of the fastest-growing cities in America are actually suburbs located in the Austin metro area – Georgetown and Cedar Park, which grew by 5.5 percent and 4.5 percent respectively in 2016.³⁵ Moreover, average neighborhood density has fallen, declining by 5 percent between 2010 and 2016.³⁶ In other words, people are moving to the Austin area, but a large amount of that growth has consisted of low-density development on the urban fringe.

The environmental impacts of sprawling development patterns are well-documented, with numerous studies detailing the impacts in Texas cities.³⁷ The adoption of a new land development code provides Austin with an opportunity to revisit its historical development patterns in ways that can benefit the environment and quality of life.

Figure 2. Austin Has Experienced Rapid Growth Since the Beginning of the 20th Century³²



CodeNEXT Provides an Opportunity to Shift Away from Sprawl

The City of Austin is revising its land development code through the CodeNEXT process in order to achieve the goals laid out in its roadmap for a compact and connected city, the *Imagine Austin* comprehensive plan.³⁸

Imagine Austin, adopted in 2012, describes the city Austin aspires to be, a city of “complete communities” that is “natural and sustainable.”³⁹ Achieving that vision will require changes to key city policies, including the city’s land development code, which was last overhauled in 1984.

Compact development should be a core objective of CodeNEXT, which seeks to focus new growth along transit corridors and within urban centers, allowing the city’s existing neighborhoods to grow, while ensuring new develop-

ment fits into walkable, mixed-use, connected neighborhoods.⁴⁰ CodeNEXT should prioritize ensuring a resilient natural environment through water stewardship, flood mitigation, tree protection, and creation of open space, parks and nature in the city.⁴¹ By codifying compact development, CodeNEXT should seek to both avoid and mitigate the environmental impacts of sprawl, and to optimize energy, water, air quality and land use within the urban environment.

After a third draft of CodeNEXT is due to be released in late 2017, City Council will deliberate from December to January, and is scheduled to adopt the final CodeNEXT Land Development Code in April 2018, punctuating nearly a decade of public debate over the city of Austin’s future.

Sprawling, low-density development drives up the public costs for roads, water lines, and other infrastructure that must be continually extended to far-flung new development. Austin simply can’t afford to ignore the costs associated with the way we’ve grown. The patterns of the past decades are neither environmentally nor fiscally sustainable.

City of Austin, Imagine Austin Comprehensive Plan, p. 7

Austinites have consistently supported smart growth and environmental protections through the years. Land conservation is a priority for voters around the Austin metro area. Voters in Travis, Williamson, Hays, Bastrop and Caldwell Counties have voted for 27 public finance measures totaling more than \$508 million for parks and land conservation since 1992, with an average approval rate of 61 percent.⁴³ As well as land conservation, Austinites have also taken steps to influence their

city's future form. In May 1998, Austinites voted for a smart growth matrix to curtail suburbanization.⁴⁴ Because most of the land within Austin's city limits has already been developed, changes in the way the city is built must happen in compact redevelopments of previously developed areas, rather than in new developments on undeveloped land.

Revising the city's land development code is an opportunity to give the city the tools it needs to sustainably manage its growth and build a greener Austin.

What Is Compact Development?

Compact development is a land use settlement pattern that seeks to minimize land conversion while enabling population growth. To do so, compact development concentrates people and jobs in mixed-use neighborhoods, and features housing from single-family homes on small lots and townhomes to apartments and high-rises, to provide access to affordable housing and convenient employment opportunities. Successful compact development also yields a high quality of life, creating walkable neighborhoods with open spaces, interconnected streets, public transit access and proximity, and pedestrian- and bicycle-friendly street design. To minimize the impact of development on the natural environment, compact growth should focus on redeveloping previously developed property, and limit "greenfield" development on the metropolitan fringe.

In Austin, the Mueller redevelopment, the result of 20 years of community planning, is an example of a compact, pedestrian-scaled, mixed-use community that is well on its way to provide homes for 13,000 people, close to downtown.⁴²

Photos: Brian Zabcik.



Residential forms in compact development can range from courtyard housing (left) to condominiums (center and right).

How Denver's Form-Based Code Integrates Land Use and Transportation for Sustainable Growth

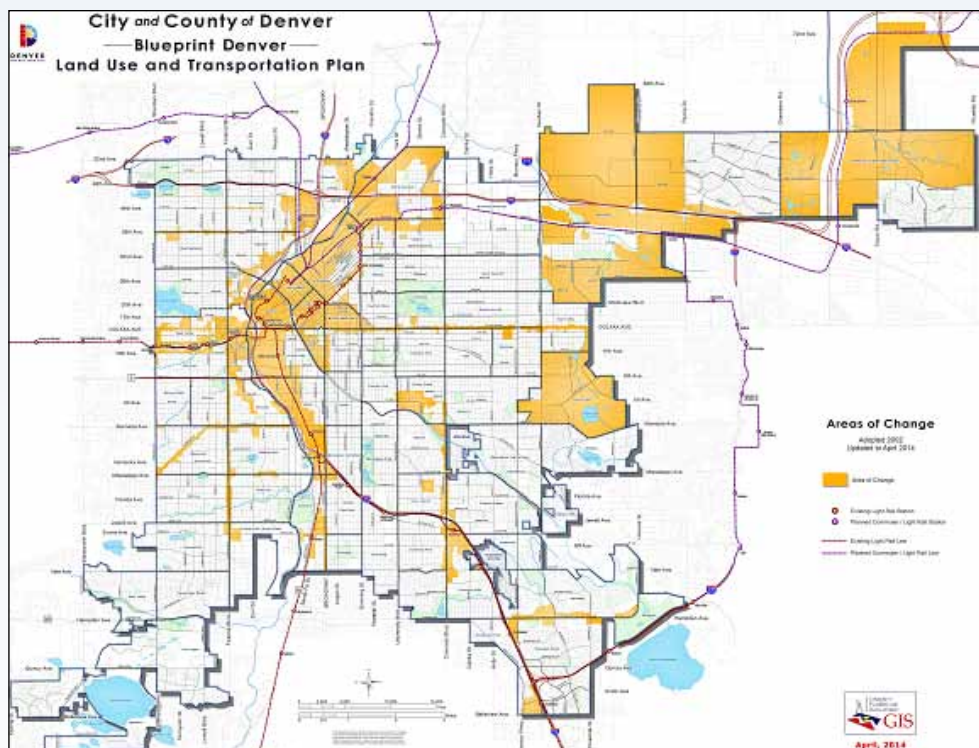
Denver provides an example of a city working to reorient 20th-century traditional development patterns. Since Blueprint Denver, the city's first integrated land-use and transportation plan, adopted in 2002, Denver has strengthened its walkable downtown, preserved old neighborhoods, developed and expanded its light rail system and rethought sustainability at a regional scale.⁴⁵ A key element of the plan is the effort to direct new development toward designated "areas of change" throughout the city where the community wished to see new growth (see Figure 3. Denver Designated Significant Portions of the City as "Areas of Change" (in Orange) to Direct New Growth. Figure 3 below), enabling preservation of community character in "areas of stability."⁴⁶

In 2010, the City and County of Denver adopted a citywide form-based code, the second major city in the U.S. to do so.⁴⁷ The code divided the city into seven different kinds of neighborhoods: Suburban, Urban Edge, Urban, General Urban, Urban Center, Downtown, and

Special. Each of those neighborhoods is broken up into zone-specific districts, which indicate what the dominant building form should be that area, such as single-family or multi-family housing, mixed-use or main street. The code also regulates building heights, setbacks, ground-floor uses and parking requirements. Denver's code complements its voter-approved expansion of the transit system by encouraging the development of diverse affordable housing close to transit and employment centers.

Although the city still has a way to go to reduce the impacts of sprawl, Denver's shift to transit-centered compact development around regional centers has improved quality of life in the region, revitalizing neighborhoods and reducing air pollution related to transportation.⁴⁸ For example, in the Mariposa neighborhood in downtown Denver, which is being redeveloped with new mixed-income housing units, average transit commute times have fallen by one-sixth, and the total crime rate has dropped by a third, indicating a healthier and safer community.⁴⁹

Figure 3. Denver Designated Significant Portions of the City as "Areas of Change" (in Orange) to Direct New Growth.



Source: Denver Community Planning and Development

Compact Development Delivers Environmental Benefits

As Austin decides how to accommodate future growth, it faces a choice between the adoption of policies that help people find housing in the kinds of compact, walkable neighborhoods that are in high demand, or the continuation of policies that shunt new development to the metropolitan fringe. The consequences of this decision for the environment and for Austin's quality of life are immense.

Research across a variety of disciplines suggests that compact development is an environmentally sound choice for Austin's future.

Compact Development Cuts Urban Energy Use and Global Warming Pollution

Planning compact cities can cut urban energy use and greenhouse gas emissions from transportation and buildings.

Compact Urban Neighborhoods Benefit from Proximity and Access to Public Transportation

The total distance traveled by Austin drivers grew by approximately a quarter between 2009 and 2015, the result of population growth and more driving per person.⁵⁰ Like many North American cities, Austin has been caught in a self-reinforcing pattern of sprawl and automobile dependency, compounded by the lack of public transportation and alternatives to individual vehicle travel.⁵¹

The link between urban density and transport-related energy consumption is well established, and the benefits of increasing density start manifesting at just six to eight dwelling units per acre, with housing forms like single-family homes on narrow lots, duplexes or townhomes.⁵²

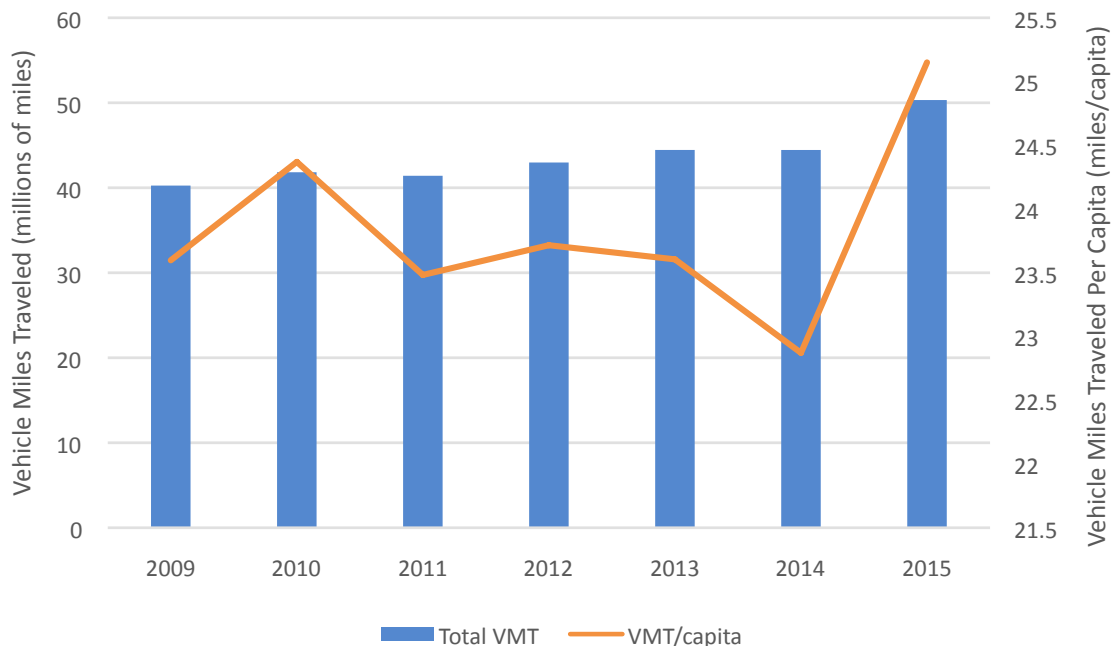
- A 2003 study published in *Transportation Research Record* analyzed sprawl and transportation outcomes in 83 large metropolitan areas and found that a 25-unit increase in compactness (measured in this study by density, land use mix, strength of activity centers and street connectivity) resulted in a 5 percent decrease in vehicle miles traveled (VMT) per person, a 3 percent increase in public transit use for work trips, as well as lower vehicle ownership.⁵³

Photo: Jon Lebkowsky via Flickr, CC-BY-SA 2.0.



Austin traffic at sunset.

Figure 4. After a Slight Downward Trend, People in the Austin Area Are Driving More⁵⁹



- A study published in 2005 in *The Review of Economics and Statistics* analyzed Nationwide Personal Transportation Survey data from 1990 and determined that moving a household 10 percent closer to the city center reduces annual VMT by 1.5 percent.⁵⁴ The study’s results also suggested that the impact of urban form is compounded by transit supply – a household in Boston, a compact city with rail and non-rail transit options, drives 21 percent less and is 17 percent less likely to drive to work than a household in a low-density city like Houston.⁵⁵
- A national-level 2013 study from the University of California Transportation Center determined that “a 50% increase in housing density gives rise to [...] about 7% decrease in mileage and fuel consumption.” According to the study, the density of the surrounding area also affects driving and fuel usage; a household in an urban area (approximately six dwelling units per acre) drives 21 percent less and consumes approximately 20 percent less fuel than a household living in a suburban area (approximately two to three dwelling units per acre).⁵⁶

Suburban households in the Austin metro area emit 4,106 pounds more of carbon dioxide per year from driving than households in the city center.⁵⁸

The dependency of suburban and rural residents on cars for travel results in higher greenhouse gas emissions.

- Peter Newman and Jeffrey Kenworthy demonstrated in their 1989 publication, *Cities and Automobile Dependence*, that low-density, car-dependent cities use more fossil fuels for transportation.⁵⁷
- A study published in the *Journal of Urban Economics* in 2010 found that suburban households in the Austin metro area emit 4,106 pounds more of carbon dioxide per year from driving than

households in the city center, or the equivalent of burning 210 more gallons of gasoline each year.⁵⁸

People who live in urban and walkable neighborhoods drive less and use less energy for transportation, resulting in fewer greenhouse gas emissions.

- The 2007 study *Growing Cooler* from the Urban Land Institute found that people living in compact neighborhoods drive 20 to 40 percent less than those living in sprawling neighborhoods.⁶⁰
- The Urban Land Institute's later study, *Moving Cooler*, concluded that if 60 to 90 percent of new development were built as compact development and coordinated with transit, it could result in a 9 to 15 percent reduction in U.S. transportation carbon dioxide emissions by 2050.⁶¹
- In the April 2017 issue of the *Journal of American Planning Association*, devoted to the question of land form and driving, researcher Mark R. Stevens published an article that analyzed 46 studies of compact development and driving.⁶² His analysis found that when housing density doubles, people drive 22 percent less.⁶³ His findings indicated that another urban parameter, distance to downtown, had a much stronger influence on driving – if a household moved from 10 miles to 5 miles from downtown, Stevens' analysis indicates it would drive 32 percent fewer miles.⁶⁴

In emphasizing walkable neighborhoods, compact development allows people to live within reasonable distance of jobs, schools, shops, and parks, which can reduce vehicle miles traveled and greenhouse gas emissions.⁶⁵

- A 2016 study published in the *Journal of Physical Activity and Health* found that residents in dense neighborhoods (more than 10,000 people per square mile, or approximately 16 people per acre) were almost three times more likely to bike for transportation than those living in low-density neighborhoods (fewer than 500 people per square mile, or fewer than one person per acre).⁶⁶

- A study published in the *Transportation Research Record* in 1994 found that people begin to shift from using single-occupancy vehicles to public transit and walking when certain density thresholds are reached.⁶⁷ When housing density exceeds seven to nine dwelling units per acre, people start to walk or take public transit instead of driving for shopping trips.⁶⁸ Increasing employment density to 75 employees per acre also results in a shift from single-occupancy vehicles to walking and transit for work trips.⁶⁹
- A 2006 study in the *Journal of Physical Activity and Health* affirmed that distance to destination and route directness consistently affected the likelihood of walking for transportation.⁷⁰
- The Urban Land Institute's *Moving Cooler* study also found that at higher densities, vehicle trips themselves tend to be shorter.⁷¹

Photo: Jeremy Stenberg via Flickr, CC-BY-NC 2.0.



Layers of highways on the outskirts of Austin. Compact development can help decrease car dependency and lower transportation-related energy use and greenhouse gas emissions.

Phoenix's Walkable Urban Code Relies on Residential Infill along Public Transit Lines

The Phoenix, AZ, metro area incentivized auto-dominated travel for decades, resulting in low-density sprawl.⁷⁶ In 2005 alone, developers received permits to build 60,000 new single-family homes on the outskirts of greater Phoenix.⁷⁷

Photo: Paul Martinez via Flickr, CC-BY-NC-ND 2.0.



Infill development along light rail lines is at the heart of Phoenix's growth strategy.

Today, infill development along the region's light rail line is a core part of the City of Phoenix's Walkable Urban Code, adopted in July 2015. The city has amended its zoning ordinance to allow single-family lots to attach an additional development unit and to reduce parking within the "Infill Development District" boundary area.⁷⁸ The framework is working so far, and Phoenix has experienced a surge in infill development over the past couple of years; in August 2016, more than 8,000 apartments were being built on infill sites in metro Phoenix.⁷⁹

A 2013 study found that under even the most conservative scenario, residential infill in vacant and paved lots along the new line could help Phoenix achieve between 6.8 percent and 13 percent reductions in total energy consumption and greenhouse gas emissions, as well as reduce respiratory impacts by 6.8 percent and smog formation by 10 percent across the life-cycle of buildings and vehicles, thanks in large part to reduced automobile use.⁸⁰

Compact and mixed land uses are also a prerequisite for successful strategies to reduce transportation-related energy use and emissions.

- A 2010 historical analysis of sprawl by the Lincoln Institute of Land Policy found that higher levels of density are associated with lower car ownership.⁷² Public transit complements compact development strategies by reducing the need for cars for commuting.
- Increasing the density of jobs and residents near transit stops increases transit demand, and makes the expansion of transit service more cost-effective.⁷³

- A 2005 report published by the Transit Cooperative Research Project identified high density, mixed land uses and limited availability of parking as factors in the early success of roundtrip carsharing programs.⁷⁴ Carsharing can reduce both vehicle miles traveled and overall vehicle ownership; for example, in a San Francisco car-sharing program, members saw their daily VMT decrease from 2.80 to 1.49 miles, and nearly a quarter of participants gave up a primary or secondary vehicle.⁷⁵

Smart urban growth expands the travel options of urban residents and reduces energy use and greenhouse gas emissions of cities.

Building More Densely Reduces the Life-Cycle Energy Use and Emissions of Buildings

Compact development can also cut energy use and greenhouse gas emissions in housing. Brian Nichols and Kara Kockelman, two University of Texas at Austin researchers, studied how the built environment in three Austin neighborhoods – Anderson Mill, Hyde Park and Riverside – and in the Westlake Hills suburb influences life-cycle energy use for buildings, transportation and infrastructure, from resource extraction and construction (embodied energy), to everyday use (operational energy).⁸¹

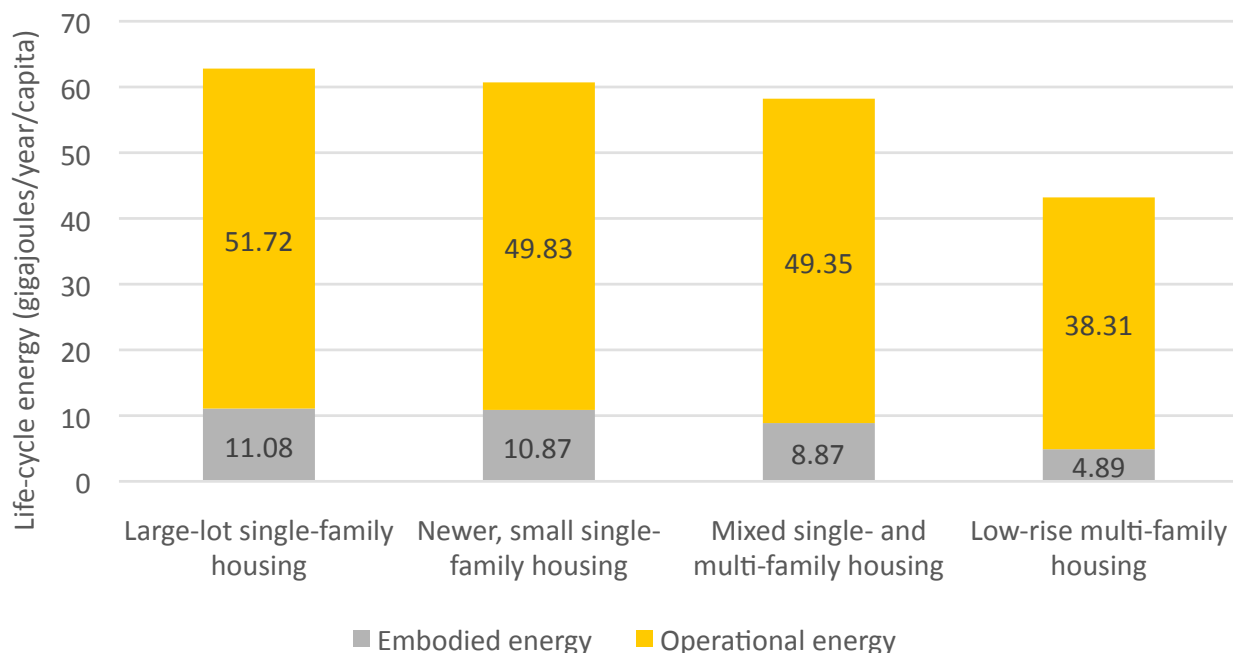
- The study, published in *Energy Policy* in 2014, found that in the Austin metro area, a densely developed neighborhood composed of low-rise multi-family homes, like Riverside, consumes about up to 37 percent less energy than more suburban neighborhoods dominated by detached single-family homes, such as Westlake and Anderson Mill.⁸²

- Results indicated that not only does the average household in a compact neighborhood consume up to 26 percent less energy (transportation excluded) on a day-to-day basis than a similar household in a sprawling neighborhood, but the home also requires less than half the energy to build, including the energy expended in production of raw materials.⁸³ With transportation included, the average household in a compact neighborhood uses approximately a third less energy on a day-to-day basis and two-thirds less energy to build than the average household in a sprawling neighborhood.⁸⁴

Compact development has been demonstrated to reduce building energy use in several cities. For example:

- In New York, building more compactly was found to decrease the amount of energy per person that was needed to heat, light, cool and power buildings.⁸⁶

Figure 5. The Building and Infrastructure Life-Cycle Energy Impacts of Four Austin Neighborhoods (from Left to Right – Westlake, Anderson Mill, Hyde Park and Riverside) Vary by Housing Type⁸⁵



- A 2006 study published in the *Journal of Urban Planning and Development* found that in Toronto, annual energy use was systematically lower in low-rise multi-family buildings than in detached single-family homes – 53 percent lower per person and 12 percent lower per square meter.⁸⁷
- A study of household energy use in Sydney found that shared walls in attached buildings resulted in 30 percent greater heating and cooling efficiency and direct energy savings as housing units share and save heat, with less leakage.⁸⁸

Increased density also allows for the use of energy saving technologies that might be more difficult to apply in more spread-out areas, like district energy systems.

- Austin Energy operates a 17-megawatt district cooling system that provides at least 32 buildings in downtown Austin, Mueller and the Domain with chilled water through a network of underground pipes. An expansion project is underway to increase the system’s delivery capacity from 20 megawatts to 30 megawatts by 2027 and to cover the new Seaholm development and the new central library.⁸⁹
- The city of Saint Paul, MN, extended its district heating and cooling system during the construction of a new light-rail line.⁹⁰ The Saint Paul system is powered in part by the largest solar installation in the Midwest as of 2011, and will be phasing out coal by 2021, which will cut more than a quarter of the system’s greenhouse gas emissions.

Compact neighborhoods use less energy and emit fewer greenhouse gases than their sprawling counterparts. Increasing density, developing walkable neighborhoods around public transit, and encouraging more sustainable material, construction and building design, can help decrease household energy consumption and greenhouse gas emissions.

Compact Development Results in Better Water Quality

Compact Development Reduces Runoff Pollution

Compact residential development slows the rate of land conversion from agricultural or natural uses to urban uses like residential development, resulting in less pollution.⁹¹

- A 2006 study in the *Journal of Environmental Management* concluded that converting land from agricultural to urban uses through new residential development has a significant effect on water quality. The more that land is converted to residential uses, the more pollution.⁹²
- A 2009 study by a pair of researchers from Texas A&M and the Baylor College of Medicine found that Houston would sprawl to occupy an additional 1,000 square miles of farmland, forest and prairies if it maintained its current suburban densities and lot sizes (approximately four dwelling units per acre).⁹³ But simply doubling the average residential density to eight dwellings per acre would spare 500 square miles of open space and natural areas, as well as reduce the total amount of pollution discharged to the area’s bays and bayous.⁹⁴
- A recent study published in *Proceedings of the National Academy of Sciences* found that losing natural land cover to sprawling development can degrade watersheds and can increase water treatment costs up to 50 percent in impacted cities.⁹⁵

Choosing to build more compactly mitigates the impact of urban growth on water quality, and may be considered a stormwater best management practice (BMP) in its own right.⁹⁶ Consolidating urban growth, particularly within already developed areas, helps to protect urban watersheds and results in cleaner water and healthy aquatic environments.



Protecting clean water in the Barton Springs Aquifer recharge zone is vital to the survival of the endangered Barton Springs salamander.

Compact Development Affects Aquifer Recharge

Compact development limits the impact of urban development on water quality. In Austin, runoff can contaminate groundwater supplies.⁹⁷

Austin's primary water source is surface water drawn from Lake Travis and Lake Austin, but in the past decade the number of private wells has also surged.⁹⁸ These wells draw from the Edwards Aquifer, a large, shallow source of groundwater that supplies Travis County with approximately 27,500 acre-feet of fresh water each year.⁹⁹ Preserving groundwater quality is essential to protect critical ecosystems that support endangered and other aquatic species, like the Barton Springs salamander.¹⁰⁰

In Travis County, the Edwards Aquifer is under significant pressure due to population growth and persistent drought conditions. Compact development limits the conversion of open land toward impervious land uses, enabling more direct recharge and mitigating the impact of population growth on groundwater quality in the Edwards Aquifer.

- A researcher at University of Texas at Austin who studied how urbanization affects groundwater recharge, with a focus on Austin, found that urban development in the Austin metro area increases impervious cover and stormwater runoff,

which affects aquifer recharge.¹⁰¹ The impermeable barrier between rainwater and the aquifer decreases the amount of water that can percolate through the soil where it falls (direct recharge).¹⁰² Instead, aquifers in urbanized watersheds are recharged with runoff that enters groundwater from gaps in impermeable surfaces, leaky sewers, storm drains and detention ponds, as well as river seepage (indirect recharge),¹⁰³ and are thus at risk of contamination from runoff.¹⁰⁴ In Austin, leaky underground storage tanks are the main source of groundwater pollution.¹⁰⁵

- In 2009, a University of Texas at Austin Ph.D candidate found indirect recharge accounts for more than half of the water recharging the Edwards Aquifer.¹⁰⁶ Indirect recharge sources, like runoff pollution, leaky sewers, or river seepage, are typically have been associated with a range of contaminants, including hydrocarbons, metals, sulfates, nutrients, bacteria, and diverse industrial chemicals.¹⁰⁷ In Austin, aquifer water quality remains excellent, but the potential for pollution with chemicals and bacteria increases with development.¹⁰⁸

By limiting the increase of impervious surface cover, compact development can help minimize the impact of urban development on groundwater quality and recharge.

Compact Development Reduces Flood Risk

Urban floods are increasingly frequent, costly and dangerous in Texas. In Austin and throughout Texas, the costs of flooding have been on the rise. Central Texas is sometimes known as Flash Flood Alley due to its steep terrain, shallow soil and high rainfall rates.¹⁰⁹

- The 1981 Memorial Day Flood killed 13 people and caused \$35.5 million in damage in the Austin metro area.¹¹⁰ The 2015 Memorial Day weekend floods killed 14 people in Central Texas and caused more than \$80 million in property damage across the region, including approximately \$10 million in damage in Travis County alone.¹¹¹
- Flash floods can also affect water quality.¹¹² During flash floods in October 2013, the South Austin Regional Wastewater Treatment Plant lost power and discharged more than 37 million gallons of raw sewage and stormwater over three days.¹¹³

When permeable soil is covered by impervious surfaces, like roofs and roads, more rainwater flows as runoff into ditches and streams, potentially leading to downstream flooding.¹¹⁴

- The U.S. Geological Survey studied the effects of urbanization on floods in the Austin metro area in 1986.¹¹⁵ Based on an analysis of 25 years of stream-flow and rainfall data from 13 sites along Waller Creek, a historically flood-prone waterway where a 1915 flood killed 60 people and destroyed over 1,000 homes, the U.S. Geological Survey found that converting land along Waller Creek for development increased the scale and frequency of flooding.¹¹⁶

Building more compactly can reduce flood risks.¹¹⁷

- A multidisciplinary review of scientific literature published in the *Journal of Urbanism* in 2008 concluded that compact development patterns minimize the area of impervious surfaces at a regional level, which mitigates the enhanced flood risk that comes with urban development.¹¹⁸ Single-family housing units tend to have larger houses and longer driveways, which translates to more impervious surface per household.
- A 2010 study published in the *Journal of Water Resources and Planning* found that high- and medium-density development increased impervious cover 72 percent less than low-density development.¹¹⁹ The high- and medium-density sites

Photo: Brian Zabcik

The 2015 Memorial Day floods claimed 14 lives and caused millions of dollars in damage across Central Texas.



experienced approximately 8 percent less total on-site runoff and smaller peak flows than the low-density sites.¹²⁰

- In 2016, three Texas A&M researchers published the results of their investigation into the impacts of development on flooding along the Gulf Coast, finding that compact development reduced insured property damages caused by floods, whereas low-density development characterized by large-lot zoning significantly increases flood losses.¹²¹

Compact Development Results in Lower Water Consumption

Compact development can decrease water consumption by maximizing building-to-lot ratios and lower landscape irrigation needs, particularly when combined with provisions to capture rainwater for use within buildings and for residential lawn watering and commercial landscape irrigation.¹²²

Effective water management is vital to Austin in the face of mounting water demand and increasing scarcity.

- Austin's water use grew by a third between 1995 and 2009, and up until a couple years ago, the entire region was locked in a years-long drought that threatened to dry up Lake Travis.¹²³
- Austin's water use increases by 49 percent in the summer when lawn watering and other outdoor water uses peak; reducing summertime outdoor water use by a quarter could save nearly 14 million gallons of water each year.¹²⁴
- Austin is developing a 100-year water supply plan, *Water Forward*, that will feature a wide variety of tools to manage water demand, including rainwater harvesting and reuse.¹²⁵

Water use data suggests that multi-family homes use less water than single-family homes.¹²⁶

Austin's water use increases by 49 percent in the summer when lawn watering and other outdoor water uses peak; reducing summertime outdoor water use by a quarter could save nearly 14 million gallons of water each year.¹²⁴

- According to the Texas Water Development Board, the average daily water use of a single-family home in Texas is 246 gallons, whereas multi-family residences use an average of 367 gallons per day combined. Assuming multi-family units house at least two households, these figures indicate that a single-family home uses at least 60 gallons more water each day – the equivalent of flushing the toilet an additional 37 times¹²⁷ – than a household in a multi-family unit.¹²⁸
- Austin Water projects an average single-family household will use around 5,800 gallons per month in 2018; multi-family units (i.e., containing multiple households) typically use closer to 4,000 gallons per month, which is just two-thirds of the water usage of a single-family household.¹²⁹

Studies have found that both lot size and the urban heat island effect, a phenomenon whereby the metro area of a city is significantly warmer than its rural or natural surroundings, can influence household water demand.

- A 2010 study published in the *Journal of the American Water Resources Association* estimating the effect of urban form on residential water use in Hillsboro, Oregon, in the Portland metro area found that compact development can result in lower overall water demand than sprawling devel-

opment.¹³⁰ According to the researchers' analysis, new, large homes with high property values used the most water for external uses, like lawn watering, including during droughts.¹³¹

- Another study published in 2007 in the *Journal of the American Planning Association* showed that in Phoenix, water use in single-family units increased by 1.8 percent for each 1,000-square foot increase in average lot size.¹³² The study also found that water use in single-family units increased 1.7 percent for every 1°F rise in the average daily temperature low due to the urban heat island.¹³³ Household water demand and outdoor space are also correlated, in both arid and temperate climates, due to landscaping.¹³⁴

Compact development, associated with smaller urban heat islands, smaller lots and fewer landscaping needs, is associated with lower household water demand. Today, Austin has the highest percentage of big-lot homes among the four major metro areas of Texas, with 6.6 percent of single-family homes on 5-acre lots or more.¹³⁵ Increasing density and reducing lot sizes would help bolster the city's efforts to minimize water consumption in Austin by increasing reuse and minimizing demand.

Between 1997 and 2012, Texas lost more than 1.1 million acres of farms, ranches and forests.¹³⁶

Compact Development Slows Land Consumption

In Texas, sprawling development has changed land uses, converting open space, agricultural lands and ecologically important landscapes into urbanized spaces like roads, buildings and parking lots.

- The Texas A&M Institute of Renewable Natural Resources, which publishes the *Texas Land Trends* report every five years, published in 2014 that between 1997 and 2012, Texas lost more than 1.1 million acres of farms, ranches and forests.¹³⁶ Land loss is closely tied to population growth; 87 percent of land conversion occurred in the state's 25 fastest growing counties, as farms, prairies and forests are turned into urban and suburban development.¹³⁷

Photo: Mark Schaffer via Flickr, CC-BY-NC 2.0.

The City of Austin owns and manages part of the Balcones Canyonlands Preserve, which protects natural features like the Hamilton Pool.



- Agricultural lands, like private farms, ranches and forests, account for 83 percent of the state's land, and provide food, recreational opportunities, clean air and water, and wildlife habitat.¹³⁸

Directing population growth toward already urbanized areas can slow land conversion in Travis County, and help preserve open space, farmland and wildlands.

Compact Development Improves Regional Air Quality

Residents living in compact cities are exposed to relatively lower levels of ozone, a ground-level air pollutant used as a proxy for air pollution, as a result of lower vehicle emissions and smaller urban heat islands in compact cities than in sprawling cities.

In 2008, researchers from the University of Texas at Austin and the Molina Center for Energy and the Environment found that compact development in existing Austin neighborhoods with mixed-used zoning will produce lower exposure to high levels of ozone, a type of air pollution, than sprawling development.¹³⁹

Health Effects of Urban Air Pollution

Air pollution kills thousands of Texans each year. The higher the concentration of ozone or fine particulate matter, the greater the risk of death. Fine particle (2.5 micrometers or less in diameter) pollution causes approximately 8,700 premature deaths in Texas each year, and ozone pollution causes approximately 2,100.¹⁴² Texas loses 19.7 percent more of its population to early deaths due to particulate pollution than the average state.¹⁴³

Small particles 10 micrometers or less in diameter, or approximately the size of a single red blood cell and under, can affect both the lungs and the heart. Numerous studies have linked small particles to asthma, coughing, difficulty breathing, irregular heartbeat, and nonfatal heart attacks. In Texas, 6.7 percent of the adult population suffers from asthma.¹⁴⁴ Particle pollution is also the main cause of haze, reducing visibility in many parts of the United States.¹⁴⁵

Ozone in the upper atmosphere protects us from ultraviolet rays, but it can be dangerous on the ground. On hot sunny days, air pollutants, like oxides of nitrogen (NOx) and volatile organic compounds (VOCs), react in the presence of sunlight to produce ozone, and the concentration of ozone in the air can reach unhealthy levels. Overexposure to ozone can cause or contribute to shortness of breath, inflammation, lung infections, and lung diseases like asthma or chronic bronchitis.¹⁴⁶

Children, older adults and people with heart or lung diseases are more likely to be affected by air pollution like ozone or particulate matter. Long-term exposure of children to ozone, for example, can even cause permanent lung damage.

- A study published in the *Journal of Environmental Management* in 2008 studied the relationship between urban spatial structure and exceedances of national ozone standards in 45 large metro areas across the U.S. The study found that compact cities have been found to experience up to 62 percent fewer high ozone days than sprawling cities.¹⁴⁰

Air pollution is associated with a higher mortality risk and detrimental everyday health effects. Air pollution levels in the Austin metro area are within regulatory limits, but ozone levels remain close to the 2015 national ambient air quality standards.¹⁴¹ Building more compactly can lead to better health outcomes for Austinites.

Development patterns affect regional air quality through the urban “**heat island effect**” and by shaping **transportation patterns**.

The **urban heat island** is created when land is converted to urban uses, as impervious surfaces replace natural vegetation, which had cooling effects, and buildings, industry and cars give off waste heat. These exchanges combine to raise the average air temperature of large cities. Air pollution, like ozone and particulate matter, is sensitive to temperature. Higher temperatures tend to:

- Increase emissions of volatile organic compounds (VOCs) from vehicles and other sources,¹⁴⁷
- Increase emissions of ozone precursors from power plants in response to greater demand for air conditioning,¹⁴⁸
- Intensify ground-level ozone formation.¹⁴⁹

Compact urban forms generate less surface heat than low-density sprawl, leading to smaller urban heat islands and fewer extreme heat events.

- A Rice University researcher used satellite imagery to determine the growth of the urban heat island in Houston, where the population

grew by 20 percent between 1990 and 2000.¹⁵⁰ The study found that over that same period, the Houston heat island grew by at least 170 square kilometers, or 38 percent, and average nighttime surface temperatures increased by approximately 1.4°F.¹⁵¹

- A 2010 study published in *Environmental Health Perspectives* analyzed the frequency of extreme heat events in major U.S. cities,¹⁵² and found that the most sprawling cities experienced 14.8 more extreme heat events on average each year in 2005 than they did in 1956, whereas the most compact cities added just 5.6 extreme heat events.¹⁵³

Urban form also indirectly influences regional air quality by shaping **transportation patterns**.

- Compact urban forms, with high household and employment density, high street connectivity and urban mass transport systems, are associated with lower vehicle travel and tailpipe emissions, and with relatively lower emissions of carbon monoxide, nitrous oxides and volatile organic compounds (VOCs) from vehicles.¹⁵⁴

Increasing density and consolidating urban zones can improve regional air quality, and combat the urban heat island effect in the long term.¹⁵⁵

- The Autumn 2007 issue of the American Planning Association’s journal published a study that found that a 3.5 percent reduction in household vehicle travel and emissions may be expected with a 10 percent increase in population density in metropolitan areas.¹⁵⁶ The study also suggested that increasing density in urban zones is “more than twice as effective in reducing vehicle miles of travel and emissions [of carbon monoxide, NOx, fine particulate matter and VOCs] as the densification of non-urban zones.”¹⁵⁷
- A team of researchers from the University of Texas at Austin and Central Connecticut State

University compared different development and transportation scenarios in Austin.¹⁵⁸ Their findings, published in 2010 in *Transportation Research Record*, indicate that combining compact development with transportation policies, such as congestion pricing on freeways, can cut about 15 percent of predicted 2030 emissions of VOCs, NOx and carbon monoxide relative to a business-as-usual scenario of development.¹⁵⁹

Building more compactly in Austin can help reduce the size of the urban heat island, cut transportation emissions, and improve regional air quality, with real health benefits.¹⁶¹ Compact development is key to fighting air pollution and safeguarding public health in Austin.

Transportation and development scenarios in Austin have indicated that compact development and transportation demand management measures can reduce up to 15 percent of predicted 2030 emissions of VOCs, NOx and carbon monoxide relative to business-as-usual.¹⁶⁰

Solutions to Localized Challenges Generated by Compact Development

While building more compactly benefits the environment at the regional level, people, businesses, buildings and cars in a neighborhood can create local environmental impacts. Smart public interventions, paid for by a growing tax base produced by infill development and additional dwelling units, can mitigate these impacts – enabling Austin to gain the benefits of compact development while preserving the natural environment, public health and quality of life in all of our neighborhoods.¹⁶²

Reducing Local Flood Risks and Protecting Groundwater

Focusing on compact urban forms and deterring sprawl can help limit the total amount of impervious cover and fragmentation in watersheds, and minimize the vulnerability of the watershed to surface runoff and flash floods.¹⁶³

Although higher-density development generates less stormwater runoff per housing unit than low-density development, higher densities result in more runoff per acre.¹⁶⁴ While new, low-density, suburban development has a far greater impact on water quality at the regional level, compact development can increase flood risk on a localized scale, within city centers. Concentrating development in more densely urbanized areas, which already

have less coverage by green space and gardens, can increase impervious surface cover in those areas, resulting in greater predicted runoff.¹⁶⁵

Retrofitting stormwater drainage systems in existing urban areas and using low-impact design principles in new development can help maximize local infiltration and minimize stormwater runoff to waterways.¹⁶⁶

Several tools can help counter urban flooding:

Green stormwater infrastructure (GSI) uses plants, soil, and natural drainage to capture and cleanse rain where it falls. The benefits of GSI have already been covered extensively in a recent Environment Texas report, *Texas Stormwater Scorecard*.¹⁶⁷ Rain gardens, green roofs, and permeable pavement can remove pollutants from rain water and let the water soak into the soil, evaporate into the air, or be held temporarily for flood detention. Rain harvesting systems can collect and store water so that it can be used later for landscape irrigation and other on-site uses.¹⁶⁸

GSI features are the Swiss Army knives of stormwater management, since they can produce multiple benefits:

- **Pollution reduction:** These features can be especially successful in improving water quality, since even the lowest-capacity features can generally capture and cleanse around one inch of rain, which is also generally the amount of the

“first flush” of stormwater that picks up most of the pollutants that have accumulated on surfaces between rains.

- **Flood mitigation:** While these features generally can’t trap enough runoff to prevent the worst flooding, such as 100-year floods, they can usually retain enough water to reduce more frequent and smaller floods – the 2-, 5-, and 10-year floods.
- **Erosion mitigation:** These features can reduce both the volume and speed of runoff, which reduces the scouring effect of stormwater on stream banks.
- **Aquifer replenishment:** Because these features allow more rain to soak into the ground, they can help maintain water levels in aquifers.
- **Beautification:** Since most features use plants, they double as landscape amenities. For example, green roofs and parking lot bioswales can introduce greenery where there otherwise would be none.
- **Economic benefit:** Developers can often save money with GSI, since using these features may allow them to reduce the size (and cost) of other stormwater infrastructure such as drainage pipes and detention ponds. This in turn may sometimes allow more of the property to be developed.

By collecting rainwater and helping it percolate through the soil, GSI systems help replenish groundwater, trap between 45 and 99 percent of solid pollutants, capture carbon dioxide, and beautify the urban landscape. When combined with open space



The clubhouse of John Gaines Park in the Mueller development features a green roof and rain gardens.

preservation in flood-prone areas, GSI practices can help protect floodplains, minimize flood hazard and reduce property damage.¹⁶⁹ Finally, GSI features can mitigate any negative health effects, like mosquito breeding in ponds or excessive pollen, through thoughtful design, maintenance, and public health promotion and awareness.¹⁷⁰

Compact growth that encourages infill development could help pay for green and gray stormwater infrastructure thanks to a growing tax base.¹⁷¹ Combining green and gray infrastructure can also help lower the risk of urban floods; for example, when completed, the Waller Creek flood control tunnel will safely

By collecting rainwater and helping it percolate through the soil, GSI systems help replenish groundwater, trap between 45 and 99 percent of solid pollutants, capture carbon dioxide, and beautify the urban landscape.

redirect floodwaters from Waterloo Park to Lady Bird Lake, while features like porous pavement in the Green Alley Demonstration Project between 8th and 9th streets help to retain stormwater, which can contribute to a lower flood peak.¹⁷²

GSI features are being used in prominent locations across Austin. Rain gardens can be found in the parking lots at Vic Mathias (Auditorium) Shores, HEB's store in the Mueller development, and Zach Theater. Permeable pavement is used at Central Health Center and CapMetro's East Austin headquarters. UT's new Dell Medical School and Austin's City Hall both have green roofs, while the Austin Public Library's Twin Oaks branch and the Lady Bird Johnson Wildflower Center have rain harvesting systems.

Impervious cover limits establish caps on the percentage of an area devoted to impervious cover. Cities have used various policy mechanisms to limit impervious surface cover.

- Austin's Save Our Springs Ordinance of 1992 set a maximum impervious surface cover of 15 percent in the sensitive Barton Springs recharge zone over the Edwards Aquifer, and set limits on pollution in developed areas.¹⁷³ Impervious area limits help ensure the higher availability of porous areas where rainwater may infiltrate the soil or be stored, protecting water quality and aquifer recharge, and enhancing flood resiliency.¹⁷⁴ Impervious cover limits must be implemented with care in order to ensure that they do not increase incentives for sprawl. Two Texas A&M researchers helped co-author a study, published in *Land Use Policy* in 2013, which found that impervious area limits have contributed to urban sprawl in Austin, perversely encouraging land consumption and failing to improve water quality.¹⁷⁵ If land is readily available, developers can simply purchase more land, which allows them to comply with limits, hydrological impacts of sprawl.

- In Kitsap County, Washington, property owners must pay a standard **stormwater utility fee** based on county-wide impervious surface areas on residential land, which raises funds for mitigation and creates an incentive to further reduce imperviousness. Such fees may be combined with impervious cover allowances for denser development; for example, in Grand Rapids, MI, which also uses stormwater utility fees, developments that integrate GSI features to reduce effective imperviousness may build more densely and obtain waivers.¹⁷⁶
- Some states, such as Maryland and Oregon, use **transfer of development rights** programs to divert development pressures away from areas that communities wish to preserve.
- Stormwater discharge permits, or MS4 permits, administered by the state of Texas, require that municipalities adopt a **comprehensive stormwater management** approach, based on clear goals, public support and sound science, which often includes low-impact design, minimizing impervious surface area, and pollution source control.¹⁷⁷ Comprehensive stormwater management can help address the sources of water contamination, both in local neighborhoods and on a regional basis.¹⁷⁸

Improving Urban Air Quality

Compact development uses less energy and emits fewer greenhouse gas emissions per capita, in large part due to lower transportation needs, increased use of public transit and other alternatives to single-occupancy vehicles. For local areas experiencing increased development, however, there may be increased vehicle traffic, with localized effects on air quality – especially if alternatives to vehicle ownership and use such as transit, shared mobility, and safe biking and walking infrastructure are unavailable. Infill development along freeways, like Austin's

I-35 highway, with large areas of land available for development, risks building housing with dangerous health risks due to proximity to heavy traffic.

Compact development and poor air quality don't have to go together. With cleaner vehicles and a wider variety of smart transportation options, Austin can achieve the benefits of compact development while assuring clean air and high quality of life for all its neighborhoods.

A sustainable approach to transportation should be integral to CodeNEXT. A May 2016 report by the local organization AURA, titled *Transit City*, proposed that CodeNEXT allow and promote small-scale multi-family, neighborhood commercial and incremental density in Austin's central communities. AURA also proposed that CodeNEXT prioritize abundant housing near existing transit (rather than "leap-frog" development), improve transit priority lanes, reduce or eliminate parking minimums where appropriate, and enact parking maximums.¹⁷⁹ Indeed, reducing parking requirements can incentivize infill development by lowering the high building costs associated with providing off-street parking in denser building types, which can help lower housing costs.¹⁸⁰

Key sustainable transportation tools include:

Public transit gives residents more transportation choices and eases the increase in congestion that comes with any level of development. Consolidating growth around public transit hubs can help increase densities in already developed single-family plots close to transit stops and also help ensure transit demand.¹⁸¹ However, quality public transit service must also be able to meet the demand brought about by more compact development. Capital Metro's Connections 2025 plan will add 13 new bus routes to MetroRapid, Austin's high-capacity bus rapid transit, which currently operates two routes that use transit-priority lanes and run every 10 minutes on weekdays. Light rail has been core to the development strategy of other leading cities, such as Denver, enabling them to connect their busiest locations with energy-efficient, fast and comfortable transit.¹⁸²

Given Austin's dependence on cars and rapid bus transit, **vehicle electrification** will also contribute to cutting exhaust. Widespread adoption of plug-in electric vehicles running on clean power in Texas can improve local air quality and help regions meet national air quality standards.¹⁸⁷ Austin Energy, the city-owned

How Los Angeles Changed Course to Tackle Air Pollution

Los Angeles was once the archetypal sprawling Sunbelt city, with freeways, traffic jams and the accompanying air pollution. Los Angeles' car dependence contributed to dangerous health conditions: a 2005 study that tracked the respiratory health of children living near freeways in 10 communities in Southern California found that nearly a third of children had asthma.¹⁸³ Since the early 1990s, the city has been shifting away from sprawl, both through land-use planning and expansions of public transportation.

Los Angeles has begun to curb sprawl through effective planning and development. Formerly struggling, downtown Los Angeles has experienced a rebirth, with rapid growth in jobs and residents.¹⁸⁴ The emergence of regional-scale bus and rail systems and transit-oriented development improved commuter mobility. The "missing middle" – middle-density housing projects – became a viable commodity, due to demand for compact and walkable urban neighborhoods with local employment, retail and recreation opportunities.¹⁸⁵ Although Los Angeles continues to struggle with traffic and pollution, the metro area has shifted away from low-density development to become one of the densest cities in the U.S.¹⁸⁶

electric utility, has installed at least 547 charging ports across the Austin area that are powered exclusively by clean wind energy, ensuring electric vehicles contribute to neither regional pollution nor downtown smog.¹⁸⁸ Although its buses currently run on diesel, Capital Metro will introduce 330 electric vehicles into its fleet by 2020, saving \$3.5 million in energy costs and cutting greenhouse gas emissions.¹⁸⁹

Smart transit technology optimizes public transit to meet the needs of commuters and minimize air quality impacts. Austin has begun implementing smart transit technology throughout its street network like automated traffic signal timing.¹⁹⁰ Rapid transit with dedicated lanes results in less idling time for buses and reduced emissions and energy consumption;¹⁹¹ Austin's MetroRapid buses have a feature that allows them to turn red lights green.¹⁹² CityUP's Smart 2nd Street Living Lab explore how a smart city network in Austin can monitor energy and promote sustainability, enhance pedestrian safety, or improve parking efficiency and wayfinding.¹⁹³

Parking also deeply influences transportation energy use. Approximately 30 percent of drivers circling city blocks at any given time are looking for parking.¹⁹⁴

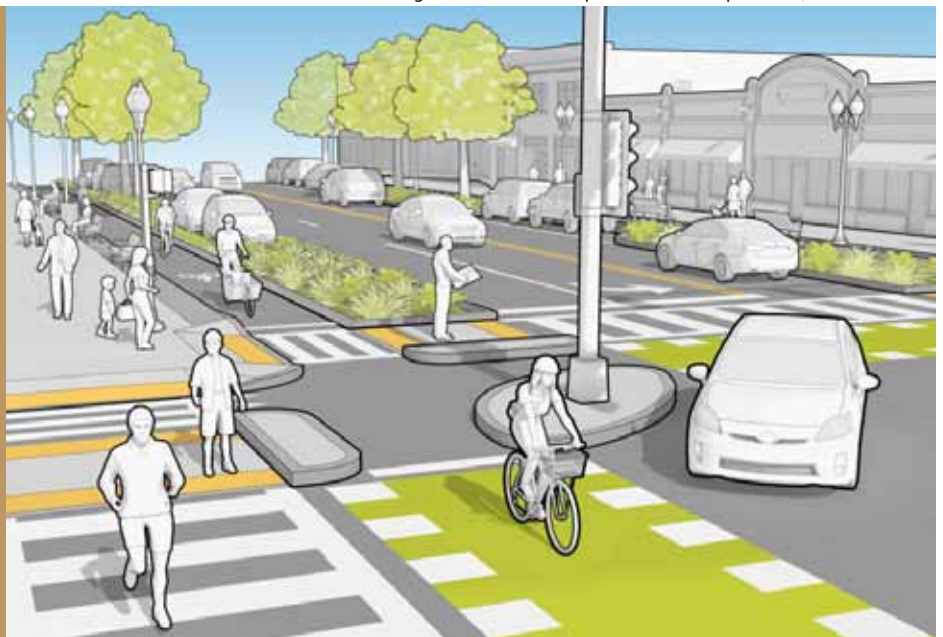
Smart technologies like those being tested at the Smart 2nd Street Living Lab can help drivers to rapidly locate parking spots.¹⁹⁵ Ridesharing and ridehailing avoid the need for parking altogether by reducing individuals' need to own a car.¹⁹⁶ Reducing minimum parking requirements can also lower housing development costs by 12.5 percent per parking space.¹⁹⁷

Transportation demand management measures focus on what makes us drive in the first place to reduce travel demand from automobiles. These measures align incentives to discourage unnecessary driving and to change behavior over the long-term. Employers, for example, can set incentives to encourage sustainable commuting practices. The Seattle Children's Hospital adopted a transportation management plan that successfully shifted 35 percent of its employees and visitors away from single-occupancy vehicles to transit, shuttles, bicycling and walking, thanks to a bikeshare program, financial rewards for employees who commute without driving alone, a shuttle-to-transit system, and more.¹⁹⁸

Bicycle and pedestrian infrastructure improvements seek to ensure bicycling and walking are viable, safe and comfortable modes of travel.

Image: Massachusetts Department of Transportation, November 2015

Bicycle infrastructure improvements include separations between bike lanes, sidewalks and roads, corner refuge islands, recessed crossings and pedestrian- and bicycle-specific lighting signals.²⁰⁰



Facilitating zero-carbon mobility is important to substitute for short car trips to local destinations, reducing congestion and emissions. Thanks to a bond measure approved by voters in November 2016, the City of Austin will spend \$70 million over three years to mend the gaps in its fragmented bike lane network and improve safety by adding physical barriers between bike lanes and car traffic, in order to double the proportion of Austinites that commute by bike.¹⁹⁹ Enticing more residents to travel by bike can reduce the congestion impact of new compact development.

A combined land use and transportation strategy can help reduce downtown congestion and smog. Austin has already incorporated a number of these tools, including electric vehicle infrastructure, bike infrastructure, and smart transit.

Fighting the Urban Heat Island Effect

Developed areas tend to have higher temperatures than their surroundings, as buildings and sidewalks absorb and radiate heat, creating the urban heat island effect. Cities can use reflective surfaces and plant urban vegetation to cool down, which helps bring down demand for air conditioning, as well as power plant emissions and air pollution.²⁰¹

Using light-colored materials and reflective coatings on roofs and in pavements is a powerful tool to combat the urban heat island effect. For instance, a light-colored roof reduces cooling energy use, both directly within the building, since it absorbs less sunlight, as well as indirectly in neighboring buildings, since the roof also radiates less heat.²⁰² One study focused on development in Houston found that placing shade trees near buildings and using light-colored roofing and paving materials that reflect sunlight could save \$82 million on energy, decrease peak power demand by 730 megawatts and cut carbon emissions by 170,000 tons, an amount equivalent to taking more than 199,000 cars off the road.²⁰³ Given



Light-colored rooftops reflect sunlight, which cools down the city and lowers cooling energy needs.

that air conditioning can account for 70 percent of Austin's summertime energy demand, this simple shift, which can be incorporated into routine re-roofing and resurfacing schedules, can lead to significant reductions in energy use and emissions.

Integrating nature into the city is key to cooling down the city, with tangible health benefits for its residents. Shade trees cool the air, block sunlight before it reaches buildings or pavements, shield streets from wind, and filter the air. Inner city temperatures in Dallas are growing faster than nearly every other city in the country, due in part to its 35 percent impervious surface cover, and a record 52 people died in Dallas in 2011 due to heat.²⁰⁴ The Texas Trees Foundation found in its 2017 *Dallas Urban Heat Island Effect* report that planting trees in the hottest areas with high-density residential buildings reduced heat-related deaths by more than 20 percent by lowering the temperature.²⁰⁵ City trees are also a form of green storm-water infrastructure, intercepting rain in their leaves and branches, and contributing to flood mitigation and runoff control.²⁰⁶

Shade trees, like these street trees in a neighborhood community in the north side of Austin, can help lower urban temperatures.



Urban heat island mitigation strategies, like cool roofs and shade trees, are easily accessible and can help reduce up to one-fifth of cooling energy, achieving energy savings and improving urban air quality. Although their impact on the urban heat island effect has not been quantified, Austin's 33.8 million urban trees reduce \$18.9 million each year in annual residential energy costs, store 1.9 million tons of carbon, and reduce 65 million cubic feet of stormwater runoff each year.²⁰⁷ The City of Austin's work to support its urban forest is crucial to fighting the urban heat island effect, and could be strengthened with other tools like reflective or light-colored roofing and pavements.

Austin's 33.8 million urban trees reduce \$18.9 million each year in annual residential energy costs, store 1.9 million tons of carbon, and reduce 65 million cubic feet of stormwater runoff each year.²⁰⁷

Conclusion

Well-designed compact development delivers environmental benefits. Compact development driven by good planning implementation can limit land consumption and flood risks, improve water quality, lower water consumption, limit greenhouse gas emissions from buildings and transportation, reduce energy use and intensity, and improve regional air quality relative to lower-density development. Compact development also delivers other benefits, creating viable affordable housing options close to the city center as Austin continues to grow and potentially improving quality of life.

Strategies are available to mitigate many of the potential local impacts of compact development. Urban density is just one of several factors that influence a

city's sustainability. Compact development should also be accompanied by sustainable public transit, transportation demand management measures, green stormwater infrastructure systems, passive building design, and other policy measures and technologies, to generate an overall sustainable city.

Living in compact mixed-use neighborhoods makes it cheaper and easier to reduce carbon emissions, protect water quality, lower water consumption, and ensure many other environmental benefits. The current revision of Austin's land development code gives the city a chance to embrace a more environmentally sustainable pathway for its future development. Austin must act to address local and global environmental concerns – and a new land development code provides that opportunity.

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