AARP Texas

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October 24, 2023

Jessica Lemann
Senior Associate State Director, AARP Texas
1905 Aldrich St., Suite 210
Austin, TX 78723

Mayor Kirk Watson
Mayor Pro Tem Paige Ellis
Members of the Austin City Council
Austin City Hall
301 W Second St., Second Floor
Austin, TX 78701

Dear Mayor Watson, Mayor Pro Tem Ellis, and members of the Austin City Council,

I am writing on behalf of AARP Texas in support of the changes to the City of Austin Land Development Code being discussed at the joint meeting of the Austin City Council and the Austin Planning Commission. These changes include allowing three units per lot in single family residential districts, allowing tiny homes and RVs to serve as accessory dwelling units, and eliminating the dwelling unit occupancy limit for residential uses.

The 2021 AARP Home and Community Preferences Survey of adults age 18 or older shows that most Americans, including the 50-plus, prefer to live in walkable neighborhoods that offer a mix of housing and transportation options — and are close to jobs, schools, shopping, entertainment and green spaces. AARP believes that "Middle Housing" developments can meet these needs. By allowing three units per lot and making it easier for the average resident to add an accessory dwelling unit to their property, Missing Middle housing can become a reality for those who want it.

As the population of older Austinites grow, the importance of creating of a variety of housing options will only increase. Older homeowners who want to sell their residence and move into something nearby that's more affordable, compact, and accessible routinely discover such housing doesn't exist.

With people living longer, more and more older adults will be increasingly reliant on family caregivers. Missing Middle Housing and housing for middle-income earners can ensure their family members can also afford to live in Austin.

AARP Texas believes that these adjustments to zoning laws is an important and vital step to making Missing Middle housing a reality in Austin, and we ask for your support.

I encourage you to review AARP Livable Community's *Discovering and Developing Missing Middle Housing Guide* and *Re-Legalizing Missing Middle Housing Guide* at AARP.org/MissingMiddleHousing.

Thank you for your time and consideration.

Sincerely,

Jessica K. Lemann

Jessica Lemann
AARP Texas

AARP®

Austin City Council Members,

On behalf of Austin EMS Association, I am writing to express our official endorsement of the HOME Act Actively supporting measures to increase housing supply and affordable homeownership opportunity is fully aligned with the Association's mission to support our members so that we can live in city we serve.

We hope you will help.

As Chief Robert Luckritz has publicly stated, the lack of housing affordable to incoming cadets only worsens an alarming 20% staffing vacancy rate and makes recruitment and retention harder. HOME is intended to make homeownership more accessible and reverse the rising cost of housing that prices our members out of Austin's housing market.

Nearly 78% of EMS medics who work for the city and county live outside Austin because our city has become so unaffordable.

We are alarmed by the widening gap between our salaries and the cost of homes, which threatens the long-term sustainability of our city and the long-term health of Austin-Travis County EMS services. We are also concerned that as more or our members must move farther from Austin, they lose their ability to vote and choose the leaders and policies that accurately reflect their values.

We are essential members of this community. Like Austin's city, county, and state workers, teachers, nurses, and small business owners, we are the life force of this city, and we deserve the chance to thrive and be part of this community as neighbors.

We urge you to support HOME and make sure Austin can be a home for everyone.

Sincerely,

Selena Xie

CapMetro
2910 East Fifth Street | Austin, Texas 78702
512.474.1200 | capmetro.org

October 26, 2023

Austin City Council & Austin Planning Commission
Austin City Hall
301 W 2nd St
Austin, TX 78701

Dear Mayor Watson, Austin City Council Members, and Austin Planning Commission Members:

First, thank you for your continued leadership and commitment to the residents of Austin and our Central Texas region. On behalf of CapMetro, I applaud your efforts to collaborate with each other to bring forward meaningful solutions to address Austin's housing and affordability challenges. Specifically, we support the City Council and Planning Commission working together to advance the proposed amendments to the City Code Chapter 25-2 (Zoning) to implement the Home Options for Middle-Income Empowerment (HOME) initiative. These proposed amendments have the potential to modify key elements in our current land development code to help provide more access to more housing and positive outcomes for more Austinites.

As you know, CapMetro cares deeply about the intersection of housing and affordability, and the impact both have on transportation. We can't have economic mobility without actual mobility, and we understand that as cities like Austin grow, it becomes increasingly important to develop policy, programs, and networks that support more options for well-connected, affordable density. As recent as this Monday at CapMetro's regular board meeting, our staff shared findings from our 2023 Origin and Destination study. We know from this work that density opens more opportunities for transit and transit thrives in density.

Fortunately, our federal partners agree that housing and transportation solutions must be thoughtful and complement each other. The potential impact of these amendments excites us for future funding opportunities at the federal level to advance more public transit projects for the benefit of CapMetro customers, residents, and visitors alike, and ultimately, improve our quality of life. Further, CapMetro is encouraged by the progress the HOME initiative would bring to bear in accessing new tools and simplified mechanisms for our ongoing and shared work around equitable transit-oriented developments; this supports not only transit customers, but also provides additional opportunities for spaces where community outcomes such as economic and workforce development, childcare and housing access and mobility occur together.

My team and I will closely follow current and ongoing discussions, including our community's feedback, and stand ready to support you by offering CapMetro's perspective. Please count us as a full partner in helping advance a more prosperous Austin.

Again, I appreciate your leadership, service, and commitment to our community. If you have any questions, please email at Dottie.Watkins@capmetro.org.

Sincerely,

Dottie L Watkins

Dottie L. Watkins
President & CEO, CapMetro

CNU
CTX

CONGRESS
FOR THE NEW
URBANISM
*CENTRAL TEXAS
CHAPTER*

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October 20, 2023

Mayor Kirk Watson
Mayor Pro Tem Paige Ellis,
Council Members: Harper-Madison, Fuentes, Velasquez, Vela, Ryan Alter, Kelly, Pool, Qadri, and Alison Alter
City Manager Jesus Garza

Dear Mayor, Mayor Pro Tem, Councilmembers, and City Manager

On behalf of the Board of Directors of The Congress for the New Urbanism - Central Texas Chapter (CNU-CTX) we are writing to express our strong support for the HOME1 initiative proposed by Councilmember Pool to allow 3 residential homes per single family lot and to also express our support for the furtherance of other recent Council resolutions to remove parking requirements, to loosen compatibility standards, and to allow smaller residential lots (to 2,500 square feet).

We support the HOME1 and other Council initiatives for several reasons:

1. Austin faces a housing crunch for lower priced lots. Research conducted by HousingWorks and ABOR, among others, shows that high property values are hurting home owners paying property taxes and renters with leases, and by increasing the housing stock and allowing more small houses we can hope to see housing cost escalation slow down and with luck, level off.

2. The Imagine Austin Comprehensive Plan states "To accommodate the increasing diversity of Austin area households, more housing options will be needed to address our demographic changes."

3. We are also informed and guided by the Charter for the New Urbanism which states that "neighborhoods should be diverse in use and population" and also that within "neighborhoods, a broad range of housing types and price levels can bring people of diverse ages, races, and incomes into daily interaction, strengthening the personal and civic bonds essential to an authentic community."

4. Evidence presented by the University of California at Berkeley[1] shows that denser housing results in lower greenhouse gas emissions per household compared to less dense housing. This is because with denser housing:

    a. Homes often share walls, thus conserving heat in cold temperatures and conserving cooling in warmer temperatures;

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We strongly encourage the City Council to approve HOME1 and to act quickly to implement other measures to boost Austin's housing stock and help provide homes and reduce sprawl and reduce greenhouse gas emissions per household. In addition to zoning code changes to allow more housing, we also encourage the City to look at local amendments to the building code, as well as the City's administrative processes to align the design and production of housing in Austin with the intent of this zoning change. This also provides for lower soft and hard costs associated with housing production.

Very respectfully yours,

Mateo Barnstone, Director
CNU-CTX

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CENTRAL TEXAS BUILDING TRADES
"WE BUILD TEXAS"

Dear Mayor and City Council Members,

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Our members will be needed for multiple critical infrastructure projects including Project Connect, the new terminal at Bergstrom International Airport, as well as multiple municipal and education district bond projects. We understand the urgent need to address the shortage of housing that is affordable to our members and their families, and we hope you will help by supporting the HOME Act.

HOME takes a crucial first step to making homeownership more accessible, and reversing the rising cost of housing that prices our members out of Austin's housing market. We are alarmed by the widening gap between the average salary and the cost of homes, which threatens the long-term sustainability of our city. We are also concerned that as more or our members must move farther from Austin, they lose their ability to vote and choose the leaders and policies that accurately reflect their values.

We are essential workers in this community. Like Austin's nurses, teachers, EMS medics, public servants, and small business owners, we are critical to building and maintaining this booming City, and we deserve the chance to live and thrive here as homeowners.

We urge you to give this initiative your full support and ensure its successful implementation to make Austin a city for everyone.

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Jeremy Hendricks, Treasurer
Riley Drake, Secretary

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Austin City Council
301 W 2nd St.
Austin, Texas 78701

Dear Council Member Pool,

I write in enthusiastic support for your HOME Initiative.

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 housing development.

Looking to the future, Austin has a choice. We can continue to sprawl farther and farther outward or we can find ways to accommodate 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 dire housing needs. In fact, this exact approach was recommended in the 2012 Imagine Austin Comprehensive plan and has been consistently reaffirmed by City Council since.

Furthermore, as documented by our 2017 report "Growing Greener,"[1] which reviewed the existing literature produced by academic and government researchers on the environmental effects of different urban densities - compact

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With strong policies to mitigate the local impacts of greater density, such as the city's new green infrastructure requirements and the proposed "Functional Green" program, Austin can develop in a way that will bring lasting environmental benefits. Thank you again for your work on this initiative and your ongoing leadership tackling Austin's environmental needs.

Sincerely,

Luke Metzger
Executive Director, Environment Texas

The Mueller redevelopment is an example of a compact, pedestrian-scaled, mixed-use community that will provide homes for 13,000 people close to downtown Austin.

Compact development reduces runoff and can help mitigate floods.

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The Environmental Benefits of a Compact and Connected Austin

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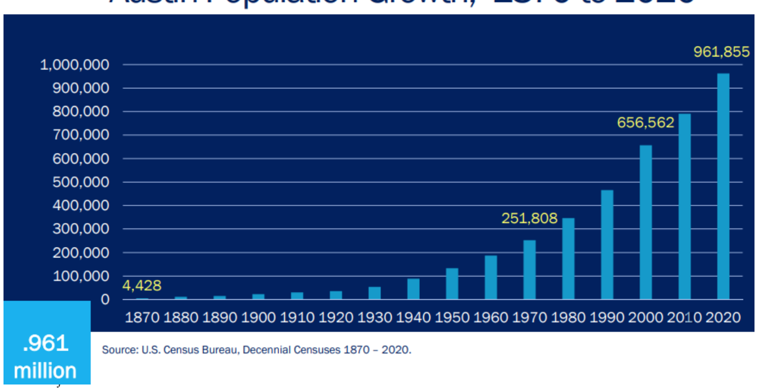
Austin Is Growing and Sprawling

The city of Austin is experiencing explosive population growth, which has brought both dynamism and environmental problems. Compact development is a greener way for Austin to grow.

Austin Population Growth, 1870 to 2020



Source: U.S. Census Bureau, Decennial Censuses 1870 – 2020.

What Is Compact Development?

Compact development focuses regional growth in population and jobs within mixed-use neighborhoods that feature a variety of types of housing, ranging from single-family homes and townhomes to apartment buildings. Compact development enables growth while minimizing conversion of natural land. Successful compact development can yield a high quality of life, creating walkable neighborhoods with open spaces, interconnected streets, access to public transit, and the ability to walk or bike safely and enjoyably.

Compact Development Delivers Environmental Benefits

Compact development benefits the environment in numerous ways:

- **Water quality:** Compact development reduces the total amount of land required for development and produces less runoff to the watershed than sprawl for the same amount of housing capacity.
- **Energy use and greenhouse gas emissions:** People living in compact neighborhoods drive 20 to 40 percent less than those living in sprawling neighborhoods, using less energy and reducing air pollution. Duplexes and low-rise apartments also use half as much energy as single-family homes.
- **Water use:** Reducing lot sizes can reduce demand for watering and other outdoor uses, which accounts for more than a fifth of Austin's annual water consumption.
- **Flood risk:** Taller buildings accommodate more people while covering less land. Compact urban development minimizes the amount of paved land at the watershed scale, which decreases runoff and combats flood risks.
- **Air quality:** Compact cities experience up to 62 percent fewer high ozone days than sprawling cities. Ozone pollution causes approximately 2,100 premature deaths in Texas each year.

Car dependence in Austin is driven by sprawling development patterns and lack of access to public transportation.

Well-designed compact development can limit the environmental impacts of urban growth, while creating a wider range of housing options and improving quality of life close to the city center.

Smart Policy Can Reduce Local Impacts of Compact Development

Compact forms of development deliver environmental benefits at the regional level, but may create localized impacts. Through smart public policy, Austin can address many of the local impacts of compact development.

- **Reducing local flood risks and protecting groundwater:** Green stormwater infrastructure (GSI) can help compensate for the increase of impervious cover in densely developed areas by using natural drainage processes to capture and cleanse rainwater on-site. GSI features can reduce water pollution and make floods less severe.
- **Improving urban air quality:** Compact development improves regional air quality, but may cause traffic congestion and air pollution on a local level. Improving public transportation, increasing the use of tailpipe emission-free electric vehicles, providing "mobility as a service" that reduces the need for car ownership, and improving conditions for walking and biking can all help improve urban air quality.
- **Fighting the urban heat island effect:** Developed areas tend to have higher temperatures than their surroundings, as buildings and sidewalks absorb and radiate heat. 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 energy, decrease peak power demand, and cut carbon emissions by an amount equivalent to taking more than 199,000 passenger vehicles off the road.

Code Changes provide an Opportunity to Shift Away From Sprawl

To accommodate the continued influx of new people to the city while minimizing the increase of developed land, Austin is proposing changes to code. The changes include updates to the number of allowable units on a single-family lot, adjusting minimum lot sizes and parking requirements, the elimination of occupancy limits, compatibility setbacks, and adjusting code that regulates smaller more sustainable housing footprints.

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 code that increases and celebrates neighborhood walkability, provides affordable "missing middle" housing such as townhomes and small single-family houses, and reduces the considerable environmental damage caused by sprawl.

Strategies are available to mitigate many of the potential local impacts of compact development. 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 make Austin a sustainable city.

ENVIRONMENT TEXAS
RESEARCH & POLICY CENTER

For more information and the full report, please visit: environmenttexascenter.org

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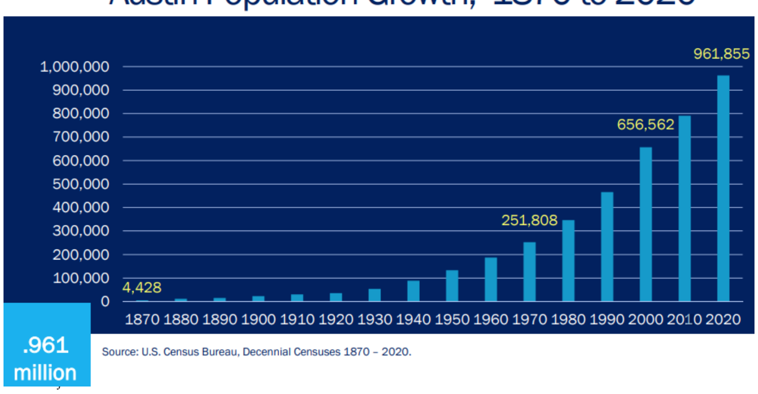
Austin Population Growth, 1870 to 2020



What Is Compact Development?

Compact development focuses regional growth in population and jobs within mixed-use neighborhoods that feature a variety of types of housing, ranging from single-family homes and townhomes to apartment buildings. Compact development enables growth while minimizing conversion of natural land. Successful compact development can yield a high quality of life, creating walkable neighborhoods with open spaces, interconnected streets, access to public transit, and the ability to walk or bike safely and enjoyably.

Compact Development Delivers Environmental Benefits

Compact development benefits the environment in numerous ways:

- **Water quality:** Compact development reduces the total amount of land required for development and produces less runoff to the watershed than sprawl for the same amount of housing capacity.
- **Energy use and greenhouse gas emissions:** People living in compact neighborhoods drive 20 to 40 percent less than those living in sprawling neighborhoods, using less energy and reducing air pollution. Duplexes and low-rise apartments also use half as much energy as single-family homes.
- **Water use:** Reducing lot sizes can reduce demand for watering and other outdoor uses, which accounts for more than a fifth of Austin's annual water consumption.
- **Flood risk:** Taller buildings accommodate more people while covering less land. Compact urban development minimizes the amount of paved land at the watershed scale, which decreases runoff and combats flood risks.
- **Air quality:** Compact cities experience up to 62 percent fewer high ozone days than sprawling cities. Ozone pollution causes approximately 2,100 premature deaths in Texas each year.

Car dependence in Austin is driven by sprawling development patterns and lack of access to public transportation.

Well-designed compact development can limit the environmental impacts of urban growth, while creating a wider range of housing options and improving quality of life close to the city center.

Smart Policy Can Reduce Local Impacts of Compact Development

Compact forms of development deliver environmental benefits at the regional level, but may create localized impacts. Through smart public policy, Austin can address many of the local impacts of compact development.

- **Reducing local flood risks and protecting groundwater:** Green stormwater infrastructure (GSI) can help compensate for the increase of impervious cover in densely developed areas by using natural drainage processes to capture and cleanse rainwater on-site. GSI features can reduce water pollution and make floods less severe.
- **Improving urban air quality:** Compact development improves regional air quality, but may cause traffic congestion and air pollution on a local level. Improving public transportation, increasing the use of tailpipe emission-free electric vehicles, providing "mobility as a service" that reduces the need for car ownership, and improving conditions for walking and biking can all help improve urban air quality.
- **Fighting the urban heat island effect:** Developed areas tend to have higher temperatures than their surroundings, as buildings and sidewalks absorb and radiate heat. 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 energy, decrease peak power demand, and cut carbon emissions by an amount equivalent to taking more than 199,000 passenger vehicles off the road.

Code Changes provide an Opportunity to Shift Away From Sprawl

To accommodate the continued influx of new people to the city while minimizing the increase of developed land, Austin is proposing changes to code. The changes include updates to the number of allowable units on a single-family lot, adjusting minimum lot sizes and parking requirements, the elimination of occupancy limits, compatibility setbacks, and adjusting code that regulates smaller more sustainable housing footprints.

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 code that increases and celebrates neighborhood walkability, provides affordable "missing middle" housing such as townhomes and small single-family houses, and reduces the considerable environmental damage caused by sprawl.

Strategies are available to mitigate many of the potential local impacts of compact development. 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 make Austin a sustainable city.

ENVIRONMENT TEXAS
RESEARCH & POLICY CENTER

For more information and the full report, please visit: environmenttexascenter.org

Photo credits: Front — staff photos. Back — right, Jon Lebkowsky via Flickr, CC-BY-SA 2.0. and left, staff photo.

HousingWorks
AUSTIN

October 24, 2023

Dear Mayor Watson, Austin City Council Members, and Austin Planning Commission Members:

HousingWorks Austin supports adoption of the initial set of proposed amendments to the land development code to implement the Home Options for Middle-income Empowerment (HOME) initiative and the removal of dwelling unit occupancy limits in the land development code that are currently under consideration by the Planning Commission and City Council.

HousingWorks believes the intent of proposed amendments would allow for the development of a greater diversity of housing types and living arrangements than currently allowed in single-family zoning districts, which would increase access to attainable housing opportunities for households at a range of income levels, especially for first-time home buyers and seniors wishing to remain in their communities, and increase housing opportunities in high opportunity areas.

We further recommend that the Council consider providing direction to City Staff to increase access to programs that ensure low and moderate income homeowners are able to avail themselves of increased development potential of single-family lots and are protected from predatory real estate activities. Such programs might include financial counseling, access to capital, legal and technical assistance, and ensuring clear titles are held by property owners.

We thank the City Council for their leadership on these issues and hope our recommendations can help improve the efficacy of the proposed amendments. If you have any questions, please email me at nora@housingworksaustin.org and/or John-Michael Cortez, Advocacy Committee Chair, HousingWorks Board of Directors at jmvcortez@gmail.com.

Best Regards,

Nora Linares-Moeller

Nora Linares-Moeller
Executive Director

HousingWorks Austin · www.housingworksaustin.org · (512) 454-1444
1023 Springdale Road, Building 13, Suite F, Austin, TX 78721

LiUNA!
Feel the Power

Dear Mayor & Austin City Council Members,

On behalf of the Laborers' International Union of North America, Southwest Laborers District Council, and Local 1095, I am writing to express our official endorsement of the HOME Act that will help create more housing opportunities for our members. LiUNA's mission to support our members is fully aligned with the Council's efforts to create more housing we can afford, and options to live in the city we're proud to build and maintain.

Construction workers are essential workers to the future of Austin and Central Texas, but sadly our members are unable to afford to live in the places they work. This is making it more and more difficult to find the skilled workers needed to keep our building boom going, so we understand the urgent need to address the shortage of affordable housing for these workers. Home is an important step in ensuring our ability to attract a robust workforce to keep building on our successes.

Your efforts with the recent Mobility and Infrastructure Summit that focused on supporting and training a larger workforce for those big projects is an important piece of a larger picture that must include more attainable housing for those workers. We are all aware that federal dollars are at stake as part of the Infrastructure Bill and HUD's PRO Housing grant programs, both of which help fund Austin's future and support the people who construct it.

HOME takes a crucial first step to making homeownership more accessible, and reversing the rising cost of housing that prices our members out of Austin's housing market. We are alarmed by the widening gap between the average salary and the cost of homes, which threatens the long-term sustainability of our city. We are also concerned that as more or our members must move farther from Austin, they lose their ability to vote and choose the leaders and policies that accurately reflect their values.

We build this city and are vital members of this community. Like Austin's nurses, teachers, EMS medics, public servants, and small business owners, we deserve the chance to thrive and be part of this community as neighbors and homeowners.

We urge you to give this initiative your full support and ensure its successful implementation to make Austin a city for everyone.

Sincerely,

Jeremy Hendricks

Jeremy Hendricks
Assistant Business Manager
Southwest Laborers District Council – LIUNA

Austin City Council Members,

The National Nursed United (NNU) fully supports the HOME Act to create more housing opportunities. Our mission to support our member is fully aligned with the Council's efforts to create more housing our workers can afford, and options to live in the city we serve.

More nurses are needed for this growing city, especially with the staffing challenges faced by the existing health care providers and with new hospitals and medical facilities coming online. There is an urgent need to create more housing options to attract and retain nurses in Austin, and we hope the HOME initiative will help.

After a 12-hour shift, many of our members commute over an hour to get home; long commutes are not only unsafe after working such long hours but add more transportation costs and take away time with family. These realities drive our nurses to look for jobs outside of Austin hurting recruitment and retention of essential medical personnel for all of Austin's medical facilities.

HOME takes a crucial first step to making homeownership more accessible, and reversing the rising cost of housing that prices our members out of Austin's housing market. We are alarmed by the widening gap between the average salary and the cost of homeownership and rent, which threatens the long-term sustainability of our city. We are also concerned that our members who work in Austin, but don't live in Austin, are no longer able to vote on issues or leaders who represent their values in the community they serve.

We are vital members of this community. Nurses deserve the chance to thrive and be part of Austin as neighbors.

We urge you to give this initiative your full support and ensure its successful implementation to make Austin a city for everyone.

Sincerely,

Celeste Arredondo-Peterson

National Nurses United - Texas

Farm &City

PO BOX 171
AUSTIN, TX 78767
FARMANDCITY.ORG
[redacted]
713-244-4746

OCTOBER 24, 2023

MAYOR KIRK WATSON AND AUSTIN CITY COUNCIL
301 W 2ND ST.
AUSTIN, TEXAS 78701

Dear Mayor Watson and Austin City Council Members,

Thank you for your consideration of supporting the HOME initiative that will be discussed on Thursday, and for all that you do to remove the burdensome limits to the amount of people allowed to live low-carbon, healthy, affordable lifestyles in the City of Austin.

We strongly support this initiative and urge you not to water it down in ways that will keep people from finding affordable housing options in this City.

Farm&City is dedicated to high quality urban and rural human habitat in Texas in perpetuity. We are a climate change organization that focuses on changing Texas public policies so that the millions of people who want to live low-carbon lifestyles in Texas are allowed to walk to the store, ride public transit to school, and not have to drive so much.

Unfortunately policies at the City of Austin have contributed negatively to our housing crisis – along with county, metropolitan, and state policies – forcing most people to live expensive car dependent lifestyles. The City's continued use of exclusionary zoning limits the amount of people allowed to live in the City to current population plus about 25% of regional growth.

City policy is diminishing the City's share of the region's population, abrogating the City's responsibility to provide for the growing human species on our planet in a more responsible, climate-aware manner, and significantly contributing to the paving over of the hill country. As shown by City of Austin Watershed Department analysis during the CodeNEXT process and the attached EPA report, land use reforms of this type will significantly reduce the future total impervious surface in our region, while actually slightly decreasing the total inside the City, even while allowing significantly more people to live in the City.

The climate costs of exclusionary zoning are profound. Not letting more people live in existing neighborhoods with existing underutilized infrastructure is an extraordinarily unwise choice at this time in history, with what we know very well about climate science and the impacts of housing and transportation policies. The City of Austin should not engage in an anti-science

Farm &City

PO BOX 171
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713-244-4746

position opposed to the overwhelming consensus of environmental groups and policy makers, including the position of the Federal Government and President Biden, urging the City of Austin to abandon exclusionary zoning and replace it with equitable growth strategies. As shown in our second attached report, those living in dense areas in our region are able to live their lives without emitting as much carbon as their neighbors who live in car dependent places. We should remove city limits on the amount of people allowed to not drive so much.

In spite of persistent mis-perceptions – significantly informed by elite projections and a focus on home sale prices – the more dense parts of the Austin region are the most affordable parts of the region, both in terms of housing and transportation costs, as documented in our attached report. Limiting the number of people allowed to live in the City drives up housing and transportation costs for people living in the City and those living in the rest of the region. Displacement is primarily caused by zoning rules that drive housing costs up and accelerate the competition for the artificially limited number of homes remaining in the City.

Our region is growing from 2 to 4 million people with a majority of the additional people expected to be people of color. The Austin City Council should seek to allow as many of those additional people as possible to live within the City in walkable transit-oriented places where low-carbon lifestyles are possible.

The HOME initiative is an important element of a responsible climate and equitable growth policy. While every homeowner can choose to keep their home exactly as they want, the City itself should not enforce broad dictates banning affordable housing types from any neighborhood. As stressed in the UT Uprooted report, allowing low-income homeowners to better utilize their lot, to share their space with other people, is an essential strategy to keep communities connected and preserve the most important character of our City, the people who live here today and their welcoming nature as our human population grows across the planet. Let's not be on the side of exclusion anymore, here in Austin, Texas.

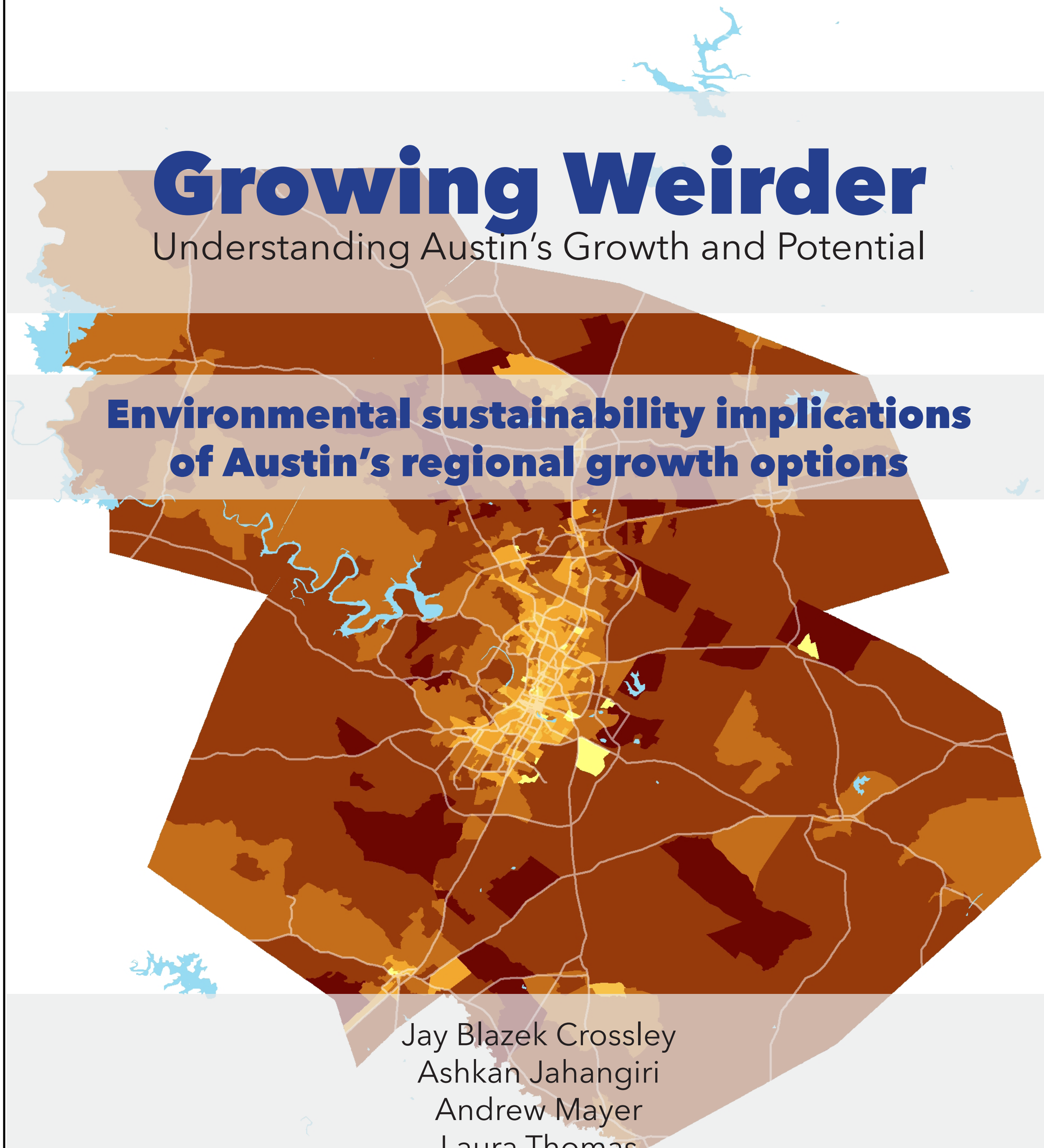
Thank you for all that you do for the people of the City of Austin – past, present, and future – and for your consideration of voting in favor of the HOME initiative.

Sincerely,

Jay Blazek Crossley
Executive Director

Growing Weirder

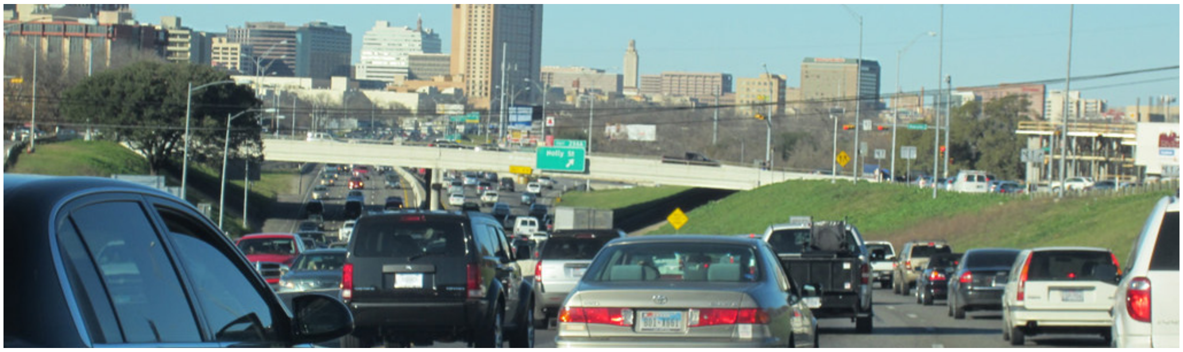
Understanding Austin's Growth and Potential



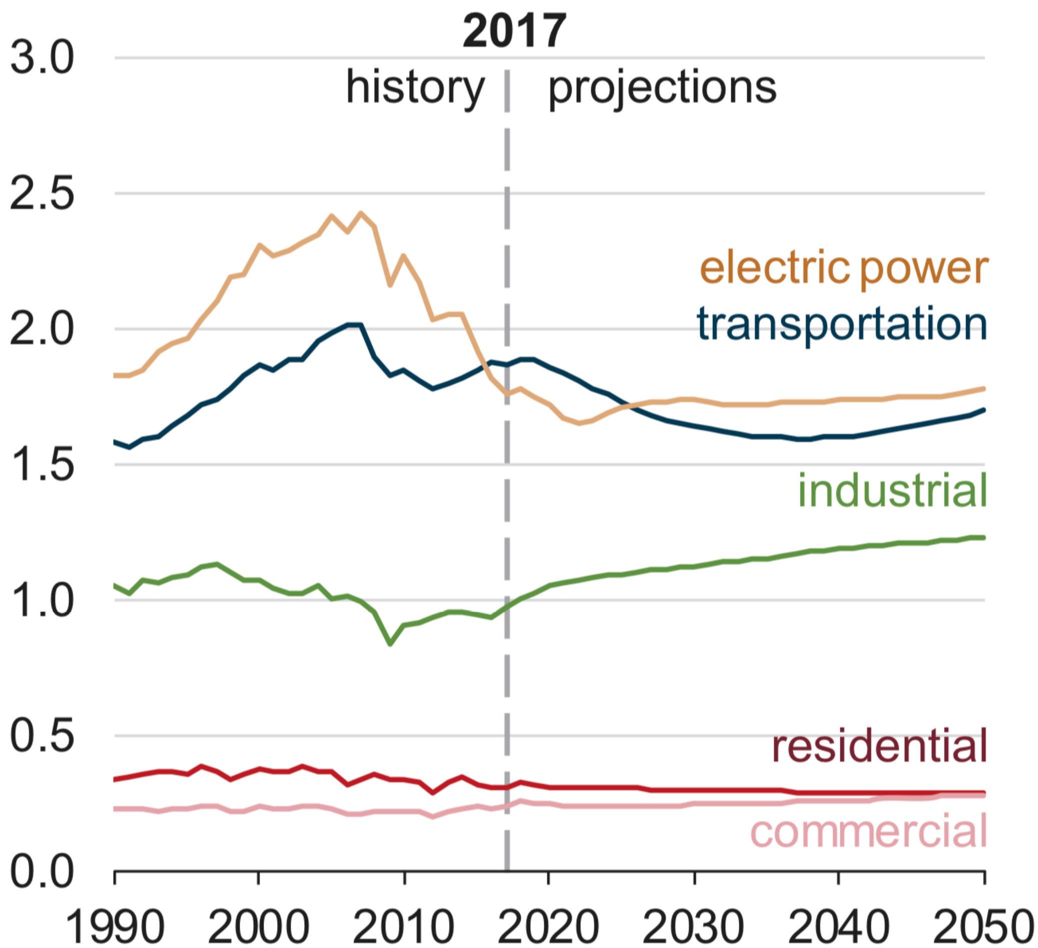
Environmental sustainability implications of Austin's regional growth options

Jay Blazek Crossley
Ashkan Jahangiri
Andrew Mayer
Laura Thomas

Farm & City



Energy-related carbon dioxide emissions by sector (Reference Case)
billion metric tons of carbon dioxide



Growing Cooler

A decade later, the seminal report grows even more important and influential

In 2007, the Urban Land Institute released *Growing Cooler*, a highly-cited landmark publication linking climate change and transportation. It is a good report.

Our work here – to empower communities and elected officials with better information and analysis to help build a sustainable, equitable Austin region – is based upon Growing Cooler.

Carbon emissions from transportation account for over a third of our national emissions, and have been a larger problem than the US energy sector since 2014.

Growing Cooler found transportation emissions can only be meaningfully reduced by reducing vehicle miles traveled (VMT) by choosing compact development. We agree with this general framework.

Many efforts – including the emphasis by the City of Austin – to curb transportation emissions have focused on reducing tailpipe emissions without questioning VMT. The result has been no improvement in the national fuel economy from 1990-2005 and a 50% increase in VMT. 70% of the increased VMT is directly attributable to our sprawl, with only 13 % from growth.

Population growth is generally slightly associated with a reduction in per capita VMT, a reflection of shifting trends towards compact development. Characterized by density & regional diversity of land use, compact development is a low-cost method of reducing VMT. As we grow together, we grow more efficient.

A local push for compact development to manage existing demand could yield a 30% reduction in VMT and a concomitant 10% reduction in vehicle based carbon emission by 2050.

Compact development allows for safe access by all modes of transportation, while meaningful access by transit and other modes are not possible to provide to people living in low density sprawl.

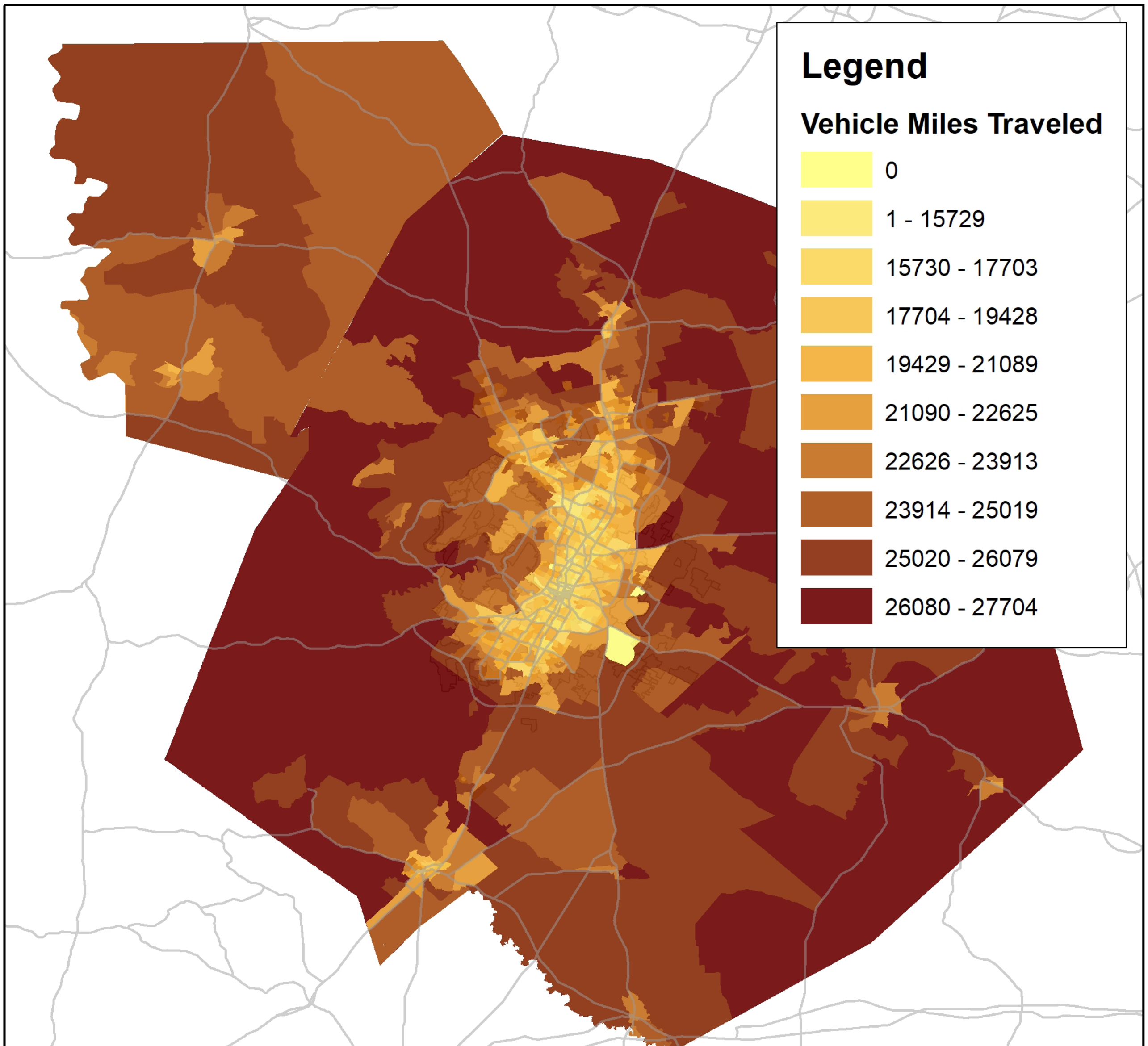
Water quality and existing forestry are protected by compact development. There are also public health benefits through increased access to healthy lifestyles, improved air quality, and reduced pollution.

Growing Cooler promotes compact development and discourages sprawl. Cities, counties, and MPOs can curb transportation emissions by adopting land use codes that promote infill and mixed uses to build complete communities for all.

Our work on Growing Weirder is an attempt to build on *Growing Cooler*'s wisdom and apply it to current policy debates across the Austin region.

We're analyzing vehicle miles traveled, carbon emissions, traffic, and climate emissions costs of various CodeNEXT and regional growth proposals, and seeking solutions.

Preserving the livability of the Austin region requires making these difficult decisions today, based upon the best available data.



Vehicle Miles Traveled (VMT) is a crucial measure of how much individuals, neighborhoods, and entire metropolitan areas travel.

Traditionally, VMT has been regarded as an unavoidable consequence of regional growth. Many elected officials actively work to sustain VMT increases, believing economic growth to be dependent on VMT. Texas transportation planners continue to allocate billions of dollars based on the notion that we must allow VMT growth. However, this assumption is not necessarily correct. Nationwide per capita VMT has a slight negative correlation with growth. TxDOT's own data also suggests economic growth and VMT are decoupling.

VMT does have concrete negative consequences; every additional mile travelled increases traffic and the risk of collisions. Crashes cost Texans $162 billion every year, while congestion drains a further $14 billion in unproductive time spent in cars. With an annual statewide VMT of 258 billion, every mile driven is respon-

Vehicle Miles Traveled

Tell me your address, and I can tell you how much your neighbors drive.

	SuperUrban	Urban	Suburban	Rural
People	11,434	735,639	672,614	592,271
Households	3,296	272,582	251,433	207,080
Total VMT	44,693,190	5,206,634,672	5,568,521,504	5,236,638,780
VMT per capita	3,909	7,078	8,279	8,842
Carbon per capita (tonnes)	1.96	2.93	3.43	3.69
Total carbon (tonnes)	15,923	2,157,910	2,310,421	2,186,908

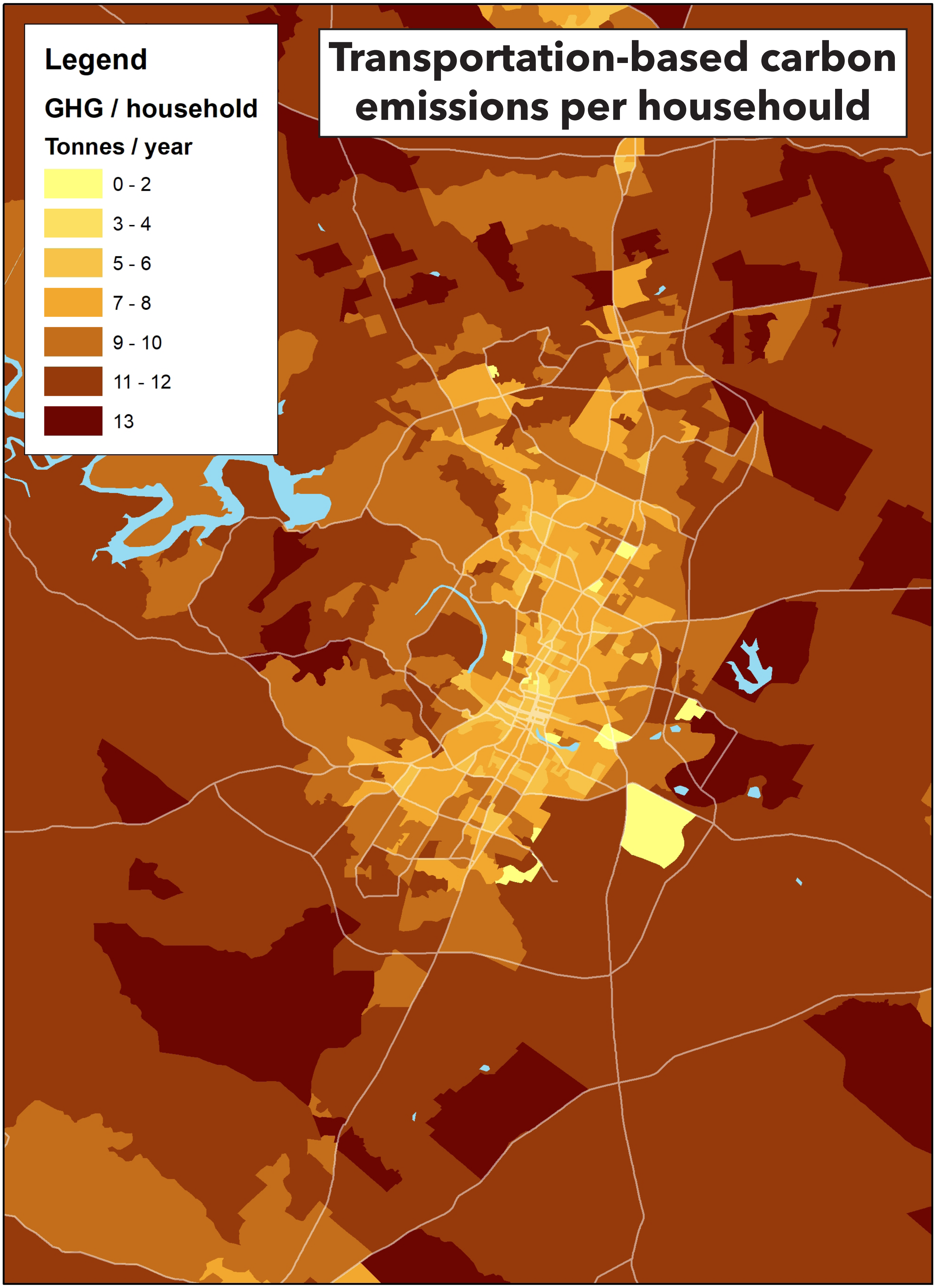
sible for $0.63 of property and vehicle damage. The human cost is also steep; ten people die every day on Texas roads, causing immeasureable pain and suffering.

Our transportation decision-making system also hides the cost of "free" roads, underrepresents people of color, and provides scant data on the true costs of our transportation system. Given the steep risks associated with distances travelled, planners must explicitly aim to reduce VMT.

Transportation is responsible for over one third of carbon emissions in the United States. These emissions are a simple function of fuel efficiency and VMT. The federal government has successfully regulated fuel efficiency through increased mileage standards for vehicles & the gas tax. On an individual and local level, VMT reduction is the most significant way to reduce carbon emissions. VMT can be reduced through use of public transportation and location efficiency, which is achieved by positioning housing, work, and schools in compact, easily-accessible locations.

Unfortunately, the availability of low-carbon lifestyle options depends on our urban environment. As the Austin region grows from two to four million people over the coming decades, the decisions made in CodeNEXT and the 2045 Regional Transportation Plan will determine how many people are allowed affordable access to sustainable, healthy, walkable urban neighborhoods.

The Center for Neighborhood Technology maintains a H+T Affordability Index that provides detailed data on the financial and environmental costs of housing and transportation across the US. It forms the basis of our analysis on VMT and transportation-related carbon emissions.


Transportation-based carbon emissions per househould
Legend
GHG / household
Tonnes / year
0 - 2
3 - 4
5 - 6
7 - 8
9 - 10
11 - 12
13

Carbon Policy

Transportation-based carbon emissions vary by where you live across the region

We must reduce our metropolitan carbon emissions to play a responsible role in the 21st century world community. Unfortunately, many of our public policies continue to increase our carbon footprint--especially land use and transportation policies.

As we grow from a population of two million to four million, we have the oportunity to lower our carbon footprint significantly by allowing existing and new residents better options to live healthy, low-carbon lifestyles, by reducing car dependency.

Austin's urban grid, density, transit and pedestrian access, and multimodal street safety dictate how much it costs to access the benefits of this American metropolis. While environmental costs can be less obvious, they are expressed in carbon emissions, air quality, and loss of trees and open space.

Today's Austin provides low-carbon lifestyles for a very select few, but that select few contains a diverse mix of socio-demographics. Long-standing traditional urban street grids continue to provide both rich and poor Austinites with low-carbon lifestyles. Allowing more housing in the environmentally sound existinurban grid means more people having access to the current benefits, while also reducing the carbon footprint and travel needs of those there today.

More people in your neighborhood will mean more services at your fingertips, including retail, schools, and offices within walking distance as well as allowing for high quality, frequent transit access.

There are areas of our region where the average household emits ten times as much transportation-based carbon than in other, more efficient parts of our region.

A key element of transportation based carbon emissions is that the tailpipe emissions are not the only contirbution to global warming for every mile you drive. A new car - whether it is electric or internal combustion - already has an amount of embedded carbon when you buy it.

The factory, parts, and materials contributed to global warming before the engine was ever turned on. Some estimates show that this amount of embedded carbon is about equal to the amount that a new internal combustion car will release over its life cycle.

But this isn't all. Driving requires roads and parking spots. The Austin region has more lane miles per capita than most Texas metros. All of those miles of road required extensive green house gas emissions through bulldozing the road, bringing the material, paving the road, and ongoing maintenance.

Cutting the Austin region's vehicle miles traveled is a crucial element of climate responsibility, which will primarily be determnined by our regional growth policies, especially CodeNEXT and the 2045 Regional Transportation Plan.

Each additional person allowed to live in the region, but not inside the City of Austin = **0.46 additional tonnes of carbon emissions** annually.

Adopting CodeNEXT V.2 today would mean 108,951,401 less vehicle miles traveled in 2027 compared to currently-used segregation zoning. This would be equivalent to planting **2 million trees** every year.

These are very conservative estimates of the benefits of allowing more people to live within the City of Austin. As more people and jobs are added to our neighborhoods, each one of us actually ends up driving less and emitting less carbon, while gaining greater access to people and opportunities. This proposal is a rare environmental / societal win-win.

Code Impacts on Carbon

Average housing + transportation costs as a percent of regional typical income

We drive a lot in Texas. Americans drive more than most wealthy nations, and Texans in our major metropolitan regions drive more than most Americans in other major metropolitan regions.

Austinites, in particular, drive more than those in most other Texas metros, meaning the region lags behind Houston and Dallas in responsibly addressing climate change.

If you live in the City of Austin, you're responsible for an average of 7,602 vehicle miles traveled every year. However, if you live in the Austin region but outside the City, you're averaging 8,259 miles a year.

Each additional man, woman, & child not allowed to live in the City of Austin, who instead lives in the more car-dependent parts of the region means around 2 miles more of driving every day.

Transportation accounts for more green house gas emissions for Americans than energy. On average, every person living outside the City of Austin accounts for 0.46 more tonnes of transportation based carbon emissions than if they lived inside the city, based upon the VMT differences.

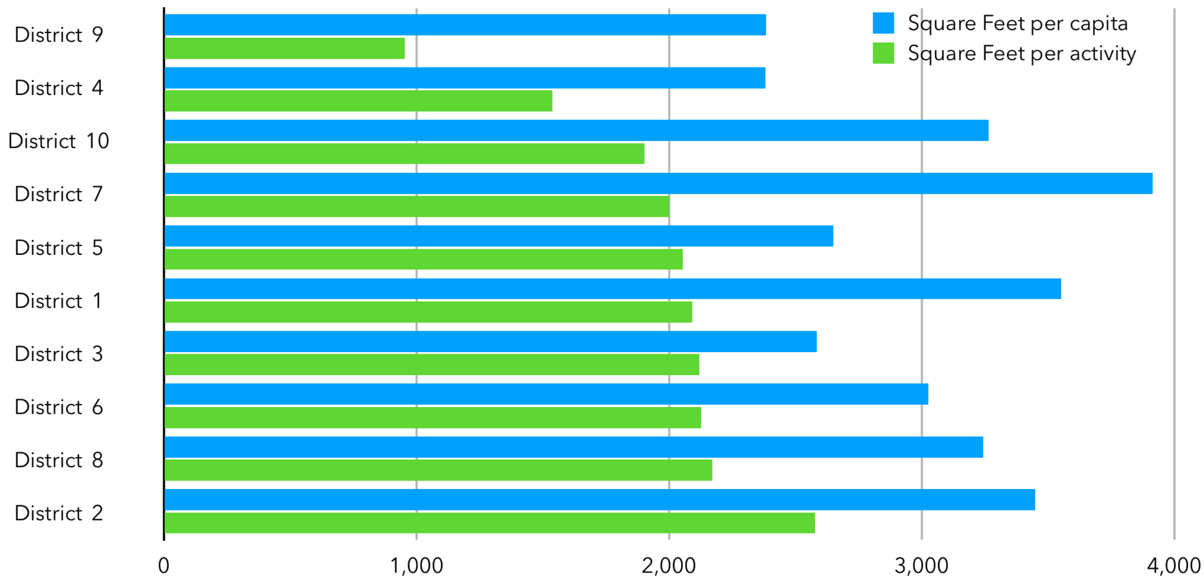
When we analyze potential future growth scenarios, we often underestimate the difference between living in and out of the City. Even so, the distinction is important.

The more people an attractions are nearby, the less people have to drive long distances to get to them. The land development code must be tweaked to allow every neighborhood to develop into a complete community.

A progressive, climate responsible CodeNEXT can meaningfully reduce future carbon emissions and traffic.

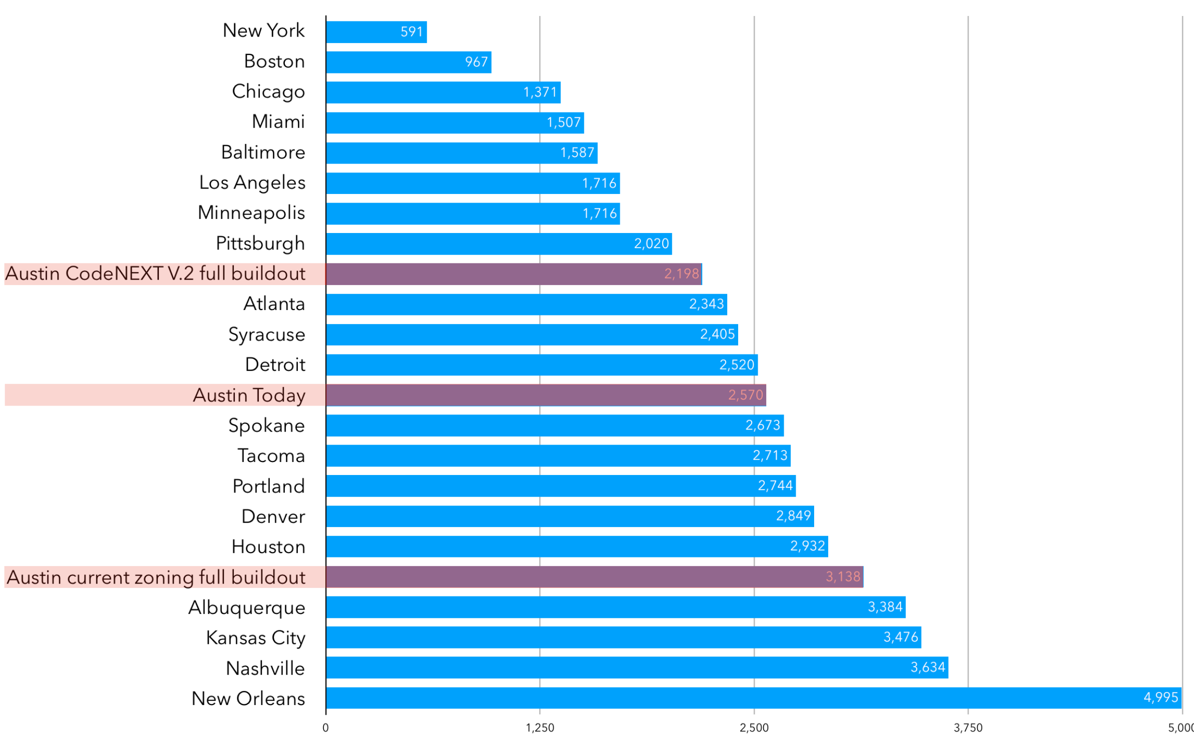
Most calculations herein are based on our analysis of CNT data. as explained in our Affordability report. Please explore the source data here: https://htaindex.cnt.org

Impervious Surface By Austin Council District



Population is 2010 Census estimates as presented by the City of Austin Demographer online. Jobs were derived from the CAMPO Regional Forecasts baseline 2010 data using the percent clip method to extract the data to council districts from TAZs. Activity Intensity is the amount of jobs and population in an area. So an activity means someone lives there or works there.

Square feet of impervious surface per person in major US cities



Impervious Surface

Average housing + transportation costs as a percent of regional typical income

According to numbers from the City of Austin Watershed Department, the proposed CodeNEXT Version 2 would have been a slight improvement over current zoning in terms of the total amount of impervious surface expected in the City of Austin by 2027 - comparing both options using a fantasy scenario where all entitlements are actually used.

However, our potential future development affects impervious surface in part by controlling the number of people allowed to live inside the City of Austin or outside.

Allowing people to live inside the City of Austin helps ease the heavy impervious surface costs of subsidizing growth outside the City, reducing flooding. Allowing higher population densities inside the city – as CodeNEXT V.2 does – would yield environmental benefits for the region.

As far as we know, this analysis has not been redone for the most recent drafts of CodeNEXT, but the impervious surface benefits are likely similar or better in Version 3.5 than Version 2.

Today in the region – according to TXDOT's "FY2005 - 2016 Roadway Data Tables" – the people of Travis County are responsible for 55% of the amount of roads and streets per capita that the people of Hays County are, as shown in the chart to the left.

Low density car dependent neighborhoods require more roads per person, which means more flooding.

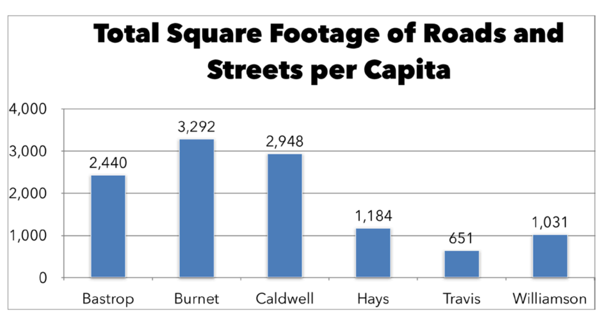
Current projections of impervious surface coverage contradicts anyone citing environmental, flooding, heat island, or water quality fears as reasons to vote against CodeNEXT V.2 (see chart opposite).

A full buildout of CodeNEXT V.2 will result in about 1,000 fewer acres of impervious land than a buildout of current zoning. Each resident of the City of Austin would be responsible for almost 1,000 fewer square feet of impervous surface.

This means roughly 1% of the city would be left open rather than paved, giving clear indication that the new proposal is more environmentally friendly than its alternatives.

In addition, the current zoning code is responsible for many of Austin's localized flooding problems. As we move further into the anthropocene towards an ever-increasing number of unexpected weather events, efficient land development codes are vital in disaster preparedness.

Passing CodeNEXT would reduce future total regional impervious surface, and dramatically reduce impervious surface per capita for residents of the City.



Dedication ceremony for the Rio Grande Protected Bike Lane
Photo Credit: our friends at BikeTexas

UNO: Austin's CodeNEXT Pilot

There's a place in Texas with astounding environmental results of public policy

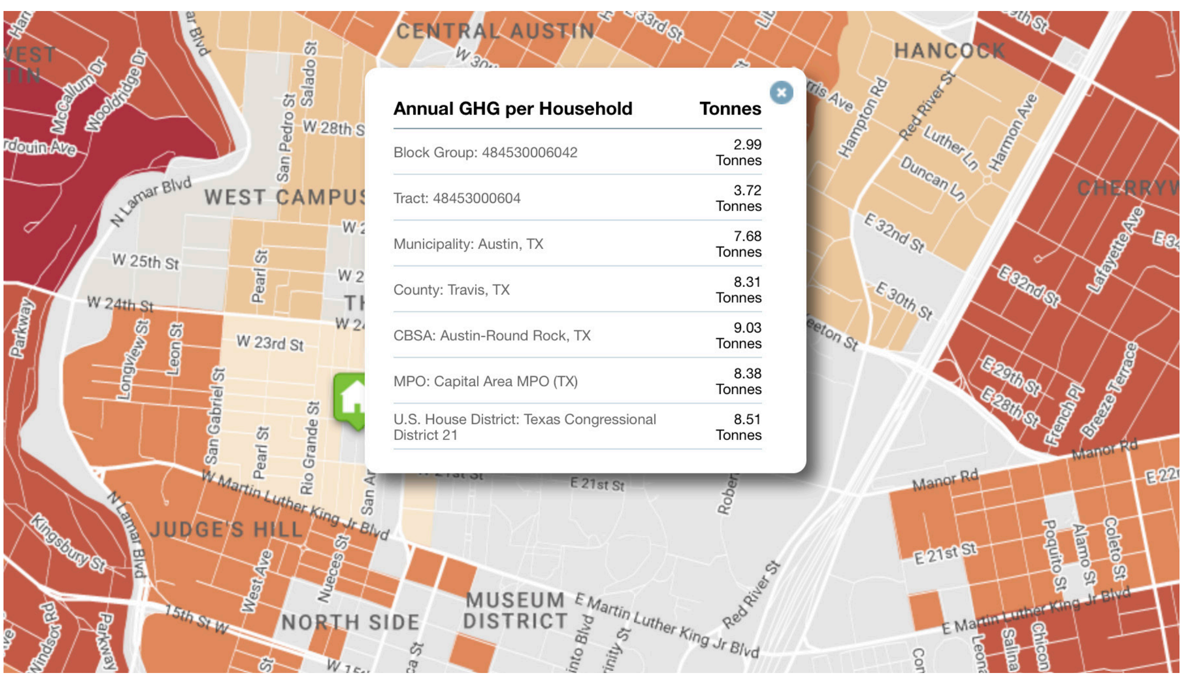
West Campus is a Texas neighborhood that has radically changed since – some of us lived there in – the 90s due to leadership and direction from Austin City Council, with astounding metrics on what has been achieved in terms of people living better.

Clearly the area has gained safe street improvements faster than anywhere else in Texas. According to Dan Keshet's blog *Austin on Your Feet*, the student-rich neighborhood now contains double the apartments that were available 15 years ago.

While rents in West Campus have risen dramatically, its residents are driving less than other Texans. West Campus is easily the most eco-friendly place to live in the Austin region – if not all of Texas – with residents of West Campus emitting just 23% of the regional population's average transportation-based carbon emissions.

For urban planning and climate responsibility purposes, students' trips to class are equal to work commutes. City Council's effort to provide convenient, affordable access by all modes for students demonstrates the power of transit improvements.

We are very well aware of the costs and benefits. These policies have allowed affordable, low-carbon lifestyles to many Texans, and should be spread beyond West Campus.



Growing Weirder is made possible by the generous contributions of these equitable sustainability focused entities:

GREATER AUSTIN NEIGHBORHOODS

Blazek & Vetterling | CERTIFIED PUBLIC ACCOUNTANTS

IMPACT HUB AUSTIN

MY BRILLIANT CITY

Growing Weirder

Understanding Austin's Growth and Potential

We can tell a new story of Texas metropolitan growth that empowers communities to engage in more productive conversations to build the future they want.

We can provide the analysis decision-makers and the public need to optimize our freedoms, our environment, and our quality of life. We can begin to shift our thinking to treat our growth as a shared responsibility and opportunity to complete our communities.

We intend to substantially impact the outcomes of City of Austin's CodeNEXT, Capital Area Metropolitan Planning Organization's Regional Transportation Plan, Capital Metro's Project Connect, City of Austin Strategic Mobility Plan, state legislation, and various related public processes, such as local budgets and bond proposals.

Displacement is real. Profit and abundance are real. Successful mixed-income, mixed-use community building is also real. We need to determine strategies and best practices that will minimize displacement, maximize affordable housing units in accessible and affordable locations, and achieve citizen priorities. The region's policy-makers and finance community need to learn the lexicon of location efficiency.

We need a holistic set of understandings of growth, best practices for equitable policy making, and synergistic transportation policies to produce true affordability.

Ultimately this work is intended to provide affordable access to a high quality of life to all the people of Austin.

We must measure our success by the ability of low income and disadvantaged people to live comfortably and access all the benefits of a modern city. We are trying to change the paradigm of growth, development, and transportation in their favor, but it will take time.

This report is part of a series of in-depth investigations on the various consequences of our major land use and transportation policy decisions. This is necessarily messy- our built environment impacts every aspect of how we live our lives in ways that aren't obvious and that we are only beginning to understand.

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Growing Weirder

Understanding Austin's Growth and Potential

Updated and republished June 8, 2018
http://www.GrowingWeirder.org
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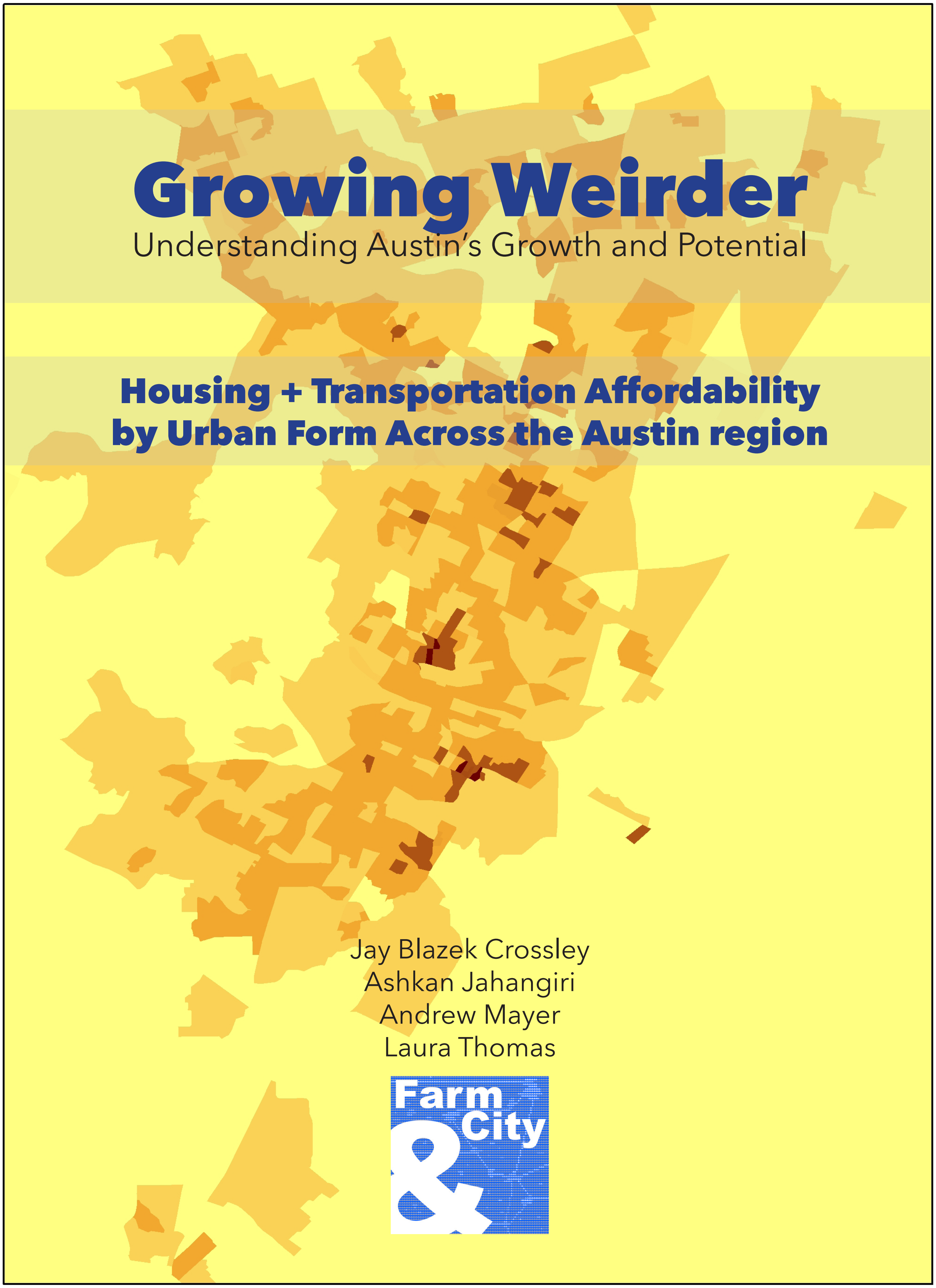


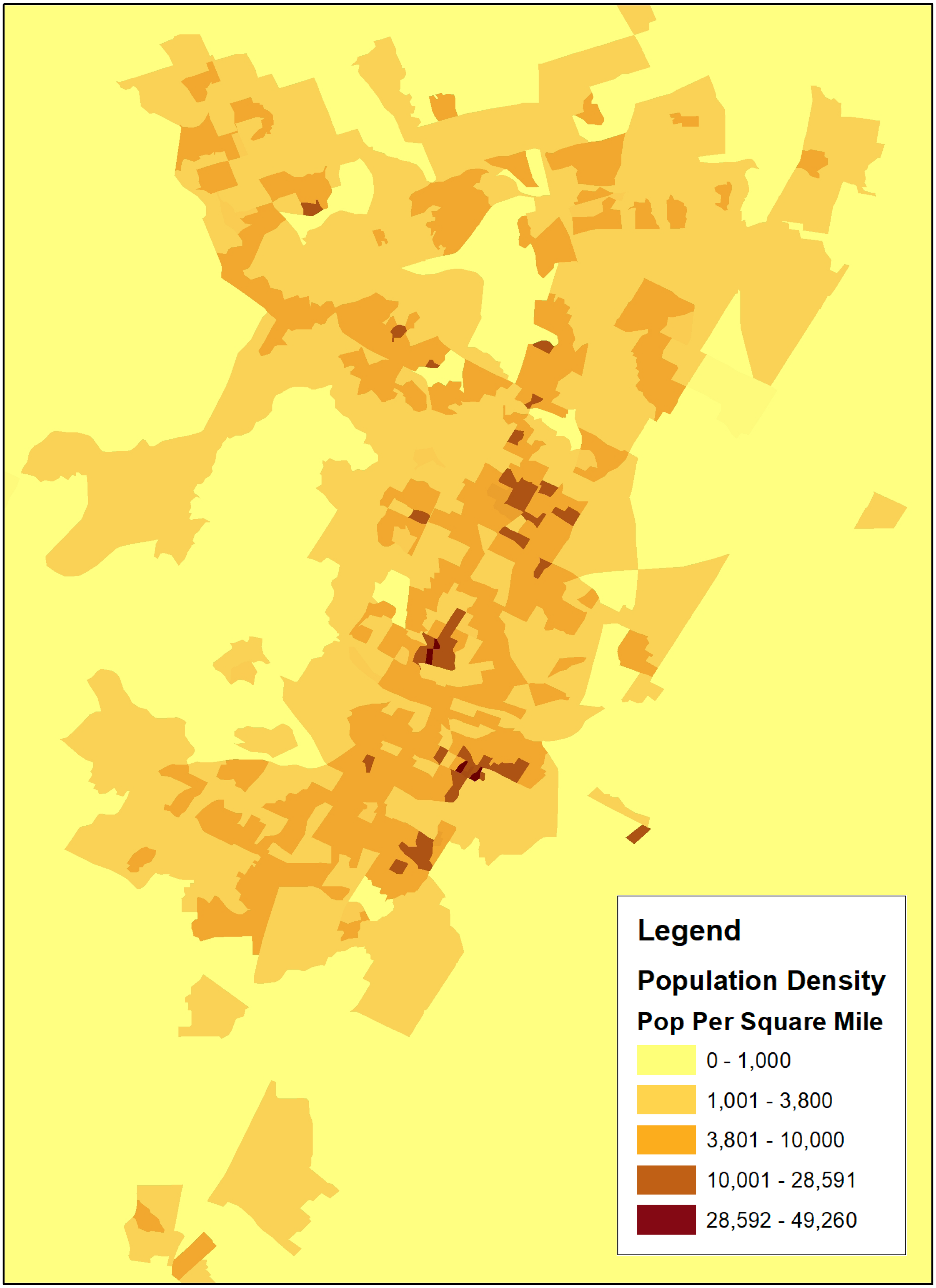
Growing Weirder

Understanding Austin's Growth and Potential

Housing + Transportation Affordability by Urban Form Across the Austin region

Jay Blazek Crossley
Ashkan Jahangiri
Andrew Mayer
Laura Thomas

Farm & City


Legend
Population Density
Pop Per Square Mile
0 - 1,000
1,001 - 3,800
3,801 - 10,000
10,001 - 28,591
28,592 - 49,260

Three Austins

In this report, we examine the relationship between density and affordability

Affordability is often defined by the cost of housing. While housing is the most significant single household expense, transportation is second largest and therefore a significant component of true affordability. Transportation costs are primarily a function of location. Multimodal transportation options are more available in urban areas of higher density. In the Austin region, people can walk, bike, use transit, or take short car trips to their daily destinations primarily in dense urban areas.

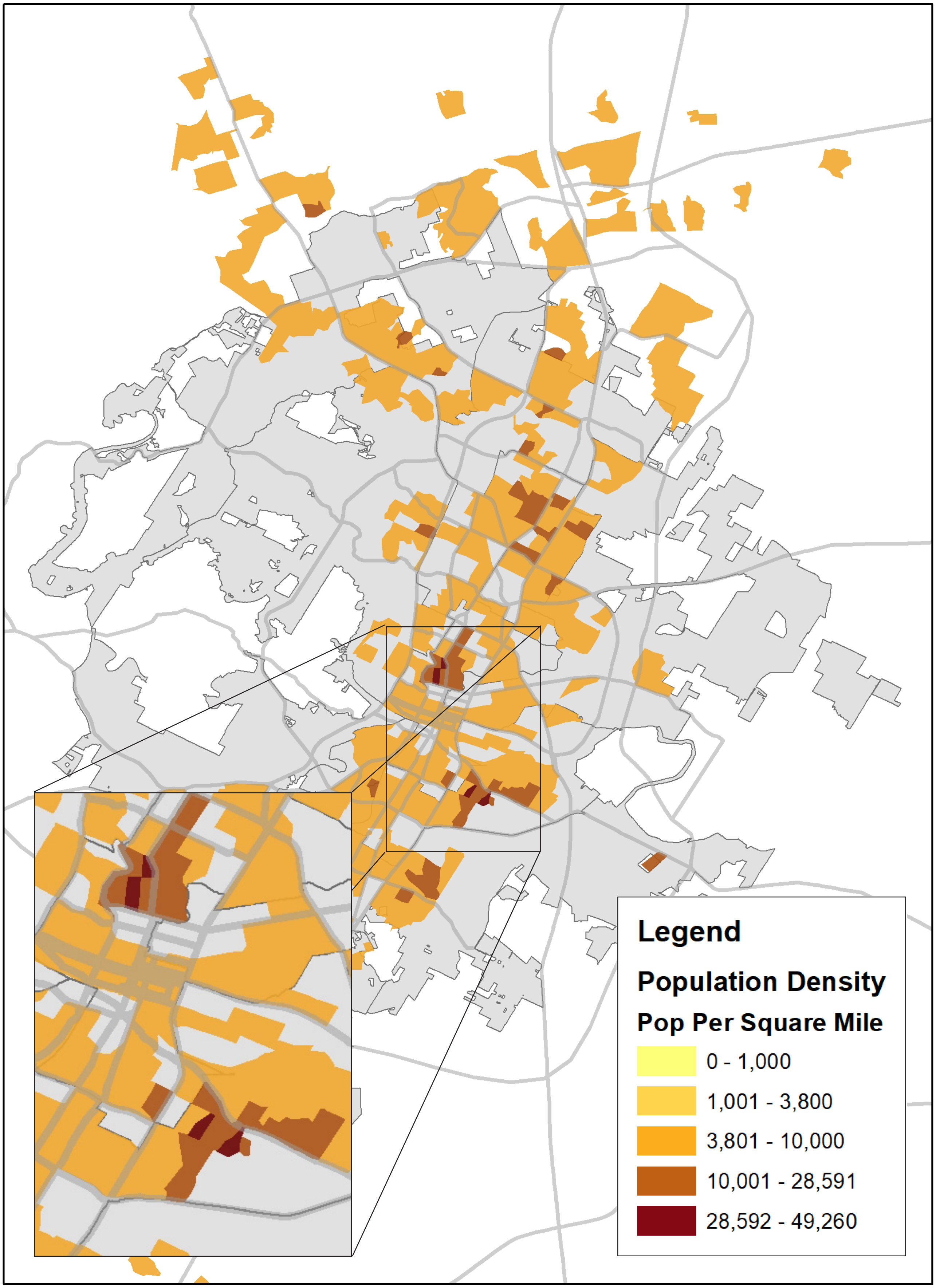
We would expect those living in car-dependent, low density housing to spend more on transportation. The map on the left shows urban, sub-urban, and rural portions of the Austin region as defined by standard density measures.

Our astonishing discovery is that today it is on average more affordable to live in the urban areas of Austin than in suburban and rural, not just in terms of transportation, but also housing costs. Urban Austinites spend 45% of the typical regional median income on housing and transportation. This number rises to 52% in sub-urban Austin, and 55% in the rural, least dense parts of the region. These figures challenge conventional notions of affordability.

Average Housing + Transportation Costs as a Percent of Regional Typical Income in the Three Austins

	H+T	H	T
Urban	45%	25%	20%
Sub-urban	52%	31%	21%
Rural	55%	30%	25%

Many public policy decisions impact the amount of people realistically able to live in these three Austins. We should make those with a better understanding of the housing + transportation affordability implications.


Legend
Population Density
Pop Per Square Mile
0 - 1,000
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Urban Austin

Places that are home to over 3,800 people per square mile

Numbers in black represent all urban areas, followed by particularly dense regions of 10,000-28,590 people per square mile and super urban areas home to over 25,000 per square mile.

People
735,659 109,982 11,434

Households
272,582 33,422 3,296

Average Housing + Transportation Costs as % of Regional Typical Income
45% 36% 39%

Renter-occupied households
154,813 28,097 3,245

% of households that rent
57% 84% 98%

% of city's renters
52% 9% 1%

Average household size
2.7 3.3 3.5

Total Vehicle Miles Traveled (millions)
5,206 534 45

VMT per capita
7,078 4,852 3,909

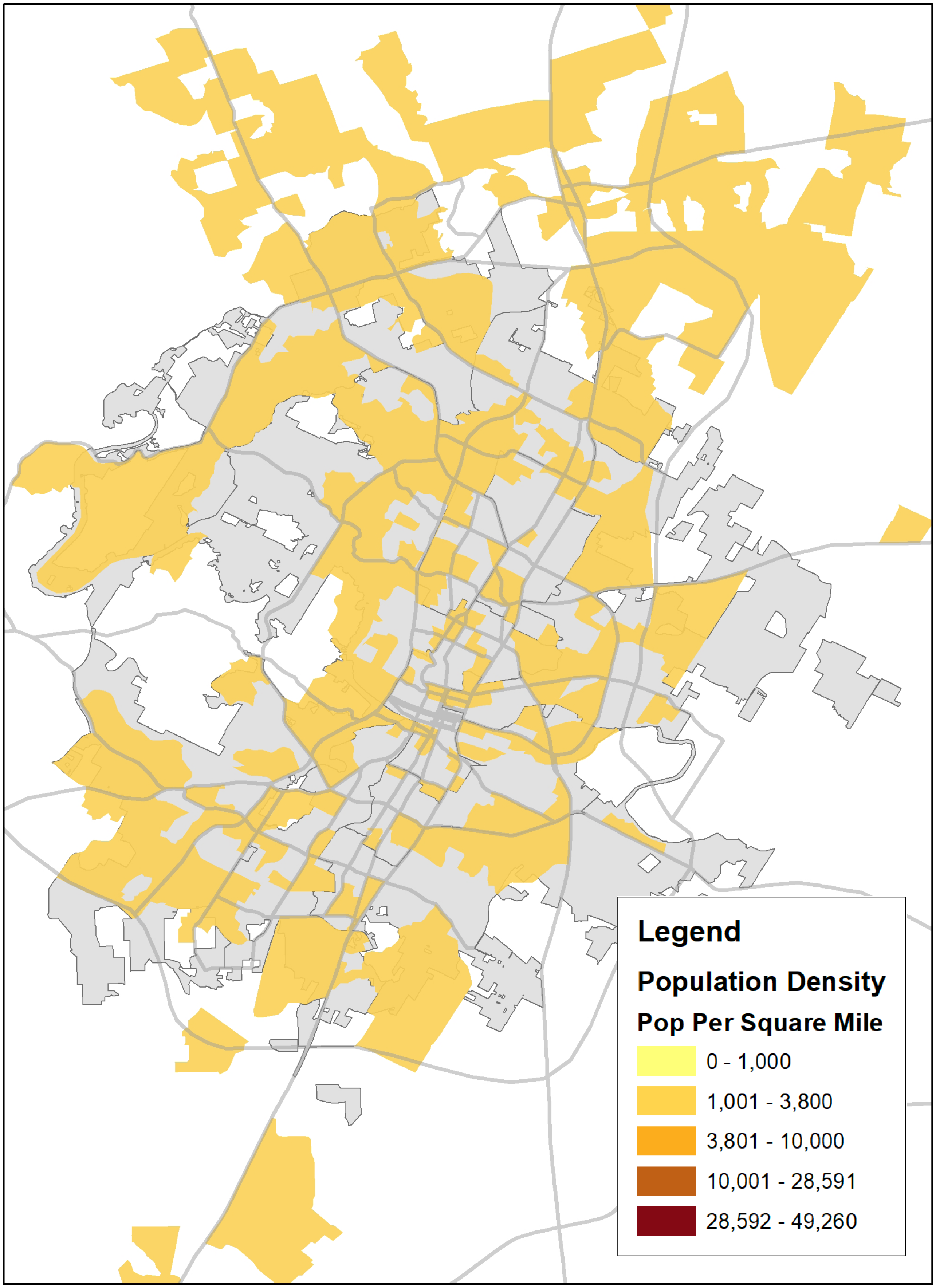
Total Annual CO2 emissions from household transportation use
2,157,910 215,205 15,923

CO2 emissions per capita
2.93 1.96 1.39

Total square miles
118 7.8 0.3

The darkest regions on the map (left) have the highest residential density in Austin, including sections of West Campus and Pleasant Valley. These fare the most green parts of our region, and perhaps of all of Texas, in terms of the greenhouse gas emissions from transportation - one of the elements of the climate change crisis most squarely a responsibility of local government.

In the coming decades, a substantial portion of Austin may graduate into areas of complex, mixed-use, mixed-income high density, but the extent to which many more Austinites of all income levels are allowed options for healthy, low carbon lifestyles will depend upon two as-of-yet undecided major initiatives: CodeNEXT and the 2045 Regional Transportation Plan.


Legend
Population Density
Pop Per Square Mile
0 - 1,000
1,001 - 3,800
3,801 - 10,000
10,001 - 28,591
28,592 - 49,260

Sub-urban Austin

Places that are home to 1,000 - 3,800 people per square mile

People
672,614

Households
251,433

Average Housing + Transportation Costs as % of Regional Typical Income
52%

Renter-occupied households
96,084

% of households that rent
38%

% of city's renters
32%

Average household size
2.7

Total Vehicle Miles Traveled (millions)
5,568,521,504

VMT per capita
8,279

Total Annual CO2 emissions from household transportation use
2,310,421

CO2 emissions per capita
3.43

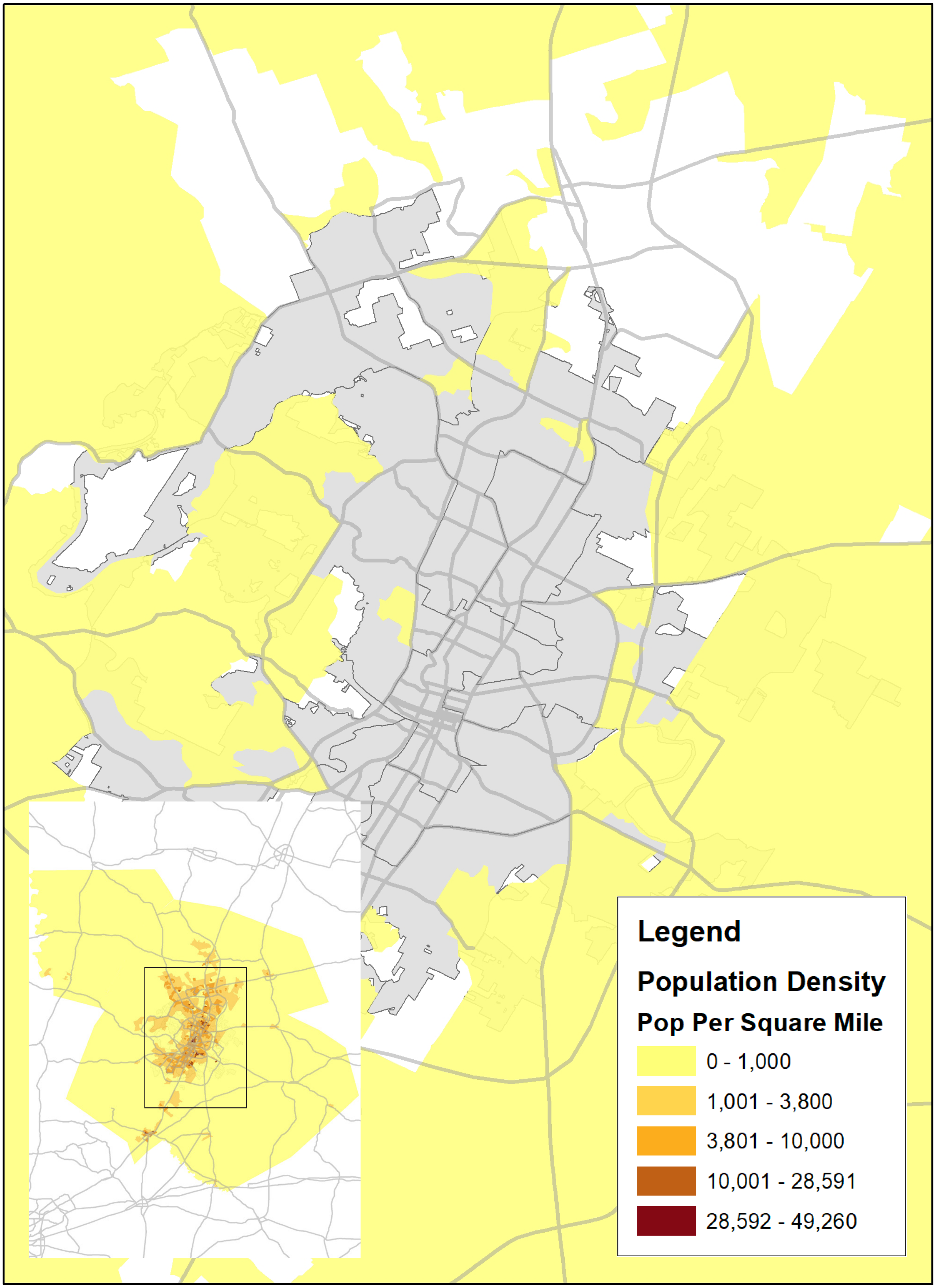
Total square miles
348

Sub-urban Austin is an economically diverse place, with low- and moderate-income neighborhoods alongside the expensive car-dependent neighborhoods of the hill country on the west side. All inhabitants of sub-urban Austin share a high cost of transportation.

A citizen would have to spend 21.47% of their income on transportation to live in sub-urban Austin, compared to 19.65% in urban Austin or 15.31% in super-urban Austin. Interestingly, sub-urban Austin is also more expensive in terms of housing, with average households spending 30.6% of their income on housing compared to 26.2% in urban areas.

Sub-urban Austin also has smaller household sizes, higher carbon footprints, and more vehicle miles traveled than urban Austin.

Austin's sub-urbanites drive twice as much as residents of the very high density areas of West Campus and Pleasant Valley.


Legend
Population Density
Pop Per Square Mile
0 - 1,000
1,001 - 3,800
3,801 - 10,000
10,001 - 28,591
28,592 - 49,260

Rural Austin

Places that are home to fewer than 1,000 people per square mile

People
592,217

Households
207,080

Average Housing + Transportation Costs as a % of Regional Typical Income
55%

Renter-occupied households
96,083

% of households that rent
23%

% of city's renters
16%

Average household size
2.9

Total Vehicle Miles Traveled (millions)
5,236,638,780

VMT per capita
8,842

Total Annual CO2 emissions from household transportation use
2,186,908

CO2 emissions per capita
3.69

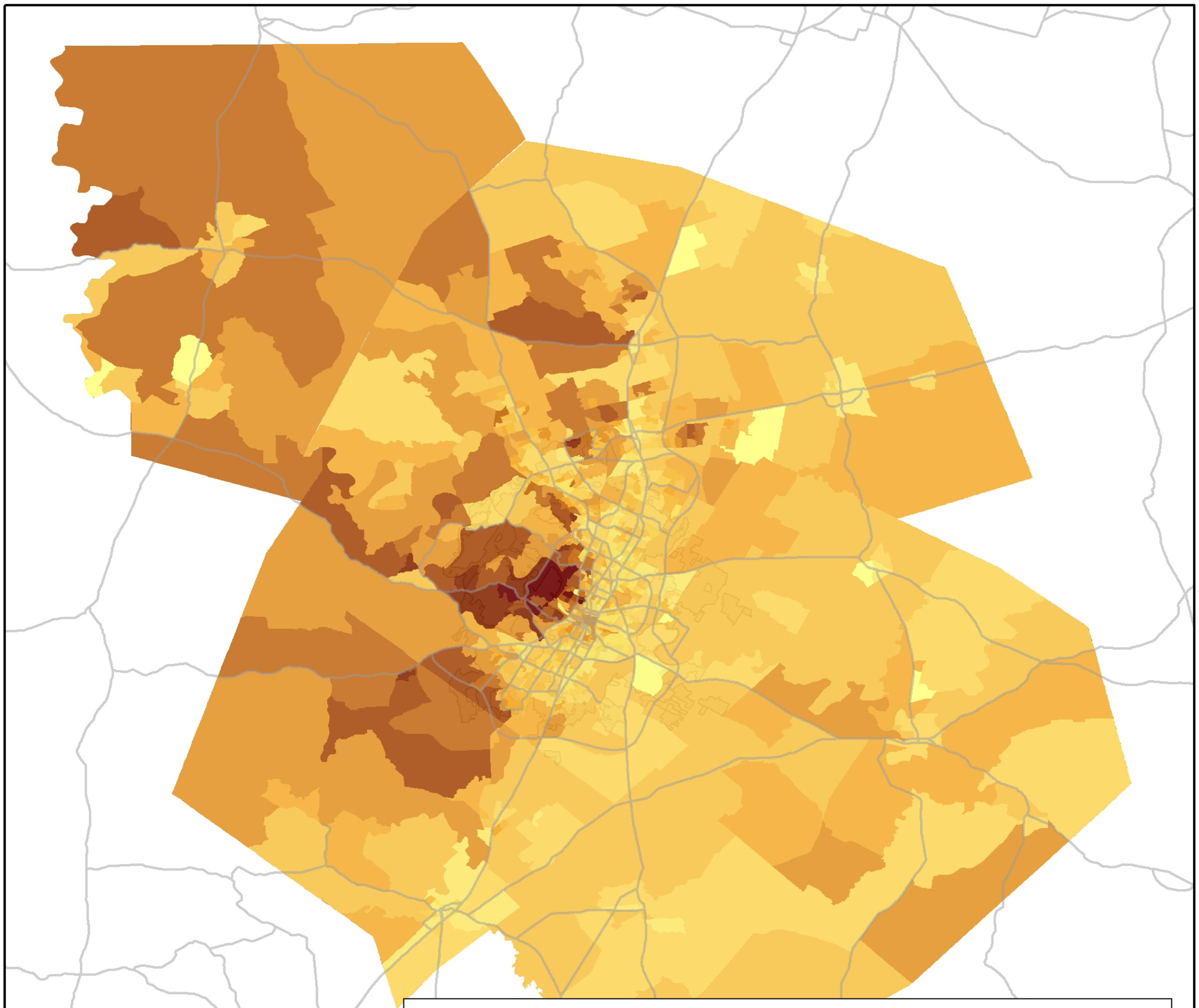
Total square miles
8,747

Rural Austin has equivalent housing costs as sub-urban Austin, requiring roughly 30% of regional typical family income. However, rural Austin has the highest transportation costs at 25.19% of regional typical family income.

Rural Austin drives the most and is responsible for the most carbon emissions per capita from household transportation. The costs of transportation are 65% higher for rural Austin than for the residents of the most dense part of the Austin region.

The proportion of the Austin metro area population who live in these very low density situations seems unique for Texas. Identical analysis was done on the Houston metro region, finding that 14% of Houstonians live in rural settings, compared to 30% of the residents of the Austin region.

This perhaps is a significant explanation for why the Austin region has a much higher rate of vehicle miles traveled and traffic deaths than Houston and most other Texas metros.



Definitions

Density
Urban regions house over 3,800 people per square mile
Sub-urban are home to 1,000 - 3,800 people
Rural areas have a density of 0 - 1000 people

Income
Regional Typical Household Income: $63,437

The H + T Index represents the affordability experience of the 2 million people of the Austin region using this method: "the Regional Typical Household assumes a household earning the median income for the region, with the average household size for the region, and the average number of commuters per household for the region."

CNT H+T Index

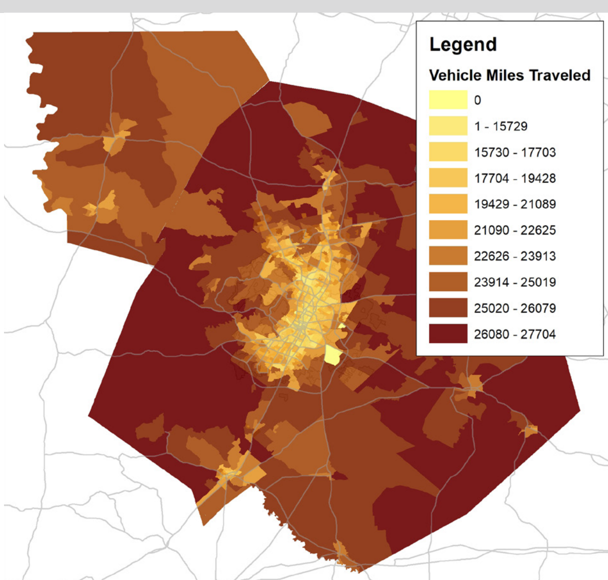
The data this report is based upon is readily available on-line for all to use.

All of the maps and data in this report are derived from the Center for Neighborhood Technology's Housing and Transportation Index project. We believe this index is perhaps one of the most important and underused tool available on the Internet for urban planning, transportation, affordability, and environmental policies in American metropolitan regions.

The map to the left, enlarged on the next page, is the housing + transportation affordability map of the Austin region. Accounting for transportation as well as housing costs presents a dramatically different picture than many of the predominant narratives about affordability. For example, the map reveals no truly affordable neighborhoods in Manor. Most affordable housing in the Austin region remains in the City of Austin, where location efficiency means dramatic reductions in transportation costs.

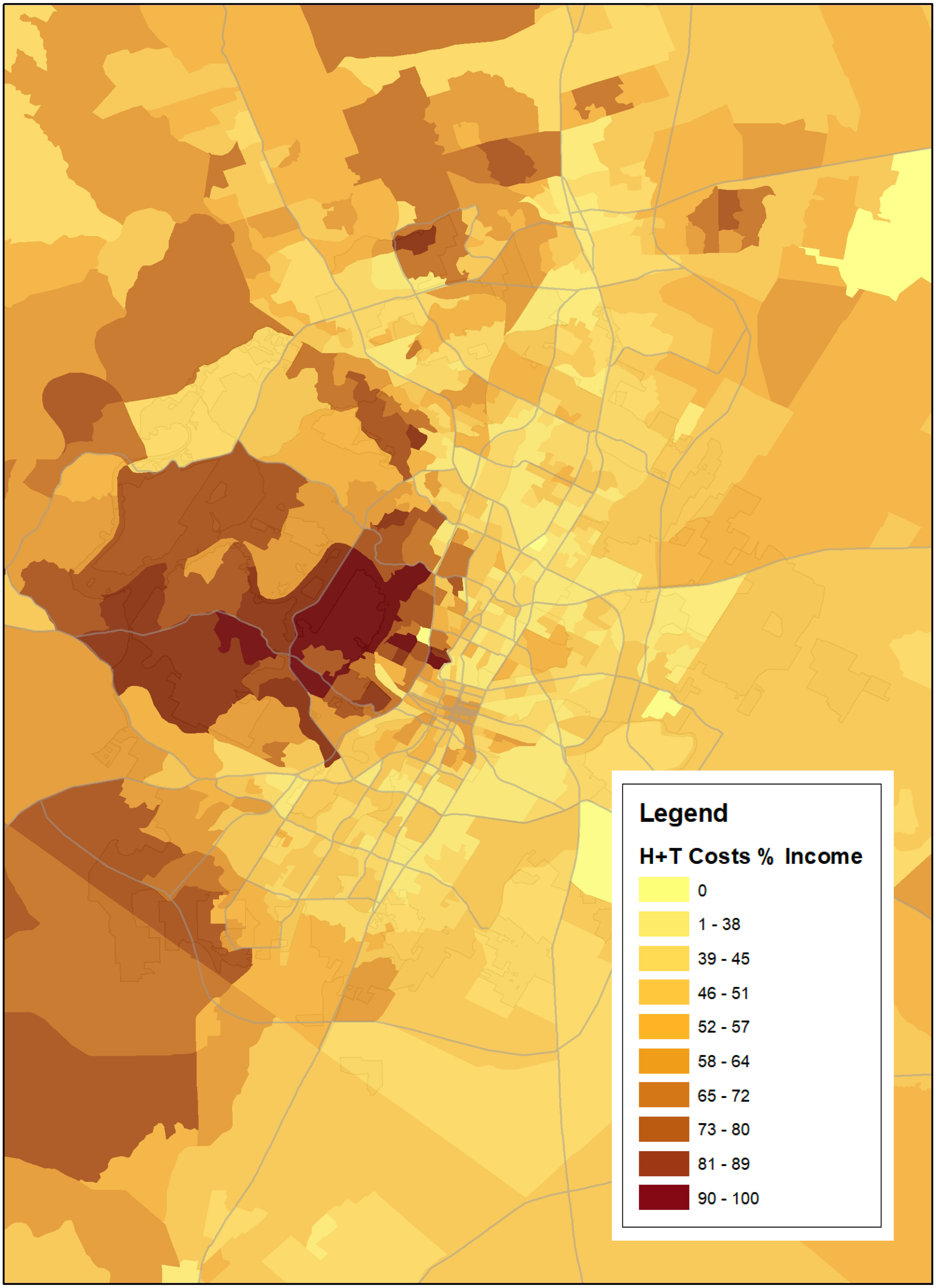
Location efficiency can and should be integrated in all housing and transportation-related public policies as well as private programs, such as websites related to realty and finding new housing. Regional growth policies such as CodeNEXT or the 2045 Regional Transportation Plan should fully integrate this view of affordability to give as many people as possible access to affordable housing options with better access.

Check out the CNT H+T Index yourself here: https://htaindex.cnt.org



The amount people drive is dictated by where they live. It accounts for more than our work commutes, which make up only 15% of total trips. If citizens can't walk to a park, to dinner, or to retail stores from their house, they make another trip in the car.

We can reduce this reliance on driving by improving location efficiency through optimized housing, planning, development, and transportation policy.


Legend
H+T Costs % Income
0
1 - 38
39 - 45
46 - 51
52 - 57
58 - 64
65 - 72
73 - 80
81 - 89
90 - 100

Location-Efficient Solutions

Meaningful affordability will require myriad wise policy choices. Here are some.

Austin is experiencing an affordability crisis. Debate over potential solutions rages at city hall, neighborhood association meetings, and throughout the city. We support the following strategies for regional decision makers to consider to help the people of Austin:

Location-efficient mortgages

As this report details, driving is expensive. Individual consumers feel the immediate financial impact, but the rest of society pays in congestion, reduced air quality, and the immeasurable suffering wrought by traffic injuries and fatalities, not to mention the heavy, and generally unaccounted for public costs.

Foregoing ownership of a single car allows Austinites to afford an estimated additional $100,000 of a mortgage. Explicit policies enabling location-efficient mortgages would allow greater choice in housing location, allowing families to get by with just one car, and to instead invest the fuel and perishable asset budget into housing equity.

Better Transit and More Transit Funding

People without cars still need to get around. People with cars deserve options for safe, multimodal transportation to reduce car trips. High-quality, frequent public transportation makes the city accessible and affordable to all, yet Texas radically limits its cities with poor transportation funding policies.

Allowing more people to live in the City of Austin through CodeNEXT

The region is projected to grow by 699,552 people over next 10 years. Who will be allowed to live in the city, and thus benefit from the affordable multimodal transportation options, is determined by zoning.

The current land use code allows 192,099 additional residents in the city's center; CodeNEXT Draft 3 increased this projection to 369,348. This is more closely examined in another of our Growing Weirder reports.

Funding affordable housing through Tax Increment Finance Zones

As suggested by the Austin nonprofit Community Not Commodity and Council Member Greg Casar, allocating increased tax revenue towards the establishment and maintenance of affordable housing could provide one targeted funding source for improvements. We are working on a TIF proposal to fund light rail on Guadalupe integrated with affordable housing.

Equitable Transit-Oriented Development

Transit-Oriented Development is recognition of the intersecting impacts of different aspects of land use. Our complementary report on an ETOD fund showcases the tremendous potential benefits of planning for equitable growth.

Growing Weirder is made possible by the generous contributions of these equitable sustainability focused entities:

GREATER AUSTIN NEIGHBORHOODS

Blazek & Vetterling | CERTIFIED PUBLIC ACCOUNTANTS

IMPACT HUB AUSTIN

MY BRILLIANT CITY

Growing Weirder

Understanding Austin's Growth and Potential

We can tell a new story of Texas metropolitan growth that empowers communities to engage in more productive conversations to build the future they want.

We can provide the analysis decision-makers and the public need to optimize our freedoms, our environment, and our quality of life. We can begin to shift our thinking to treat our growth as a shared responsibility and opportunity to complete our communities.

We intend to substantially impact the outcomes of City of Austin's CodeNEXT, Capital Area Metropolitan Planning Organization's Regional Transportation Plan, Capital Metro's Project Connect, City of Austin Strategic Mobility Plan, state legislation, and various related public processes, such as local budgets and bond proposals.

Displacement is real. Profit and abundance are real. Successful mixed-income, mixed-use community building is also real. We need to determine strategies and best practices that will minimize displacement, maximize affordable housing units in accessible and affordable locations, and achieve citizen priorities. The region's policy-makers and finance community need to learn the lexicon of location efficiency.

We need a holistic set of understandings of growth, best practices for equitable policy making, and synergistic transportation policies to produce true affordability.

Ultimately this work is intended to provide affordable access to a high quality of life to all the people of Austin.

We must measure our success by the ability of low income and disadvantaged people to live comfortably and access all the benefits of a modern city. We are trying to change the paradigm of growth, development, and transportation in their favor, but it will take time.

This report is part of a series of in-depth investigations on the various consequences of our major land use and transportation policy decisions. This is necessarily messy- our built environment impacts every aspect of how we live our lives in ways that aren't obvious and that we are only beginning to understand.

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The high impervious surface costs of Austin's current zoning scheme

February 8, 2018 Ashkan Jahangiri

In December, the City of Austin Watershed Department released a memo that looks at the impervious surface impacts of two alternatives: keeping current zoning or switching to the draft CodeNEXT V.2. They looked at the expected impervious surface in the full buildout scenario – meaning that every entitlement would be used up – something that never happens. But it provides a useful way to compare two plans for future growth.

And so far it seems most discussions of this memo completely miss the powerful findings.

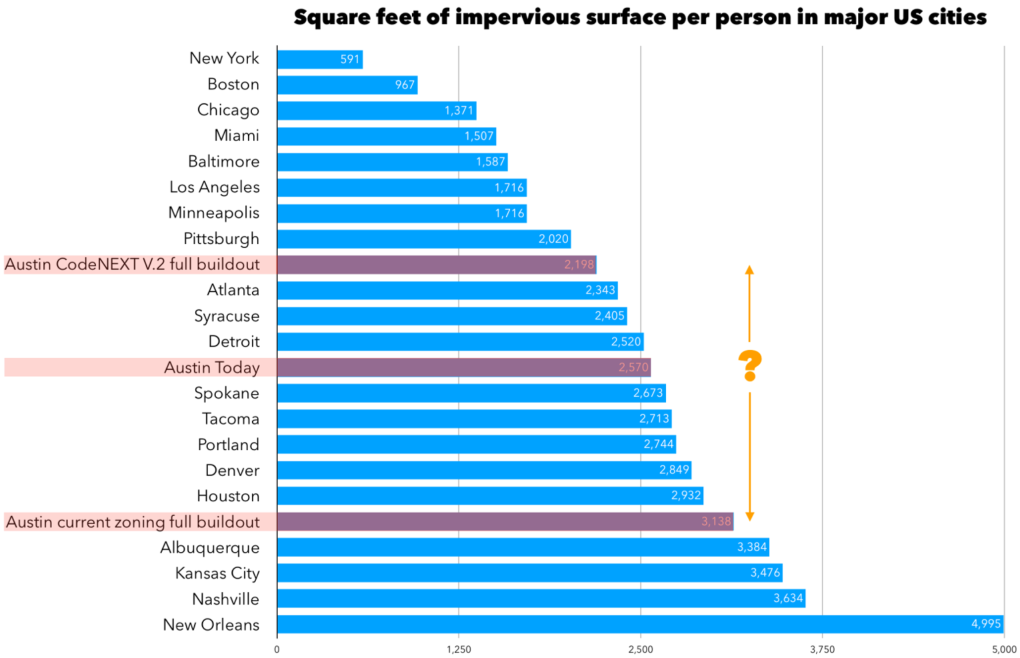
Their conclusion was that the proposed CodeNEXT V.2 was a slight improvement over current zoning, with about 1,200 less acres of land paved over in the city or about 1% of the city left open rather than paved, because of the change.

This is already a very strong rebuke of any claims that keeping the current zoning is good for flooding or environmentally friendly.

However, we can go further, because these two scenarios actually mean quite different things in terms of the numbers of people allowed to live in the City of Austin. Allowing more people to live in the City of Austin not only is the most significant step we can make to counter displacement, but also has a tremendous environmental advantage.

When we take the different future populations into account, we see that these two paths represent dramatically different future impervious surface per capita for the people of the City of Austin and the region. In these two scenarios, the CodeNEXT V.2 future would

mean each resident of the City of Austin were responsible for almost 1,000 less square feet of impervious surface, compared to the future we expect if we keep the current zoning scheme.



There are also regional impervious surface benefits of this shift just inside the City of Austin toward more sustainable compact, connected development. If a lot more people lived inside the City of Austin, thus not living the high impervious surface per capita lifestyle that most new housing in our region outside the city of Austin provides, the total regional effects would be dramatic. And these benefits are not captured in this current analysis. So we could similarly go further with this argument and intend to do so.

But this chart is already a very strong rebuke to anyone pretending to claim environmental or flooding or water quality (or heat island) reasons to argue against CodeNEXT in favor of keeping the current zoning code that has caused so many localized flooding problems for Austin.

Join us Friday, February 16 for the 3rd of 4 events in the Growing Weirder Breakfast Seriesto talk about this and other environmental sustainability issues related to regional growth, CodeNEXT, and the regional transportation plan. Get your tickets today.

About Post Author

Ashkan Jahangiri

See author's posts

for meaningful climate and air quality analysis of the proposal to fix I-35

[Archive] You have until March 7, 2023 at midnight to submit comments on I35. We made it easy.

2022: The year in Farm&City media hits

United States Environmental Protection Agency

EPA 231-R-06-001
January 2006
www.epa.gov/smartgrowth

Protecting Water Resources with Higher-Density Development

Office of Sustainable Communities
Smart Growth Program

Acknowledgements

The principal author, Lynn Richards, from the U.S. Environmental Protection Agency's Development, Community, and Environment Division, would like to recognize people who contributed insights and comments on this document as it was being developed: Chester Arnold, University of Connecticut—Non-Point Source Education for Municipal Officials; John Bailey, Smart Growth America; Deron Lovaas, Natural Resources Defense Council; Bill Matuszeski, formerly with EPA Chesapeake Bay Program; Philip Metzger, EPA Office of Water; Rosemary Monahan, EPA Region 1; Betsy Otto, American Rivers; Joe Persky, University of Illinois at Chicago; Milt Rhodes, formerly with the North Carolina Department of Environment and Natural Resources; and William Shuster, EPA Office of Research and Development. Additional recognition is extended to EPA staff from Office of Water (Robert Goo, Jamal Kadri, and Stacy Swartwood) as well as staff at EPA's Development, Community, and Environment Division (Geoffrey Anderson, Mary Kay Bailey, and Megan Susman).

To request additional copies of this report, contact EPA's National Service Center for Environmental Publications at 800-490-9198 or by email at [redacted] and ask for publication number 231-R-06-001.

To access this report online, visit <www.epa.gov/smartgrowth> or <www.smartgrowth.org>.

Front cover photos:

Left: The Snake River flows outside Jackson, Wyoming. Photo courtesy of USDA NRCS.
Top right: Rosslyn-Ballston Corridor, Arlington County, Virginia. Arlington County Department of Community Planning, Housing, and Development received a 2002 National Award for Smart Growth Achievement in the Overall Excellence category for its planning efforts in the Rosslyn-Ballston Corridor. Photo courtesy of Arlington County.
Middle right: People gather at Pioneer Square in Portland, Oregon. Photo courtesy of US EPA.

Back cover photos:

Top left: This hillside in Northern California is covered by wildflowers. This open space provides habitat to wildlife as well as serving important watershed services. Photo courtesy of USDA NRCS.
Middle left: A family enjoys open space in central Iowa. Photo courtesy of USDA NRCS.
Bottom left: A stream flows through western Maryland. Photo courtesy of USDA NRCS.
Right: This redevelopment site in Arlington, Virginia, which includes stores, apartments townhomes, single family homes, parking garages, and a one-acre public park, was formerly a large department store surrounded by surface parking. Photo courtesy of US EPA.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

Dear Colleague:

We are excited to share with you the enclosed report, *Protecting Water Resources with Higher-Density Development*. For most of EPA's 35-year history, policymakers have focused on regulatory and technological approaches to reducing pollution. These efforts have met with significant success. But, the environmental challenges of the 21st century require new solutions, and our approach to environmental protection must become more sophisticated. One approach is to partner with communities to provide them with the tools and information necessary to address current environmental challenges. It is our belief that good environmental information is necessary to make sound decisions. This report strives to meet that goal by providing fresh information and perspectives.

Our regions, cities, towns, and neighborhoods are growing. Every day, new buildings or houses are proposed, planned, and built. Local governments, working with planners, citizen groups, and developers, are thinking about where and how this new development can enhance existing neighborhoods and also protect the community's natural environment. They are identifying the characteristics of development that can build vibrant neighborhoods, rich in natural and historic assets, with jobs, housing, and amenities for all types of people. They are directing growth to maintain and improve the buildings and infrastructure in which they have already invested.

In addition to enjoying the many benefits of growth, communities are also grappling with growth's challenges, including development's impact on water resources. In the face of increasing challenges from non-point source pollution, local governments are looking for, and using, policies, tools, and information that enhance existing neighborhoods and protect water resources. This report gives communities a different perspective and set of information to address the complex interactions between development and water quality.

Protecting Water Resources with Higher-Density Development is intended for water quality professionals, communities, local governments, and state and regional planners who are grappling with protecting or enhancing their water resources while accommodating growing populations. We hope that you find this report informative as your community strives to enjoy the many benefits of growth and development and cleaner water.

For additional free copies, please send an e-mail to [redacted] or call (800) 490-9198 and request EPA publication 231-R-06-001. If you have any questions concerning this study, please do not hesitate to contact Lynn Richards at (202) 566-2858.

Sincerely,

Ben Grumbles
Assistant Administrator
Office of Water

Brian F. Mannix
Associate Administrator
Office of Policy, Economics, and Innovation

Protecting Water Resources with Higher-Density Development

Contents

Exhibits

Examples

Executive Summary

Growth and development expand communities' opportunities by bringing in new residents, businesses, and investments. Growth can give a community the resources to revitalize a downtown, refurbish a main street, build new schools, and develop vibrant places to live, work, shop, and play. However, with the benefits come challenges. The environmental impacts of development can make it more difficult for communities to protect their natural resources. Where and how communities accommodate growth has a profound impact on the quality of their streams, rivers, lakes, and beaches. Development that uses land efficiently and protects undisturbed natural lands allows a community to grow and still protect its water resources.

The U.S. Census Bureau projects that the U.S. population will grow by 50 million people, or approximately 18 percent, between 2000 and 2020. Many communities are asking where and how they can accommodate this growth while maintaining and improving their water resources. Some communities have interpreted water-quality research to mean that low-density development will best protect water resources. However, some water-quality experts argue that this strategy can backfire and actually harm water resources. Higher-density development, they believe, may be a better way to protect water resources. This study intends to help guide communities through this debate to better understand the impacts of high- and low-density development on water resources.

To more fully explore this issue, EPA modeled three scenarios of different densities at three scales—one-acre level, lot level, and watershed level—and at three different time series build-out examples to examine the premise that lower-density development is always better for water quality. EPA examined stormwater runoff from different development densities to determine the comparative difference between scenarios. This analysis demonstrated:

- The higher-density scenarios generate less stormwater runoff per house at all scales—one acre, lot, and watershed—and time series build-out examples;
- For the same amount of development, higher-density development produces less runoff and less impervious cover than low-density development; and
- For a given amount of growth, lower-density development impacts more of the watershed.

Taken together, these findings indicate that low-density development may not always be the preferred strategy for protecting water resources. Higher densities may better protect water quality—especially at the lot and watershed levels. To accommodate the same number of houses, denser developments consume less land than lower density developments. Consuming less land means creating less impervious cover in the watershed. EPA believes that increasing development densities is one strategy communities can use to minimize regional water quality impacts. To fully protect water resources, communities need to employ a wide range of land use strategies, based on local factors, including building a range of development densities, incorporating adequate open space, preserving critical ecological and buffer areas, and minimizing land disturbance.

Introduction

Growth and development expand communities' opportunities by bringing in new residents, businesses, and investments. Growth can give a community the resources to revitalize a downtown, refurbish a main street, build new schools, and develop vibrant places to live, work, shop, and play. However, with the benefits come challenges. The environmental impacts of development can make it more difficult for communities to protect their natural resources. Where and how communities accommodate growth has a profound impact on the quality of their streams, rivers, lakes, and beaches. Development that uses land efficiently and protects undisturbed natural lands allows a community to grow and still protect its water resources.

Which is a better strategy to protect water quality: low- or high-density development?

The U.S. Census Bureau projects that the U.S. population will grow by 50 million people, or approximately 18 percent, between 2000 and 2020. Many communities are asking where and how they can accommodate this growth while maintaining and improving their water resources. Some communities have interpreted water-quality research to mean that low-density development will best protect water resources. However, some water-quality experts argue that this strategy can backfire and actually harm water resources. Higher-density development, they believe, may be a better way to protect water resources. This study intends to help guide communities through this debate to better understand the impacts of high- and low-density development on water resources.

Virtually every metropolitan area in the United States has expanded substantially in land area in recent decades. According to the U.S. Department of Agriculture's National Resources Inventory (NRI), between 1954 and 1997, urban land area almost quadrupled, from 18.6 million acres to about 74 million acres in the contiguous 48 states (USDA, 1997b). From 1982 to 1997, when population in the contiguous United States grew by about 15 percent, developed land increased by 25 million acres, or 34 percent. Most of this growth is taking place at the edge of developed areas, on greenfield sites, which can include forestland, meadows, pasture, and rangeland (USDA, 1997a). Indeed, in one analysis of building permits in 22 metropolitan areas between 1989 and 1998, approximately 95 percent of building permits were on greenfield sites (Farris, 2001).

Between 1954 and 1997, urban land area almost quadrupled, from 18.6 million acres to about 74 million acres in the contiguous 48 states.

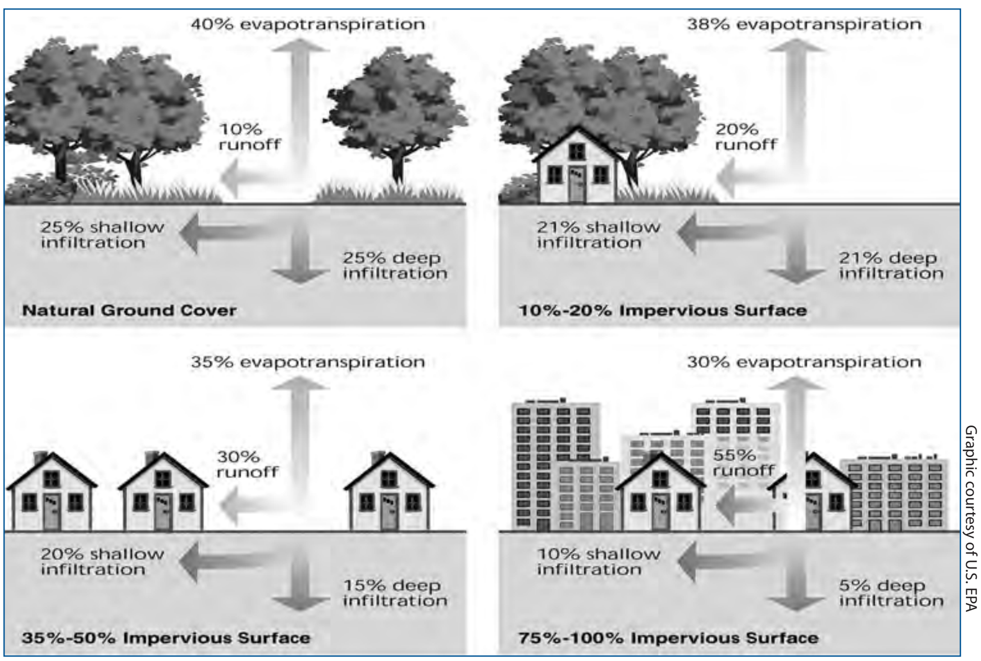
According to the American Housing Survey, 35 percent of new housing is built on lots between two and five acres, and the median lot size is just under one-half acre (Census, 2001). Local zoning may encourage building on relatively large lots, in part because local governments often believe that it helps protect their water quality. Indeed, research has revealed that more impervious cover can degrade water quality. Studies have demonstrated that at 10 percent imperviousness, a watershed is likely to become impaired and grows more so as imperviousness increases (Arnold, 1996; Schueler, 1994). This research has prompted many communities to adopt low-density zoning and site-level imperviousness limits, e.g., establishing a percentage of the site, such as 10 or 20 percent, that can be covered by impervious surfaces such as houses, garages, and driveways. These types of zoning and development ordinances are biased against higher-density development because it has more impervious cover. But do low-density approaches protect our water resources?

This study examines the assumption that low-density development is always better for water quality.[1] EPA modeled stormwater runoff from different development densities at the site level and then extrapolated and analyzed these findings at the watershed level. Modeling results were used to compare stormwater runoff associated with several variations of residential density.

Impacts from Development on Watershed Functions

A watershed is a land area that drains to a given body of water. Precipitation that falls in the watershed will either infiltrate into the ground, evapotranspirate back into the air, or run off into streams, lakes, or coastal waters. This dynamic is described in Exhibit 1.

EXHIBIT 1: Watershed Services



As land cover changes, so does the amount of precipitation that absorbs into the ground, evaporates into the air, or runs off.

A watershed may be large or small. The Mississippi River, for example, drains a one-million-square-mile watershed made up of thousands of smaller watersheds, such as the drainage basins of the creeks that flow into tributaries of the Mississippi. In smaller watersheds, a few acres of land may drain into small streams, which flow into larger streams or rivers; the lands drained by these streams or rivers make up a larger watershed. These streams support

[1] Stormwater runoff was used as a proxy for overall water quality. In general, the more stormwater runoff a region experiences, the more associated pollutants, such as total nitrogen, phosphorus, and suspended solids, will enter receiving waterbodies.

diverse aquatic communities and perform the vital ecological roles of processing the carbon, sediments, and nutrients upon which downstream ecosystems depend. Healthy, functioning watersheds naturally filter pollutants and moderate water quality by slowing surface runoff and increasing the infiltration of water into soil. The result is less flooding and soil erosion, cleaner water downstream, and greater ground water reserves.

Land development directly affects watershed functions. When development occurs in previously undeveloped areas, the resulting alterations to the land can dramatically change how water is transported and stored. Residential and commercial development create impervious surfaces and compacted soils that filter less water, which increases surface runoff and decreases ground water infiltration. These changes can increase the volume and velocity of runoff, the frequency and severity of flooding, and peak storm flows.

Moreover, during construction, exposed sediments and construction materials can be washed into storm drains or directly into nearby bodies of water. After construction, development usually replaces native meadows, forested areas, and other natural landscape features with compacted lawns, pavement, and rooftops. These largely impervious surfaces generate substantial runoff. For these reasons, limiting or minimizing the amount of land disturbed and impervious cover created during development can help protect water quality.

Critical Land Use Components for Protecting Water Quality for Both Low- and High-Density Development

What strategies can communities use to continue to grow while protecting their water quality? Watershed hydrology suggests that three primary land use strategies can help to ensure adequate water resource protection:

- Preserve large, continuous areas of absorbent open space;
- Preserve critical ecological areas, such as wetlands, floodplains, and riparian corridors; and
- Minimize overall land disturbance and impervious surface associated with development.

These approaches work because, from a watershed perspective, different land areas have different levels of ecological value. For example, a nutrient-rich floodplain has a higher ecological value than a grass meadow. Communities should view these strategies as basic steps to preserve watershed function and as the framework within which all development occurs.

Preserving Open Space

Preserving open space is critical to maintaining water quality at the regional level. Large, continuous areas of open space reduce and slow runoff, absorb sediments, serve as flood control, and help maintain aquatic communities. To ensure well-functioning watersheds, regions should set aside sufficient amounts of undisturbed, open space to absorb, filter, and store rainwater. In most regions, this undeveloped land comprises large portions of a watershed, filtering out trash, debris, and chemical pollutants before they enter a community's water system. Open space provides other benefits, including habitat for plants and animals, recreational opportunities, forest and ranch land, places of natural beauty, and community recreation areas.

To protect these benefits, some communities are preserving undeveloped parcels or regional swaths of open space. One of the most dramatic examples is the New York City Watershed Agreement. New York City, New York State, over 70 towns, eight counties, and EPA signed the agreement to support an enhanced watershed protection program for the New York City drinking water supply. The city-funded, multi-year, $1.4-billion agreement developed a multi-faceted land conservation approach, which includes the purchase of 80,000 acres within the watershed as a buffer around the city's drinking water supply. This plan allows the city to avoid the construction of filtration facilities estimated to cost six to eight billion dollars (New York City, 2002).

Preserving Ecologically Sensitive Areas

Some types of land perform watershed functions better than others do. Preserving ecologically important land, such as wetlands, buffer zones, riparian corridors, and floodplains, is critical for regional water quality. Wetlands are natural filtration plants, slowing water flow and allowing sediments to settle and the water to clarify. Trace metals bound to clay carried in runoff also drop out and become sequestered in the soils and peat at the bed of the marsh instead of entering waterbodies, such as streams, lakes, or rivers. Preserving and maintaining wetlands are critical to maintain water quality.

Photo courtesy of USDA NRCS

Wetlands, such as this one in Butte County, California, provide critical watershed services for the region.

In addition, strips of vegetation along streams and around reservoirs are important buffers, with wooded buffers offering the greatest protection. For example, if soil conditions are right, a 20- to 30-foot-wide strip of woodland removes 90 percent of the nitrates in stormwater runoff (Trust for Public Land, 1997). These buffer zones decrease the amount of pollution entering the water system. Tree and shrub roots hold the bank in place, preventing erosion and its resulting sedimentation and turbidity. Organic matter and grasses slow the flow of runoff, giving the sediment time to settle and water time to percolate, filter through the soil, and recharge underlying ground water. Research has shown that wetlands and buffer zones, by slowing and holding water, increase ground water recharge, which directly reduces the potential for flooding (Schueler, 1994). By identifying and preserving these critical ecological areas, communities are actively protecting and enhancing their water quality.

Minimizing Land Disturbance and Impervious Cover

Minimizing land disturbance and impervious cover is critical to maintaining watershed health. The amount of land that is converted, or "disturbed," from undeveloped uses, such as forests and meadows, to developed uses, such as lawns and playing fields, significantly affects watershed health. Research now shows that the volume of runoff from highly compacted lawns is almost as high as from paved surfaces (Schueler, 1995, 2000; USDA, 2001). This research indicates that lawns and other residential landscape features do not function, with regard to water, in the same way as nondegraded natural areas. In part, the difference arises because developing land in greenfield areas involves wholesale grading of the site and removal of topsoil, which can lead to severe erosion during construction, and soil compaction by heavy equipment. However, most communities focus not on total land disturbed, but on the amount of impervious cover created.

Photo courtesy of USDA NRCS

Current construction practices generally disturb the entire development site, as shown by this site in Des Moines, Iowa.

Research has revealed a strong relationship between impervious cover and water quality (Arnold, 1996; Schueler, 1994; EPA, 1997). Impervious surfaces collect and accumulate pollutants deposited from the atmosphere, leaked from vehicles, or derived from other sources. During storms, accumulated pollutants are quickly washed off and rapidly delivered to aquatic systems. Studies have demonstrated that at 10 percent imperviousness,[2] a watershed is likely to become impaired (Schueler, 1996; Caraco, 1998; Montgomery County, 2000), the stream channel becomes unstable due to increased water volumes and stream bank erosion, and water quality and stream biodiversity decrease. At 25 percent imperviousness, a watershed becomes severely impaired, the stream channel can become highly unstable, and water quality and stream biodiversity are poor[3] (Schueler, 2000). The amount of impervious cover is an important indicator of watershed health, and managing the degree to which a watershed is developed is critical to maintaining watershed function.

Although the 10 percent threshold refers to overall imperviousness within the watershed, municipalities have applied it to individual sites within the watershed, believing that lower densities better protect watershed functions. Indeed, as mentioned earlier, some localities have gone so far as to create strong incentives for, or even require, low densities—with water resource protection as an explicit goal. These communities are attempting to minimize hard

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[2] The 10 percent figure is not an absolute threshold. Recent studies have indicated that in some watersheds, serious degradation may begin well below 10 percent. However, the level at which watershed degradation begins is not the focus of this study. For purposes of our analysis, EPA uses the 10 percent threshold as an indicator that water resources might be impacted.

[3] There are different levels of impairment. In general, when the term is used in EPA publications, it usually means that a waterbody is not meeting its designated water quality standard. However, the term can also imply a decline or absence of biological integrity; for example, the waterbody can no longer sustain critical indicator species, such as trout or salmon. Further, there is a wide breadth of levels of impairment, from waterbodies that are unable to support endangered species to waterbodies that cannot support any of the beneficial-use designations.

surfaces at the site level. They believe that limiting densities within particular development sites limits regional imperviousness and thus protects regional water quality. The next section examines this proposition and finds that low-density development can, in fact, harm water quality.

Low-Density Development—Critiquing Conventional Wisdom

As discussed, studies have demonstrated that watersheds can suffer impairment at 10 percent impervious cover and that at 25 percent imperviousness, the watershed is typically considered severely impaired. Communities have often translated these findings into the notion that low-density development at the site level results in better water quality. Such conclusions often come from analysis such as: a one-acre site has one or two homes with a driveway and a road passing by the property. The remainder of the site is lawn. Assuming an average housing footprint of 2,265 square feet[4] (National Association of Home Builders, 2001), the impervious cover for this one-acre site is approximately 35 percent (Soil Conservation Service, 1986). By contrast, a higher-density scenario might have eight to 10 homes per acre and upwards of 85 percent impervious cover (Soil Conservation Service, 1986). The houses' footprints account for most of the impervious cover. Thus, low-density zoning appears to create less impervious cover, which ought to protect water quality at the site and regional levels. However, this logic overlooks several key caveats.

1. *The "pervious" surface left in low-density development often acts like impervious surface.* In general, impervious surfaces, such as a structure's footprint, driveways, and roads, have higher amounts of runoff and associated pollutants than pervious surfaces. However, most lawns, though pervious, still contribute to runoff because they are compacted. Lawns are thought to provide "open space" for infiltration of water. However, because of construction practices, the soil becomes compacted by heavy equipment and filling of depressions (Schueler, 1995, 2000). The effects of this compaction can remain for years and even increase due to mowing and the presence of a dense mat of roots. Therefore, a one- or two-acre lawn does not offer the same infiltration or other water quality functions as a one- or two-acre undisturbed forest. Minimizing impervious surfaces by limiting the number of houses but allowing larger lawns does not compensate for the loss of watershed services that the area provided before development (USDA, 2001).

   Lawns still contribute to runoff because they are compacted and disturbed.

2. *Density and imperviousness are not equivalent.* Depending on the design, two houses may actually create as much imperviousness as four houses. The impervious area per home can vary widely due to road infrastructure, housing design (single story or multistory), or length and width of driveways. To illustrate, a three-story condominium building of 10 units on one acre can have less impervious surface than four single-family homes on the same acre. Furthermore, treatment of the remaining undeveloped land on that acre can

[4] The average house built in 2001 included three or more bedrooms, two and a half baths, and a two-car garage.

vary dramatically between housing types. For example, in some dispersed, low-density communities, such as Fairfax County, Virginia, some homeowners are paving their front lawns to create more parking for their cars (Rein, 2002).

3. *Low-density developments often mean more off-site impervious infrastructure.* Development in the watershed is not simply the sum of the sites within it. Rather, total impervious area in a watershed is the sum of site developments plus the impervious surface associated with infrastructure supporting those sites, such as roads and parking lots. Lower-density development can require substantially higher amounts of this infrastructure per house and per acre than denser developments. Recent research has demonstrated that on sites with two homes per acre, impervious surfaces attributed to streets, driveways, and parking lots can represent upwards of 75 percent of the total site imperviousness (Cappiella, 2001). That number decreases to 56 percent on sites with eight homes per acre. This research indicates that low densities often require more off-site transportation-related impervious infrastructure, which is generally not included when calculating impervious cover.

Water quality suffers not only from the increase in impervious surface, but also from the associated activities: construction, increased travel to and from the development, and extension of infrastructure.

   Furthermore, water quality suffers not only from the increase in impervious surface, but also from the associated activities: construction, increased travel to and from the development, extension of infrastructure, and chemical maintenance of the areas in and surrounding the development. Oil and other waste products, such as heavy metals, from motor vehicles, lawn fertilizers, and other common solvents, combined with the increased flow of runoff, contribute substantially to water pollution. As imperviousness increases, so do associated activities, thereby increasing the impact on water quality.

4. *If growth is coming to the region, limiting density on a given site does not eliminate that growth*. Density limits constrain the amount of development on a site but have little effect on the region's total growth (Pendall, 1999, 2000). The rest of the growth that was going to come to the region still comes, regardless of density limits in a particular place. Forecasting future population growth is a standard task for metropolitan planning organizations as they plan where and how to accommodate growth in their region. They project future population growth based on standard regional population modeling practices, where wage or amenity differentials, such as climate or culture (Mills, 1994)—and not zoning practices such as density limits—account for most of a metropolitan area's population gain or loss.[5] While estimates of future growth within a particular time frame are rarely precise, a region must use a fixed amount of growth to test the effects of adopting

Growth is still coming to a region, regardless of density limits in a particular place.

[5] The most widely-used such model—the REMI® Policy Insight™ model—uses an amenity variable. However, even this is implemented as an additional change in the wage rate. See Remi Model Structure. <www.remi.com/Overview/Evaluation/Structure/structure.html>. The in-house model used by the San Diego Association of Governments is an advanced example of the type used by councils of governments around the country.<www.sandag.cog.ca.us/resources/demographics_and_other_data/demographics/forecasts/index.asp>.

different growth planning strategies because it still must understand the economic, social, and environmental impacts of accommodating a growing population. Absent regional coordination and planning, covering a large part of a region with density limits will likely drive growth to other parts of the region. Depending on local conditions, water quality may be more severely impaired than if the growth had been accommodated at higher densities on fewer sites.

Testing the Alternative: Can Compact Development Minimize Regional Water Quality Impacts?

To more fully understand the potential water quality impacts of different density levels, this section compares three hypothetical communities, each accommodating development at different densities—one house per acre, four houses per acre, and eight houses per acre.[6] To assess regional water quality impacts, EPA modeled the stormwater impacts from different development densities. In general, the more stormwater runoff generated within a region, the more associated pollutants, such as total nitrogen, phosphorus, and suspended solids, will enter receiving waterbodies. The three density levels capture some of the wide range of zoning practices in use throughout the country. All of these densities are consistent with single-family, detached housing. EPA examined the stormwater impacts from each density scenario at various scales of residential development[7]—one-acre, lot, and watershed levels—and through a 40-year time series build-out analysis.

The Model and Data Inputs

The model used to compare the stormwater impact from the scenarios is the Smart Growth Water Assessment Tool for Estimating Runoff (SG WATER), which is a peer-reviewed sketch model that was developed specifically to compare water quantity and quality differences among different development patterns (EPA, 2002). SG WATER's methodology is based on the Natural Resources Conservation Service (NRCS) curve numbers (Soil Conservation Service, 1986), event mean concentrations, and daily rainfall data.[8] The model requires the total number of acres developed at a certain development density. If density is unknown, total percent imperviousness can be used. The model was run using overall percent imperviousness.

EPA believes that the results presented here are conservative. SG WATER uses a general and simple methodology based on curve numbers. One limitation of curve numbers is that they tend to underestimate stormwater runoff for smaller storms (less than one inch). This underestimate

[6] Densities at one, four, and eight residential units per acre are used here for illustrative purposes only. Many communities now are zoning for one unit per two acres at the low-density end of the spectrum. Low-density residential zoning exists in places as diverse as Franklin County, Ohio, which requires no less than two acres per unit <www.co.franklin.oh.us/development/franklin_co/LDR.html#304.041>) to Cobb County, Georgia, outside of Atlanta, which requires between one and two units per acre in its low-density residential districts (<www.cobb-county.org/community/plan_bza_commission.htm>). By comparison, some communities are beginning to allow higher densities, upwards of 20 units per acre. For example, the high-density residential district in Sonoma County, California permits between 12 and 20 units per acre (<www.sonoma-county.org/prmd/Zoning/article_24.htm>), and the city of Raleigh, North Carolina, allows up to 40 units per acre in planned development districts.

[7] This example and others throughout this study compare residential units, but a similar comparison including commercial development could also be done .

[8] Daily time-step rainfall data for a 10-year period (1992-2001, inclusive) were used.

can be significant since the majority of storms are small storms. In addition, the curve numbers tend to overestimate runoff for large storms. However, curve numbers more accurately predict runoff in areas with more impervious cover.[9] For the analysis here, the runoff from the low-density site is underestimated to a larger degree than the runoff from the higher-density site because the higher-density site has more impervious cover. Simply put, because of methodology, the difference in the numbers presented here is conservative—it is likely that the comparative difference in runoff between the sites would be greater if more extensive modeling were used.

To isolate the impacts that developing at different densities makes on stormwater runoff, EPA made several simplifying assumptions in the modeling:

- EPA modeled only residential growth and not any of the corresponding commercial, retail, or industrial growth that would occur in addition to home building. Moreover, EPA assumed that all the new growth would occur in greenfields (previously undeveloped land). Infill development, brownfield redevelopment, and other types of urban development were not taken into consideration, nor were multifamily housing, apartments, or accessory dwelling units.[10]
- The modeling did not take into account any secondary or tertiary impacts, such as additional stormwater benefits, that may be realized by appropriately locating the development within the watershed. For example, siting development away from headwaters, recharge areas, or riparian corridors could better protect these sensitive areas. Denser development makes this type of protective siting easier since less land is developed. However, these impacts are not captured or calculated within the modeling.
- Whether developed at one, four, or eight houses per acre, when one acre is developed, EPA assumed the entire acre is disturbed land (e.g., no forest or meadow cover would be preserved), which is consistent with current construction practices.
- All the new growth is assumed to be single-family, detached houses.[11] Whether developed at one, four, or eight houses per acre, each home has a footprint of 2,265 square feet, roughly the current average size for new houses (National Association of Home Builders, 2001).

[9] Most existing stormwater models incorrectly predict flows associated with small rains in urban areas. Most existing urban runoff models originated from drainage and flooding evaluation procedures that emphasized very large rains (several inches in depth). These large storms contribute only very small portions of the annual average discharges. Moderate storms, occurring several times a year, are responsible for the majority of the pollutant discharges. These frequent discharges cause mostly chronic effects, such as contaminated sediment and frequent high flow rates, and the inter-event periods are not long enough to allow the receiving water conditions to recover.

[10] Single-family, detached housing dominates many low-density residential developments. However, higher-density developments support a range of housing types, including townhouses, apartments, and other forms of multifamily housing. These housing types generally have a smaller footprint per house than 2,265 square feet. Therefore, a more realistic situation for the higher-density scenarios would either be a smaller housing footprint or an increase in the number of homes accommodated on one acre. In either case, including these different housing types in the analysis would produce less overall stormwater runoff and less per house runoff for the higher-density scenarios.

[11] It is possible that when additional land uses, such as commercial, transportation, or recreation, are included in the analysis, the low-density scenarios become relatively less dense while the higher-density scenarios become relatively more dense. In general, low-density residential development tends to be associated with low-density commercial development, characterized by large retail spaces, wide roads, large parking lots, and minimal public transportation. Higher-density residential areas are more likely to have high-density commercial options, with smaller retail spaces, mixed land uses, narrower streets, parking garages, on-street parking, and sometimes a well-developed public transportation system, which can reduce parking needs.

- The same percentage of transportation-associated infrastructure, such as roads, parking lots, driveways, and sidewalks, is allocated to each community acre, based on the curve number methodology from the NRCS. For example, each scenario has the same width of road, but because the higher-density scenario is more compact, it requires fewer miles of roads than the lower-density scenarios. So while the same percentage is applied, the amounts differ by scenario. Collector roads or arterials that serve the development are not included.
- The modeled stormwater runoff quantity for each scenario is assumed to come from one hypothetical outfall.
- The model does not take into account wastewater or drinking water infrastructure, slope, or other hydrological interactions that the more complex water modeling tools use.

Summary of Scenarios

Example 1 examines the stormwater runoff impacts on a one-acre lot that accommodates one house (Scenario A), four houses (Scenario B), or eight houses (Scenario C). Example 2 expands the analysis to examine stormwater runoff impacts within a lot-level development that accommodates the same number of houses. Because of different development densities, this growth requires different amounts of land. Scenario A requires eight acres for eight houses, Scenario B requires two acres for eight houses, and Scenario C requires one acre for eight houses.

Examples 3, 4, and 5 explore the relationship between density and land consumption by building in a watershed at different densities. Again, different amounts of land are required to support the same amount of housing. Examples 6, 7, and 8 examine how the hypothetical community grows over a 40-year timeframe with different development densities.

The scenarios and scales of development are summarized in Exhibit 2. EPA expects to capture the differences in stormwater runoff associated with different development densities by using these three scenarios (Scenarios A, B, and C) at four different scales (one acre, lot, watershed, and build-out).

EXHIBIT 2: Summary of Scenarios

Scale of Analysis	Scenario A: One house per acre	Scenario B: Four houses per acre	Scenario C: Eight houses per acre
Example 1: One acre	1 house per acre	4 houses per acre	8 houses per acre
Example 2: Lot—Each development lot accommodates the same number of houses	8 houses built on 8 acres	8 houses built on 2 acres	8 houses built on 1 acre

Example 3: Watershed—Each 10,000-acre watershed accommodates the same number of houses	10,000 houses built on 10,000 acres	10,000 houses built on 2,500 acres or ¼ of the watershed	10,000 houses built on 1,250 acres or ⅛ of the watershed
Example 4: Watershed—Each 10,000-acre watershed is fully built out at different densities	10,000 houses built on 10,000 acres	40,000 houses built on 10,000 acres	80,000 houses built on 10,000 acres
Example 5: Watershed—Each scenario accommodates the same number of houses	80,000 houses consume 8 watersheds	80,000 houses consume 2 watersheds	80,000 houses consume 1 watershed
Example 6: Hypothetical build-out in the year 2000	10,000 houses built on 10,000 acres	10,000 houses built on 2,500 acres	10,000 houses built on 1,250 acres
Example 7: Hypothetical build-out in the year 2020	20,000 houses built on 20,000 acres, or 2 watersheds	20,000 houses built on 5,000 acres, or ½ of 1 watershed	20,000 houses built on 2,500 acres, or ¼ of 1 watershed
Example 8: Hypothetical build-out in the year 2040	40,000 houses built on 40,000 acres, or 4 watersheds	40,000 houses built on 10,000 acres, or 1 watershed	40,000 houses built on 5,000 acres, or ½ of 1 watershed

Before analyzing the impacts of these different scenarios, it is useful to clarify some underlying premises. This analysis assumes that:

1. Metropolitan regions will continue to grow. This assumption is consistent with U.S. Census Bureau projections that the U.S. population will grow by roughly 50 million people by 2020 (Census, 2000). Given this projected population growth, most communities across the country are or will be determining where and how to accommodate expected population increases in their regions.

2. Housing density affects the distribution of new growth within a given region, not the amount of growth. Individual states and regions grow at different rates depending on a variety of factors, including macroeconomic trends (e.g., the technology boom in the 1980s spurring development in the Silicon Valley region in California) and demographic shifts. Distribution and density of new development do not significantly affect these factors.

3. The model focuses on the comparative differences in stormwater runoff between scenarios, not absolute values. As discussed, using the curve number and event mean concentration approach can underestimate the total quantity of stormwater runoff for smaller storm events and in areas of lower densities. Because of this and other model simplifications discussed above, the analysis does not focus on the absolute value of stormwater runoff generated for each scenario but instead focuses on the comparative difference, or the delta, in runoff between scenarios.

Results

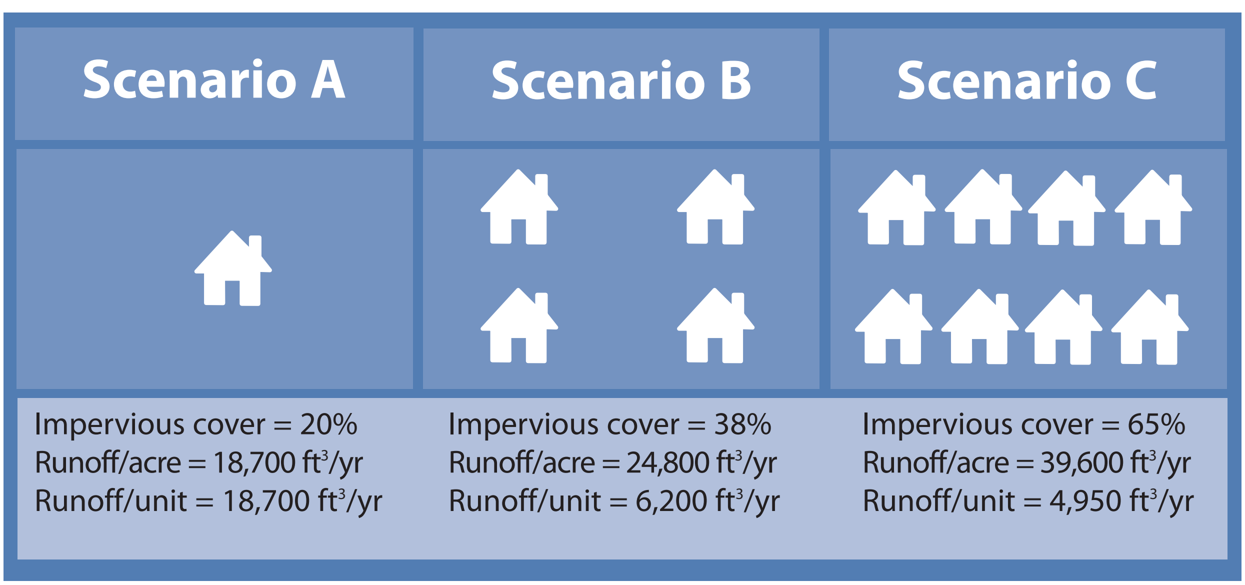
The results from the eight examples for all three scenarios are presented below.

Example 1: One-Acre Level

Scale of Analysis	Scenario A	Scenario B	Scenario C
One Acre	1 house	4 houses	8 houses

EPA examined one acre developed at three different densities: one house, four houses, and eight houses. The results are presented in Exhibit 3. As Exhibit 3 demonstrates, the overall percent imperviousness for Scenario A is approximately 20 percent with one house per acre, 38 percent for Scenario B with four houses per acre, and 65 percent for Scenario C with eight houses per acre (Soil Conservation Service, 1986).

EXHIBIT 3: Total Average Annual Stormwater Runoff for All Scenarios



Examining the estimated average annual runoff at the acre level, as illustrated in Exhibit 4, the low-density Scenario A, with just one house, produces an average runoff volume of 18,700 cubic feet per year (ft^3/yr). Scenario C, with eight houses, produces 39,600 ft^3/yr, and Scenario B falls between Scenarios A and C at 24,800 ft^3/yr. In short, looking at the comparative differences between scenarios, runoff roughly doubles as the number of houses increases from one house per acre to eight houses per acre. Scenario C, with more houses on the acre, has the greatest amount of impervious surface cover and thus generates the most runoff at the acre level.

Looking at the comparative difference of how much runoff each individual house produces, in Scenario A, one house yields 18,700 ft^3/yr, the same as the per acre level. In the denser Scenario C, however, each house produces 4,950 ft^3/yr average runoff. The middle scenario, Scenario B, produces considerably less runoff—6,200 ft^3/yr—per house than Scenario A, but more than Scenario C. Each house in Scenario B produces approximately 67 percent less runoff than a house in Scenario A, and each house in Scenario C produces 74 percent less runoff than a house in Scenario A. This is because the houses in Scenarios B and C create less impervious surface per house than the house in Scenario A. Therefore, per house, each home in the higher-density communities results in less stormwater runoff.

Each house in Scenario B produces approximately 67 percent less runoff than a house in Scenario A, and each house in Scenario C produces 74 percent less runoff than a house in Scenario A.

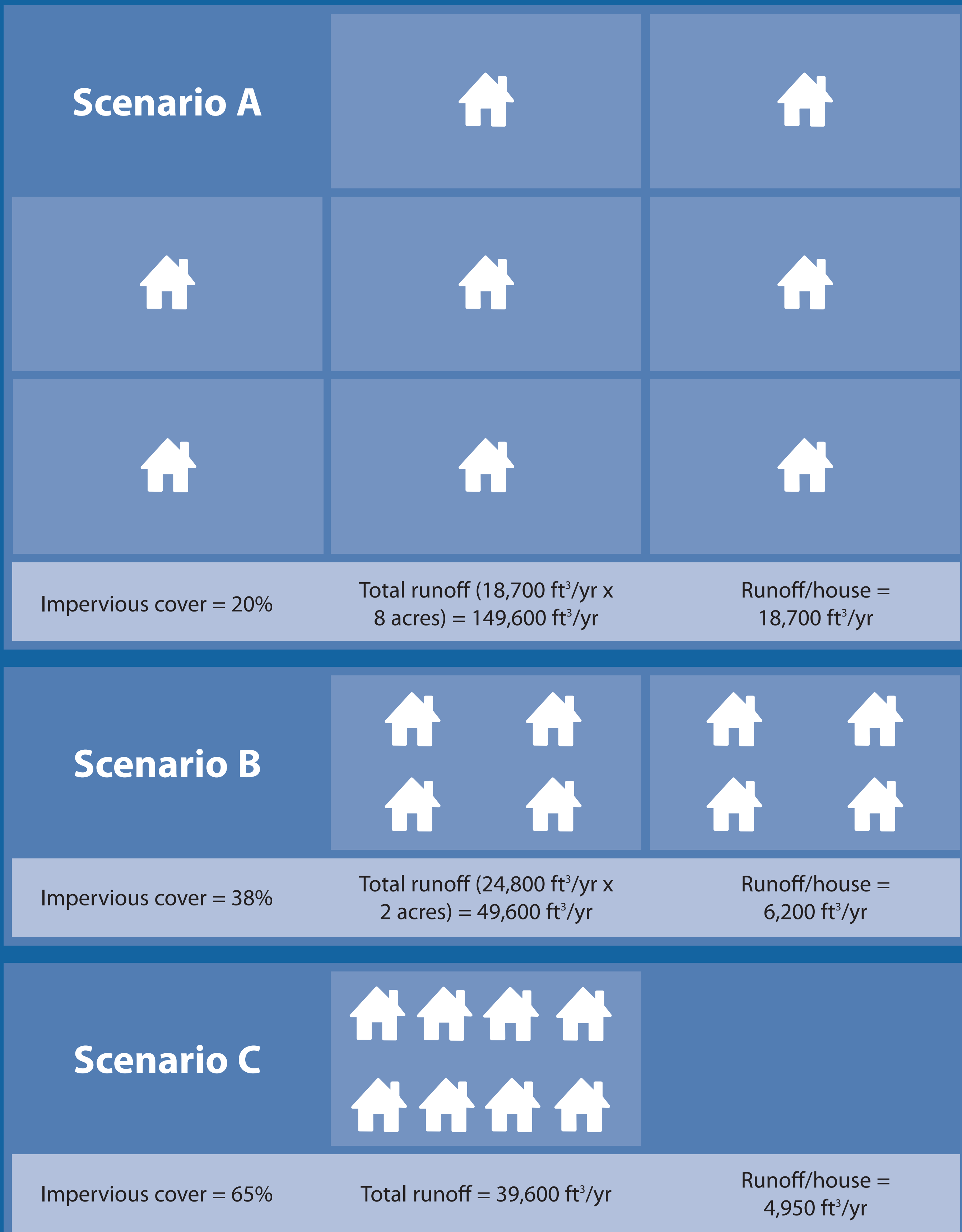
Modeling at the acre level demonstrates that, in this example, when density is quadrupled (from one house to four houses), stormwater runoff increases by one-third per acre, but decreases by two-thirds per house. Moreover, when density increases by a factor of eight—from one house to eight houses—stormwater runoff doubles per acre, but decreases by almost three-quarters per house.

These results indicate when runoff is measured by the acre, limiting density does minimize water quality impacts compared to the higher-density scenarios. However, when measured by the house, higher densities produce less stormwater runoff.

Example 2: Lot Level

Scale of Analysis	Scenario A	Scenario B	Scenario C
Lot	8 houses built on 8 acres	8 houses built on 2 acres	8 houses built on 1 acre

EXHIBIT 4: Each Scenario Accommodates Eight Houses



For each development to accommodate the same number of houses, the lower-density scenarios require more land to accommodate the same number of houses that Scenario C has accommodated on one acre. Specifically, Scenario A must develop seven additional acres, or eight acres total, to accommodate the same number of houses as Scenario C. Scenario B must develop two acres to accommodate the same number of houses. Exhibit 4 illustrates.

The increase in runoff for Scenario A is due to the additional land consumption.

With each scenario accommodating the same number of houses, this analysis shows that total average runoff in Scenario A is 149,600 ft^3/yr (18,700 ft^3/yr x 8 acres), which is a 278 percent increase from the 39,600 ft^3/yr total runoff in Scenario C. Total average runoff from eight houses in Scenario B is 49,600 ft^3/yr (24,800 ft^3/yr x 2 acres), which is a 25 percent increase in runoff from Scenario C. The increase in runoff for Scenario A is due to the additional land consumption and associated runoff. The impervious cover for Scenario A remains the same at 20 percent, but now, seven additional acres have 20 percent impervious cover.

Examining the comparative difference in runoff between scenarios shows that lower densities can create less total impervious cover, but produce more runoff when the number of houses is kept consistent between scenarios. Furthermore, the higher-density scenario produces less runoff per house and per lot.

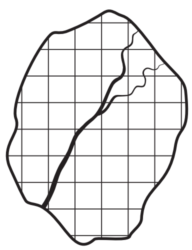
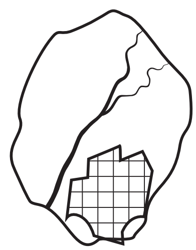
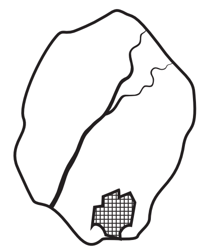
Example 3: Watershed Level

Scale of Analysis	Scenario A	Scenario B	Scenario C
Watershed—Each 10,000-acre watershed accommodates the same number of houses	10,000 houses built on 10,000 acres	10,000 houses built on 2,500 acres	10,000 houses built on 1,250 acres

Taking the analysis to the watershed level, EPA examined the comparative watershed stormwater runoff impacts from accommodating growth at different densities. The watershed used in this analysis is a hypothetical 10,000-acre watershed accommodating only houses. As discussed, the modeling does not include retail, business centers, farms, or any other land uses typically seen in communities, nor does it take into consideration where the development occurs within the watershed. Research has shown that upper sub-watersheds, which contain smaller streams, are generally more sensitive to development than lower sub-watersheds (Center for Watershed Protection, 2001).

Accommodating 10,000 houses at one house per acre in the 10,000-acre watershed would fully build out the watershed. At the higher density of four houses per acre, one-quarter of the watershed would be developed, and at eight houses per acre, one-eighth of the watershed would be developed. Exhibit 5 shows the runoff associated with each of these scenarios.

EXHIBIT 5: 10,000-Acre Watershed Accommodating 10,000 Houses

Scenario A	Scenario B	Scenario C
		
10,000 houses built on 10,000 acres produce:	10,000 houses built on 2,500 acres produce:	10,000 houses built on 1,250 acres produce:
10,000 acres x 1 house x 18,700 ft^3/yr of runoff =	2,500 acres x 4 houses x 6,200 ft^3/yr of runoff =	1,250 acres x 8 houses x 4,950 ft^3/yr of runoff =
187 million ft^3/yr of stormwater runoff	**62 million ft^3/yr of stormwater runoff**	**49.5 million ft^3/yr of stormwater runoff**
Site: 20% impervious cover	**Site: 38% impervious cover**	**Site: 65% impervious cover**
Watershed: 20% impervious cover	**Watershed: 9.5% impervious cover**	**Watershed: 8.1% impervious cover**

As Exhibit 5 illustrates, if development occurs at a lower density, e.g., one house per acre, the entire watershed will be built out, generating 187 million ft^3/yr of stormwater runoff. Scenario B, at four houses per acre, consumes less land and produces approximately 62 million ft^3/yr of stormwater runoff, while Scenario C, at the highest density, consumes the least amount of land and produces just 49.5 million ft^3/yr of stormwater runoff. Looking at the comparative differences, Scenario A generates approximately three times as much runoff from development as Scenario B, and approximately four times as much stormwater runoff as Scenario C.

Exhibit 5 also illustrates that, in this example, overall impervious cover for the watershed decreases as site density increases. Scenario C, which has a lot-level imperviousness of 65 percent, has a watershed-level imperviousness of only 8.1 percent, which is lower than the 10

Overall impervious cover for the watershed decreases as site density increases.

percent threshold discussed earlier. Scenario B, with a density of four houses per acre, has a site-level impervious cover of 38 percent, but a watershed imperviousness of 9.5 percent, which is still lower than the 10 percent threshold. Finally, Scenario A, at a lot-level imperviousness of 20 percent, has the same overall imperviousness at the watershed level. **Both of the higher-density scenarios consume less land and maintain below-the-threshold imperviousness.**

This simplistic illustration demonstrates a basic point of this analysis—higher-density developments can minimize stormwater impacts because they consume less land than their lower-density counterparts. For example, imagine if Manhattan, which accommodates 1.54 million people on 14,720 acres (23 square miles) (Census, 2000), were developed not at its current density of 52 houses per acre, but at one or four houses per acre. At one house per acre, Manhattan would need approximately 750,000 more acres, or an additional 1,170 square miles, to accommodate its current population at two people per household. That's approximately the size of Rhode Island. At four houses per acre, Manhattan would need approximately 175,000 more acres, or an additional 273 square miles.

At one house per acre, Manhattan would need approximately 750,000 more acres, or an additional 1,170 square miles, to accommodate its current population at two people per household.

Reducing land consumption is crucial to preserving water quality because, as discussed previously, preserving large, continuous areas of open space and sensitive ecological areas is critical for maintaining watershed services. In addition, because of their dense development pattern, Scenarios B and C may realize additional stormwater benefits if the developed land is appropriately sited in the watershed to protect sensitive ecological areas, such as headwaters, wetlands, riparian corridors, and floodplains.

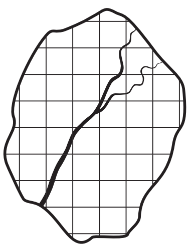
Example 4: Remaining Land in the Watershed Developed

What happens if the remaining undeveloped parts of the watershed in Scenarios B and C are developed? Exhibit 6 considers this situation.

Scale of Analysis	Scenario A	Scenario B	Scenario C
Watershed—Each 10,000-acre watershed is fully built out at different densities	10,000 houses built on 10,000 acres	40,000 houses built on 10,000 acres	80,000 houses built on 10,000 acres

EXHIBIT 6: 10,000-Acre Watershed Accommodating Different Numbers of Houses

Scenario A



The watershed is fully built out at *1 house per acre*. 10,000 acres accommodates **10,000 houses**, translating to:

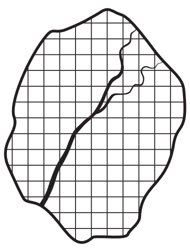
10,000 acres x 1 house x 18,700 ft^3/yr of runoff =

187 million ft^3/yr stormwater runoff

Site: 20% impervious cover

Watershed: 20% impervious cover

Scenario B



The watershed is fully built out at *4 houses per acre*. 10,000 acres accommodates **40,000 houses**, translating to:

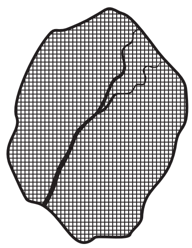
10,000 acres x 4 houses x 6,200 ft^3/yr of runoff =

248 million ft^3/yr stormwater runoff

Site: 38% impervious cover

Watershed: 38% impervious cover

Scenario C



The watershed is fully built out at 8 *houses per acre*. 10,000 acres accommodates **80,000 houses**, translating to:

10,000 acres x 8 houses x 4,950 ft^3/yr of runoff =

396 million ft^3/yr stormwater runoff

Site: 65% impervious cover

Watershed: 65% impervious cover

Each watershed is fully built out, and the watershed developed at the highest density (Scenario C) is generating approximately double the total stormwater runoff of Scenario A. Scenario B is generating approximately one-third more runoff than Scenario A. Similar to the acre-level and lot-level results, Scenario C has the highest degree of impervious cover at 65 percent, while Scenario A maintains the lowest level at 20 percent.

Scenarios A and B accommodate only a small portion of the expected growth. The rest will have to be built in other watersheds.

The higher densities found in Scenario B and C are degrading their watershed services to a greater extent than Scenario A. However, the number of houses accommodated in each community is not the same. Scenario B is accommodating **30,000 more houses** (four times the number of Scenario A), and Scenario C is accommodating **70,000 more houses** (eight times the number of Scenario A). Recall that density limits shift growth and do not generally affect the total amount of growth in a given time period. Therefore, this is not a fair comparison. Scenarios A and B accommodate only one-eighth and one-half, respectively, of the 80,000 houses accommodated in Scenario C. Where do the other houses, households, and families go? To get a true appreciation for the effects of density, Scenarios A and B must also show where those homes will be accommodated. It is likely that they would be built in nearby or adjacent watersheds. Our hypothetical community that develops at one house per acre (Scenario A) is able to accommodate only 10,000 houses. For the community that develops at that density to accommodate the same number of houses that Scenario C contains, it must disturb and develop land from nearby or adjacent watersheds.

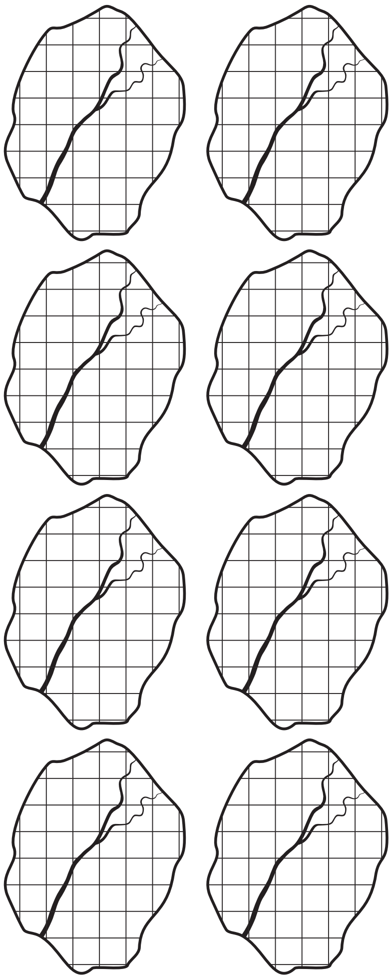
Example 5: Accommodating the Same Number of Houses

Scale of Analysis	Scenario A	Scenario B	Scenario C
Watershed—Each scenario accommodates the same number of houses	1 house per acre—80,000 houses consume 8 watersheds	4 houses per acre—80,000 houses consume 2 watersheds	8 houses per acre—80,000 houses consume 1 watershed

As discussed, the U.S. population will increase by an estimated 50 million people by 2020. Different areas of the country will grow at different rates in the future. Whether a region anticipates 1,000 or 80,000 new households to come to the region over the next 10 years, comparisons between build-out scenarios must keep the number of homes consistent. In this case, if Scenario C is developed so that its entire watershed is built out to 80,000 houses, then for a fair comparison, Scenarios A and B must also include 80,000 houses. Exhibit 7 illustrates this situation.

EXHIBIT 7: 80,000 Houses Accommodated

Scenario A



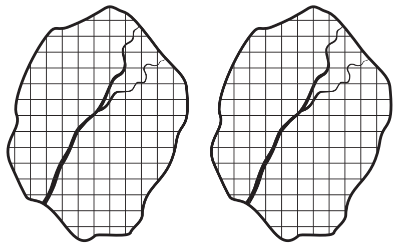
At 1 house per acre, 80,000 houses require 80,000 acres, or *8 watersheds*, translating to:

80,000 acres x 1 house x 18,700 ft^3/yr of runoff =

1.496 billion ft^3/yr of stormwater runoff

8 watersheds at 20% impervious cover

Scenario B



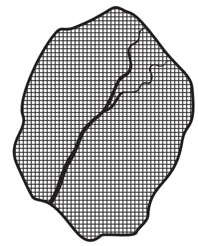
At 4 houses per acre, 80,000 houses require 20,000 acres, or *2 watersheds*, translating to:

20,000 acres x 4 houses x 6,200 ft^3/yr of runoff =

496 million ft^3/yr of stormwater runoff

2 watersheds at 38% impervious cover

Scenario C



At 8 houses per acre, 80,000 houses require 10,000 acres, or *1 watershed*, translating to:

10,000 acres x 8 houses x 4,950 ft^3/yr of runoff =

396 million ft^3/yr of stormwater runoff

1 watershed at 65% impervious cover

When the number of houses is kept consistent, Scenario A would need to develop an *additional seven watersheds* (assuming the same size watersheds) and Scenario B would need to develop *one additional watershed* to accommodate the same growth found in Scenario C.

As Exhibit 7 demonstrates, for Scenario A to accommodate the additional 70,000 homes already accommodated in Scenario C, it must develop another seven watersheds. This generates 1.496 billion ft^3/yr of stormwater runoff. Scenario C, with a development density of eight houses per acre, has still developed just one watershed and is generating approximately 74 percent less stormwater runoff than Scenario A—or 396 million ft^3/yr. Scenario B, at four houses per acre, is generating 496 million ft^3/yr runoff, or two-thirds less runoff than Scenario A, but 100 million ft^3/yr more than Scenario C.

Scenario A would need to develop an *additional seven watersheds* and Scenario B would need to develop *one additional watershed* in order to accommodate the same growth found in Scenario C.

Example 6: Time Series Build-out Analysis: Build-out in 2000

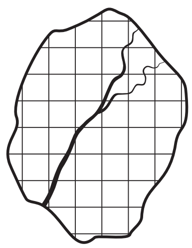
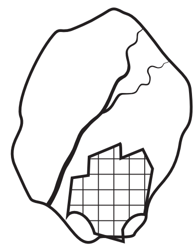
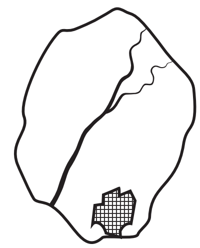
Scale of Analysis	Scenario A	Scenario B	Scenario C
Hypothetical build-out in the year 2000	10,000 houses built on 10,000 acres	10,000 houses built on 2,500 acres	10,000 houses built on 1,250 acres

Another way to examine this issue is to look at what happens to build-out of the three scenarios over time. A basic assumption for EPA's modeling is that growth is coming to the hypothetical community, and that growth will be accommodated within a fixed time horizon. But what happens to growth in the hypothetical community over several, sequential time horizons?

Given the dynamic nature of population growth, what will build-out look like in the hypothetical community in 2000, 2020, and 2040 at different development densities? The next several examples examine the amount of land required to accommodate increasing populations within a watershed that develops at different densities. The purpose of this time series build-out is to examine how much land is consumed as the population grows in 20-year increments.

Starting in the year 2000, the three watersheds each begin with 10,000 homes. The only difference between the watersheds is the densities at which the building occurs. In 2000, they might look something like Exhibit 8.

EXHIBIT 8: Time Series Build-out Analysis: Build-out in 2000

Scenario A	Scenario B	Scenario C
		
10,000 houses on 10,000 acres at a density of *1 house per acre* consume 1 entire watershed.	10,000 houses on 2,500 acres at a density of *4 houses per acre* consume ¼ of 1 watershed.	10,000 houses on 1,250 acres at a density of *8 houses per acre* consume ⅛ of 1 watershed.

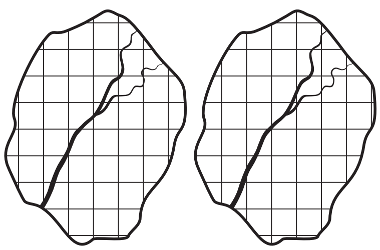
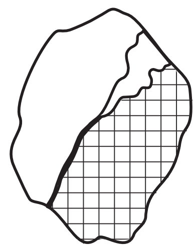
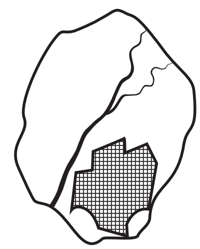
As previously demonstrated in Example 3, building at higher densities consumes, or converts, less land within the watershed. Scenario A, developing at one unit per acre, requires the entire 10,000-acre watershed to accommodate 10,000 houses. Scenario C, on the other hand, developing at eight units an acre, requires significantly less land to accommodate the same amount of development.

Example 7: Time Series Build-out Analysis: Build-out in 2020

Scale of Analysis	Scenario A	Scenario B	Scenario C
Hypothetical build-out in the year 2020	20,000 houses built on 20,000 acres, or 2 watersheds	20,000 houses built on 5,000 acres, or ½ of 1 watershed	20,000 houses built on 2,500 acres, or ¼ of 1 watershed

Fast-forwarding 20 years, the population in the hypothetical community has doubled from 10,000 houses to 20,000 houses. Each scenario must accommodate this additional growth at different development densities. Exhibit 9 demonstrates how this development might look.

EXHIBIT 9: Time Series Build-out Analysis: Build-out in 2020

Scenario A	Scenario B	Scenario C
		
20,000 houses accommodated on 20,000 acres at a density of *1 house per acre* will consume 2 watersheds.	20,000 houses accommodated on 5,000 acres at a density of *4 houses per acre* will consume ½ of 1 watershed.	20,000 houses accommodated on 2,500 acres at a density of *eight houses per acre* will consume ¼ of 1 watershed.

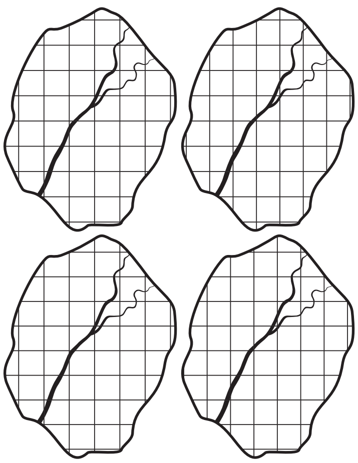
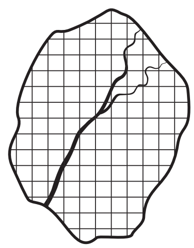
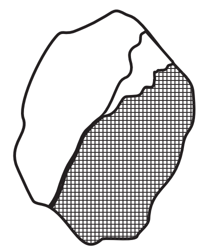
As Exhibit 9 demonstrates, Scenario A, developing at one house per acre, requires another whole watershed to accommodate the additional growth. Scenarios B and C, developing at higher densities, can accommodate the additional growth within the same watershed. Moreover, by developing at higher densities within the watershed, ample open space or otherwise undeveloped land remains to perform critical watershed functions. No such land exists in Scenario A, and, as previously discussed, lawns typically associated with one house per acre are not able to provide the same type of watershed services as forests, meadows, or other types of unconverted land.

EXAMPLE 8: TIME SERIES BUILD-OUT ANALYSIS: BUILD-OUT IN 2040

Scale of Analysis	Scenario A	Scenario B	Scenario C
Hypothetical build-out in the year 2040	40,000 houses built on 40,000 acres, or 4 watersheds	40,000 houses built on 10,000 acres, or 1 watershed	40,000 houses built on 5,000 acres, or ½ of 1 watershed

The hypothetical community continues to grow and, in another 20 years, population has doubled again, requiring each scenario to accommodate 20,000 more homes at different development densities. Exhibit 10 demonstrates how this development might look.

EXHIBIT 10: Time Series Build-out Analysis: Build-out in 2040

Scenario A	Scenario B	Scenario C
		
40,000 houses on 40,000 acres at a density *of 1 house per acre* will consume 4 watersheds.	40,000 houses on 10,000 acres at a density of *4 houses per acre* will consume 1 watershed.	40,000 houses on 5,000 acres at a density of *8 houses per acre* will consume ½ of 1 watershed.

As Exhibit 10 demonstrates, Scenario A, developing at one house per acre, must develop land in four watersheds, or 40,000 acres, to accommodate all its houses. Scenario B, developing at a slightly higher density, uses its remaining land to accommodate the additional growth. Scenario C is still developing within the same watershed and still has additional land available to provide watershed services. Scenario A and B do not. Any land for watershed services would need to come from additional watersheds.

Lower-density development always requires more land than higher densities to accommodate the same amount of growth.

This build-out analysis can continue indefinitely with the same result: lower-density development always requires more land than higher densities to accommodate the same amount of growth. Because more land is required, more undeveloped land is converted.

Findings/Discussion

The results indicate when runoff is measured *by the acre*, limiting density does produce less stormwater runoff when compared to the higher-density scenarios. However, when measured *by the house*, higher densities produce less stormwater runoff. So, which is the appropriate measure?

Typically, a planning department analyzes the projected stormwater runoff impacts of a developer's proposal based on the acreage, not the number of houses being built. Based on the results from the one-acre level example, communities might conclude that lower-density development would minimize runoff. Runoff from one house on one acre is roughly half the runoff from eight houses. However, where did the other houses, and the people who live in those houses, go? The answer is almost always that they went somewhere else in that region—very often somewhere within the same watershed. Thus, those households still have a stormwater impact. To better understand the stormwater runoff impacts from developing at low densities, the impacts associated with those houses locating elsewhere need to be taken into account. This approach has two advantages:

- It acknowledges that the choice is not whether to grow by one house or eight but is instead where and how to accommodate the eight houses (or whatever number by which the region is expected to grow).
- It emphasizes minimization of total imperviousness and runoff within a region or watershed rather than from particular sites—which is more consistent with the science indicating that imperviousness within the watershed is critical.

To more fully explore this dynamic, EPA modeled scenarios at three scales—one acre, lot, and watershed—and at three different time series build-out examples to examine the premise that lower-density development better protects water quality. EPA examined stormwater runoff from different development densities to determine the comparative difference between scenarios. The higher-density scenarios generated less stormwater runoff per house at all scales and time series build-out examples. Exhibit 11 summarizes these findings.

EXHIBIT 11: Summary of Findings

Scenario	Number of Acres Developed	Impervious Cover (%)	Total Runoff (ft^3/yr)	Runoff Per Unit (ft^3/yr)	Savings Over Scenario A: runoff per unit (%)
One-Acre Level: Different densities developed on one acre					
A: One house/acre	1	20.0	18,700	18,700	0
B: Four houses/acre	1	38.0	24,800	6,200	67
C: Eight houses/acre	1	65.0	39,600	4,950	74
Lot Level: Eight houses accommodated at different density levels					
Scenario A	8	20.0	149,600	18,700	0
Scenario B	2	38.0	49,600	6,200	67
Scenario C	1	65.0	39,600	4,950	74
Watershed Level: 10,000 houses accommodated in one 10,000-acre watershed					
Scenario A	10,000	20.0	187 M	18,700	0
Scenario B	2,500	9.5	62 M	6,200	67
Scenario C	1,250	8.1	49.5 M	4,950	74

Scenario	Summary of Build-out Examples
Watershed Level: Time Series Build-out Analysis: Build-out in 2000	
Scenario A	10,000 houses built on 10,000 acres: 1 watershed is consumed
Scenario B	10,000 houses built on 2,500 acres: ¼ of 1 watershed is consumed
Scenario C	10,000 houses built on 1,250 acres: ⅛ of 1 watershed is consumed
Watershed Level: Time Series Build-out Analysis: Build-out in 2020	
Scenario A	20,000 houses built on 20,000 acres: 2 watersheds are consumed
Scenario B	20,000 houses built on 5,000 acres: ½ of 1 watershed is consumed
Scenario C	20,000 houses built on 2,500 acres: ¼ of 1 watershed is consumed
Watershed Level: Time Series Build-out Analysis: Build-out in 2040	
Scenario A	40,000 houses built on 40,000 acres: 4 watersheds are consumed
Scenario B	40,000 houses built on 10,000 acres: 1 watershed is consumed
Scenario C	40,000 houses built on 5,000 acres: ½ of 1 watershed is consumed

Specifically, this analysis demonstrates:

- With more dense development (Scenario C), runoff rates per house decrease by approximately 74 percent from the least dense scenario (Scenario A);
- For the same amount of development, denser development produces less runoff and less impervious cover than low-density development; and
- For a given amount of growth, lower-density development uses more of the watershed.

EPA found that the higher-density scenarios generate less stormwater runoff per house at all scales—one acre, lot, watershed—and time series build-out examples.

Taken together, these findings indicate that low-density development may not always be the preferred strategy for reducing stormwater runoff. In addition, the findings indicate that higher densities may better protect water quality—especially at the lot and watershed levels. Higher-density developments consume less land to accommodate the same number of houses as lower density. Consuming less land means less impervious cover is created within the watershed. To better protect watershed function, communities must preserve large, continuous areas of open space and protect sensitive ecological areas, regardless of how densely they develop.

However, while increasing densities on a regional scale can, on the whole, better protect water resources at a regional level, higher-density development can have more site-level impervious cover, which can exacerbate water quality problems in nearby or adjacent waterbodies. To address this increased impervious cover, numerous site-level techniques are available to mitigate development impacts. When used in combination with regional techniques, these site-level techniques can prevent, treat, and store runoff and associated pollutants. Many of these practices incorporate some elements of low-impact development techniques (e.g., rain gardens, bioretention areas, and grass swales), although others go further to include changing site-design practices, such as reducing parking spaces, narrowing streets, and eliminating cul-de-sacs. Incorporating these techniques can help communities meet their water quality goals and create more interesting and enjoyable neighborhoods.

Photo courtesy of the City of Portland, Oregon

The city of Portland, Oregon, is developing urban stormwater strategies, such as these curb extensions that can absorb the street's runoff from large storm events.

A University of Oregon study, *Measuring Stormwater Impacts of Different Neighborhood Development Patterns* (University of Oregon, 2001), supports this conclusion. The study, which included a study site near Corvallis, Oregon, compared stormwater management strategies in three common neighborhood development patterns. For example, best management practices, such as disconnecting residential roofs and paved areas from the stormwater system, introducing swales and water detention ponds into the storm sewer system, and strategically locating open space, considerably reduced peak water runoff and improved infiltration. The study concluded that "some of the most effective opportunities for reducing stormwater runoff and decreasing peak flow are at the site scale and depend on strategic integration with other site planning and design decisions." The study also found that planting strips and narrower streets significantly reduced the amount of pavement and, as a result, runoff in developed areas.

A development in Tacoma, Washington, demonstrates that increasing densities and addressing stormwater at the site level can work effectively. The Salishan Housing District was built on Tacoma's eastern edge in the 1940s as temporary housing for ship workers. It is currently a public housing community with 855 units.

Redevelopment of Salishan will increase densities to include 1,200 homes (public housing, affordable and market rate rentals, and for-sale units), local retail, a farmers market, a senior housing facility, a daycare center, a health clinic, commercial office space, and an expanded community center. Among the most important priorities for the redevelopment is restoring the water quality of Swan Creek, which forms the eastern edge of Salishan. The creek is a spawning ground for indigenous salmon populations that feed into the Puyallup River and Puget Sound. The site plan seeks to restore 65 percent of the land to forest and pervious landscape. In addition, the streets will be narrowed to reduce impervious surfaces and also make the neighborhood more inviting for walking. Some streets may be eliminated and replaced with pedestrian paths. The remaining streets will be bordered by rain gardens that would accept, filter, and evapotranspire runoff. Most existing street surfaces would be reused, although some may be replaced with pervious pavers.

Salishan Housing District is replacing 855 public housing units with 1,200 units. Numerous site-level strategies, such as integrating uses, narrowing the streets, installing rain gardens, and daylighting a stream, are used to restore the water quality of Swan Creek and revitalize an existing neighborhood.

Communities can enjoy a further reduction in runoff if they take advantage of underused properties, such as infill, brownfield, or greyfield[12] sites. For example, an abandoned shopping center (a greyfield property) is often almost completely impervious cover and is already producing high volumes of runoff (Sobel, 2002). If this property were redeveloped, the net runoff increase would likely be zero since the property was already predominately impervious cover. In many cases, redevelopment of these properties breaks up or removes some portion of the impervious cover, converting it to pervious cover and allowing for some stormwater infiltration. In this case, redevelopment of these properties can produce a net improvement in regional water quality by decreasing total runoff. Exhibit 12 illustrates this opportunity.

[12] Greyfield sites generally refer to abandoned or underutilized shopping malls, strip malls, or other areas that have significant paved surface and little or no contamination.

EXHIBIT 12: Redevelopment of a Greyfield Property

Before Redevelopment	**After Redevelopment**
	

Photos courtesy of Juan Ayala, Invisioneering, for the New Jersey Office of State Planning

Redevelopment of a former shopping mall in Boca Raton, Florida, provides an example of this type of opportunity. The Mizner Park shopping mall was redesigned from its original pattern of a large retail structure surrounded by surface parking lots; the 29-acre site now includes 272 apartments and townhouses, 103,000 square feet of office space, and 156,000 square feet of retail space. Most parking is accommodated in four multistory parking garages. Designed as a village within a city, the project has a density five times higher than the rest of the city and a mix of large and small retailers, restaurants, and entertainment venues (Cooper, 2003). Most significantly, the final build-out of Mizner Park decreased overall impervious surface on the site by 15 percent through the addition of a central park plaza, flower and tree planters, and a large public amphitheater.

Redeveloping brownfield and greyfield sites can reduce regional land consumption. A recent George Washington University study found that for every brownfield acre that is redeveloped, 4.5 acres of open space are preserved (Deason, 2001). In addition to redeveloping brownfield sites, regions can identify underused properties or land, such as infill or greyfield sites, and target those areas for redevelopment. For example, a recent analysis by King County, Washington, demonstrated that property that is vacant and eligible for redevelopment in the county's growth areas can accommodate 263,000 new houses—enough for

Photo courtesy of U.S. EPA

The redevelopment of Mizner Park, a former shopping mall, decreased impervious cover by 15 percent through the addition of this central plaza.

500,000 people (Pryne, 2002). Redeveloping this property is an opportunity to accommodate new growth without expanding into other watersheds. As Kurt Zwikl, executive director of the Pottstown, Pennsylvania-based Schuylkill River Greenway Association, said, "Certainly, if we can get redevelopment going in brownfields and old industrial sites in older riverfront boroughs like Pottstown and Norristown, that's a greenfield further out in the watershed that has been preserved to absorb more stormwater" (Brandt, 2004).

Redeveloping brownfield and greyfield sites can reduce regional land consumption.

Other Research

Current research supports the findings of this study. Several site-specific studies have been conducted across the United States and in Australia that examine stormwater runoff and associated pollutants in relation to different development patterns and densities. Several case studies approach the research question with varying levels of complexity. Studies of Highland Park, Australia; Belle Hall, South Carolina; New Jersey; Chicago, Illinois; and the Chesapeake Bay each analyze the differences in runoff and associated water pollution from different types of development patterns.

Queensland University of Technology, Gold Coast City Council, and the Department of Public Works in Brisbane, Australia, examined the relationship between water quality and six different land uses to offer practical guidance in planning future developments. When comparing monitored runoff and associated pollutants from six areas, they found the most protective strategy for water quality was high-density residential development (Goonetilleke, 2005).

The Belle Hall study, by the South Carolina Coastal Conservation League, examined the water quality impacts of two development alternatives for a 583-acre site in Mount Pleasant, South Carolina. The town planners used modeling to examine the potential water quality impacts of each site design. In the "Sprawl Scenario," the property was analyzed as if it developed along a conventional suburban pattern. The "Town Scenario" incorporated traditional neighborhood patterns. In each scenario, the overall density and intensity (the number of homes and the square feet of commercial and retail space) were held constant. The results found that the "Sprawl Scenario" consumed eight times more open space and generated 43 percent more runoff, four times more sediment, almost four times more nitrogen, and three times more phosphorous than the "Town Scenario" development (South Carolina Coastal Conservation League, 1995).

These findings hold at a larger, state scale. New Jersey's State Plan calls for increasing densities in the state by directing development to existing communities and existing infrastructure. Researchers at Rutgers University analyzed the water quality impacts from current development trends and compared them to water quality impacts from the proposed compact development. The study found that compact development would generate significantly less water pollution than current development patterns, which are mostly characterized by low-density development, for all categories of pollutants (Rutgers University, 2000). The reductions ranged from over 40 percent for phosphorus and nitrogen to 30 percent for runoff. These conclusions supported a similar statewide study completed in 1992 that concluded that compact development would result in 30 percent less runoff and 40 percent less water pollution than would a lower-density scenario (Burchell, 1995).

Researchers at Purdue University examined two possible project sites in the Chicago area (Harbor, 2000). The first site was in the city; the second was on the urban fringe. The study found that placing a hypothetical low-density development on the urban fringe would produce 10 times more runoff than a higher-density development in the urban core.

Finally, a study published by the Chesapeake Bay Foundation in 1996 comparing conventional and clustered suburban development on a rural Virginia tract found that clustering would convert 75 percent less land, create 42 percent less impervious surface, and produce 41 percent less stormwater runoff (Pollard, 2001). These studies suggest that a low-density approach to development is not always the preferred strategy for protecting water resources.

Conclusions

Our regions, cities, towns, and neighborhoods are growing. Every day, new buildings or houses are proposed, planned, and built. Local governments, working with planners, citizen groups, and developers, are thinking about where and how this new development can enhance existing neighborhoods and also protect the community's natural environment. They are identifying the characteristics of development that can build vibrant neighborhoods, rich in natural and historic assets, with jobs, housing, and amenities for all types of people. They are directing growth to areas that will maintain and improve the buildings and infrastructure in which they have already invested. In addition to enjoying the many benefits of growth, communities are also grappling with growth's challenges, including development's impact on water resources.

Many communities assume that low-density development automatically protects water resources. This study has shown that this assumption is flawed and that pursuit of low-density development can in fact be counterproductive, contributing to high rates of land conversion and stormwater runoff and missing opportunities to preserve valuable land within watersheds.

The purpose of this study is to explore the effects of development density on stormwater runoff and to illustrate the problems with the assumption that low-density development is automatically a better strategy to protect water quality. To that end, three different development densities were modeled at the one-acre, lot, and watershed levels, as well as in the time series build-out examples. The modeling results suggest that low-density development is not always the preferred strategy for protecting water resources. Furthermore, the results seem to suggest that higher-density development could better protect regional water quality because it consumes less land to accommodate the same number of homes.

However, while this study shows that low-density development does not automatically better protect water resources, it does not conclude that high-density development is therefore necessarily more protective. This study has not considered all factors, such as location of development within the watershed, varying soil types, slope, advanced post-construction controls (and their performance over time), and many other factors. In that sense, this study concludes that there are good reasons to consider higher-density development as a strategy that can better protect water resources than lower-density development. However, any bias toward either is inappropriate from a water perspective. A superior approach to protect water resources locally is likely to be some combination of development densities, based on local factors, incorporating adequate open space, preserving critical ecological and buffer areas, and minimizing land disturbance.

These conclusions have implications for how communities can enjoy the benefits of growth and development while also protecting their water quality. Additional relevant information can be found in other resources, such as *Protecting Water Resources with Smart Growth* and *Using Smart Growth Techniques as Stormwater Best Management Practices.*[13] Both publications draw on the experience of local governments, which has shown that regional and site-specific strategies are most effective when implemented together. In addition, *Creating Great Neighborhoods: Density in Your Community*, by the Local Government Commission and the National Association of Realtors, can provide information on some of the other benefits from density that communities can enjoy.

Nationwide, state and local governments are considering the environmental implications of development patterns. As low-density development and its attendant infrastructure consume previously undeveloped land and create stretches of impervious cover throughout a region, the environment is increasingly affected. In turn, these land alterations are not only likely to degrade the quality of the individual watershed, but are also likely to degrade a larger number of watersheds. EPA believes that increasing development densities is one strategy communities can use to minimize regional water quality impacts.

Additional relevant information can be found in these resources:

- *Protecting Water Resources with Smart Growth,* available at: www.epa.gov/smartgrowth/pdf/waterresources_with_sg.pdf.
- *Creating Great Neighborhoods: Density in Your Community,* available at: www.epa.gov/smartgrowth/pdf/density.pdf.

[13] Forthcoming EPA publication.

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Environmental Protection
Agency

HousingWorks
AUSTIN

October 24, 2023

Dear Mayor Watson, Austin City Council Members, and Austin Planning Commission Members:

HousingWorks Austin supports adoption of the initial set of proposed amendments to the land development code to implement the Home Options for Middle-income Empowerment (HOME) initiative and the removal of dwelling unit occupancy limits in the land development code that are currently under consideration by the Planning Commission and City Council.

HousingWorks believes the intent of proposed amendments would allow for the development of a greater diversity of housing types and living arrangements than currently allowed in single-family zoning districts, which would increase access to attainable housing opportunities for households at a range of income levels, especially for first-time home buyers and seniors wishing to remain in their communities, and increase housing opportunities in high opportunity areas.

We further recommend that the Council consider providing direction to City Staff to increase access to programs that ensure low and moderate income homeowners are able to avail themselves of increased development potential of single-family lots and are protected from predatory real estate activities. Such programs might include financial counseling, access to capital, legal and technical assistance, and ensuring clear titles are held by property owners.

We thank the City Council for their leadership on these issues and hope our recommendations can help improve the efficacy of the proposed amendments. If you have any questions, please email me at nora@housingworksaustin.org and/or John-Michael Cortez, Advocacy Committee Chair, HousingWorks Board of Directors at jmvcortez@gmail.com.

Best Regards,

Nora Linares-Moeller

Nora Linares-Moeller
Executive Director

Dear Mayor & Austin City Council Members,

On behalf of the Laborers' International Union of North America, Southwest Laborers District Council, and Local 1095, I am writing to express our official endorsement of the HOME Act that will help create more housing opportunities for our members. LiUNA's mission to support our members is fully aligned with the Council's efforts to create more housing we can afford, and options to live in the city we're proud to build and maintain.

Construction workers are essential workers to the future of Austin and Central Texas, but sadly our members are unable to afford to live in the places they work. This is making it more and more difficult to find the skilled workers needed to keep our building boom going, so we understand the urgent need to address the shortage of affordable housing for these workers. Home is an important step in ensuring our ability to attract a robust workforce to keep building on our successes.

Your efforts with the recent Mobility and Infrastructure Summit that focused on supporting and training a larger workforce for those big projects is an important piece of a larger picture that must include more attainable housing for those workers. We are all aware that federal dollars are at stake as part of the Infrastructure Bill and HUD's PRO Housing grant programs, both of which help fund Austin's future and support the people who construct it.

HOME takes a crucial first step to making homeownership more accessible, and reversing the rising cost of housing that prices our members out of Austin's housing market. We are alarmed by the widening gap between the average salary and the cost of homes, which threatens the long-term sustainability of our city. We are also concerned that as more or our members must move farther from Austin, they lose their ability to vote and choose the leaders and policies that accurately reflect their values.

We build this city and are vital members of this community. Like Austin's nurses, teachers, EMS medics, public servants, and small business owners, we deserve the chance to thrive and be part of this community as neighbors and homeowners.

We urge you to give this initiative your full support and ensure its successful implementation to make Austin a city for everyone.

Sincerely,

Jeremy Hendricks

Jeremy Hendricks
Assistant Business Manager
Southwest Laborers District Council – LIUNA

Austin City Council Members,

The National Nursed United (NNU) fully supports the HOME Act to create more housing opportunities. Our mission to support our member is fully aligned with the Council's efforts to create more housing our workers can afford, and options to live in the city we serve.

More nurses are needed for this growing city, especially with the staffing challenges faced by the existing health care providers and with new hospitals and medical facilities coming online. There is an urgent need to create more housing options to attract and retain nurses in Austin, and we hope the HOME initiative will help.

After a 12-hour shift, many of our members commute over an hour to get home; long commutes are not only unsafe after working such long hours but add more transportation costs and take away time with family. These realities drive our nurses to look for jobs outside of Austin hurting recruitment and retention of essential medical personnel for all of Austin's medical facilities.

HOME takes a crucial first step to making homeownership more accessible, and reversing the rising cost of housing that prices our members out of Austin's housing market. We are alarmed by the widening gap between the average salary and the cost of homeownership and rent, which threatens the long-term sustainability of our city. We are also concerned that our members who work in Austin, but don't live in Austin, are no longer able to vote on issues or leaders who represent their values in the community they serve.

We are vital members of this community. Nurses deserve the chance to thrive and be part of Austin as neighbors.

We urge you to give this initiative your full support and ensure its successful implementation to make Austin a city for everyone.

Sincerely,

Celeste Arredondo-Peterson

National Nurses United - Texas

PO BOX 171
AUSTIN, TX 78767
FARMANDCITY.ORG
[redacted]
713-244-4746

OCTOBER 24, 2023

MAYOR KIRK WATSON AND AUSTIN CITY COUNCIL
301 W 2ND ST.
AUSTIN, TEXAS 78701

Dear Mayor Watson and Austin City Council Members,

Thank you for your consideration of supporting the HOME initiative that will be discussed on Thursday, and for all that you do to remove the burdensome limits to the amount of people allowed to live low-carbon, healthy, affordable lifestyles in the City of Austin.

We strongly support this initiative and urge you not to water it down in ways that will keep people from finding affordable housing options in this City.

Farm&City is dedicated to high quality urban and rural human habitat in Texas in perpetuity. We are a climate change organization that focuses on changing Texas public policies so that the millions of people who want to live low-carbon lifestyles in Texas are allowed to walk to the store, ride public transit to school, and not have to drive so much.

Unfortunately policies at the City of Austin have contributed negatively to our housing crisis – along with county, metropolitan, and state policies – forcing most people to live expensive car dependent lifestyles. The City's continued use of exclusionary zoning limits the amount of people allowed to live in the City to current population plus about 25% of regional growth.

City policy is diminishing the City's share of the region's population, abrogating the City's responsibility to provide for the growing human species on our planet in a more responsible, climate-aware manner, and significantly contributing to the paving over of the hill country. As shown by City of Austin Watershed Department analysis during the CodeNEXT process and the attached EPA report, land use reforms of this type will significantly reduce the future total impervious surface in our region, while actually slightly decreasing the total inside the City, even while allowing significantly more people to live in the City.

The climate costs of exclusionary zoning are profound. Not letting more people live in existing neighborhoods with existing underutilized infrastructure is an extraordinarily unwise choice at this time in history, with what we know very well about climate science and the impacts of housing and transportation policies. The City of Austin should not engage in an anti-science

Farm &City

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position opposed to the overwhelming consensus of environmental groups and policy makers, including the position of the Federal Government and President Biden, urging the City of Austin to abandon exclusionary zoning and replace it with equitable growth strategies. As shown in our second attached report, those living in dense areas in our region are able to live their lives without emitting as much carbon as their neighbors who live in car dependent places. We should remove city limits on the amount of people allowed to not drive so much.

In spite of persistent mis-perceptions – significantly informed by elite projections and a focus on home sale prices – the more dense parts of the Austin region are the most affordable parts of the region, both in terms of housing and transportation costs, as documented in our attached report. Limiting the number of people allowed to live in the City drives up housing and transportation costs for people living in the City and those living in the rest of the region. Displacement is primarily caused by zoning rules that drive housing costs up and accelerate the competition for the artificially limited number of homes remaining in the City.

Our region is growing from 2 to 4 million people with a majority of the additional people expected to be people of color. The Austin City Council should seek to allow as many of those additional people as possible to live within the City in walkable transit-oriented places where low-carbon lifestyles are possible.

The HOME initiative is an important element of a responsible climate and equitable growth policy. While every homeowner can choose to keep their home exactly as they want, the City itself should not enforce broad dictates banning affordable housing types from any neighborhood. As stressed in the UT Uprooted report, allowing low-income homeowners to better utilize their lot, to share their space with other people, is an essential strategy to keep communities connected and preserve the most important character of our City, the people who live here today and their welcoming nature as our human population grows across the planet. Let’s not be on the side of exclusion anymore, here in Austin, Texas.

Thank you for all that you do for the people of the City of Austin – past, present, and future – and for your consideration of voting in favor of the HOME initiative.

Sincerely,

Jay Blazek Crossley
Executive Director

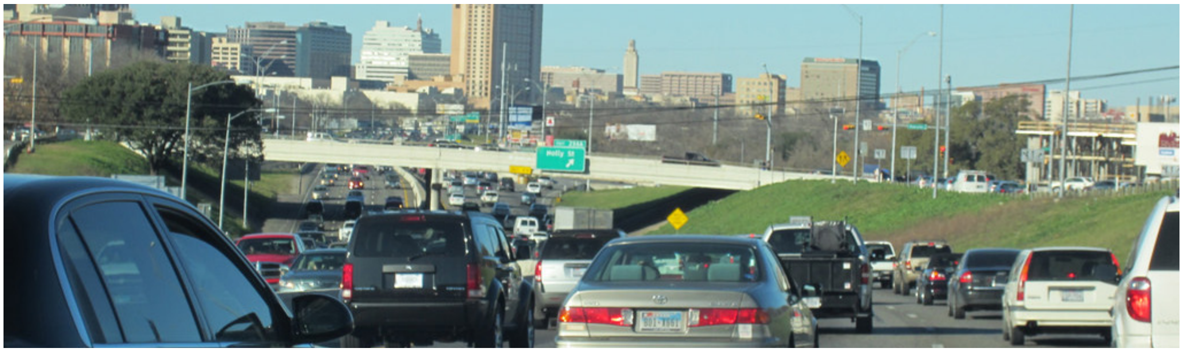
Growing Weirder

Understanding Austin's Growth and Potential

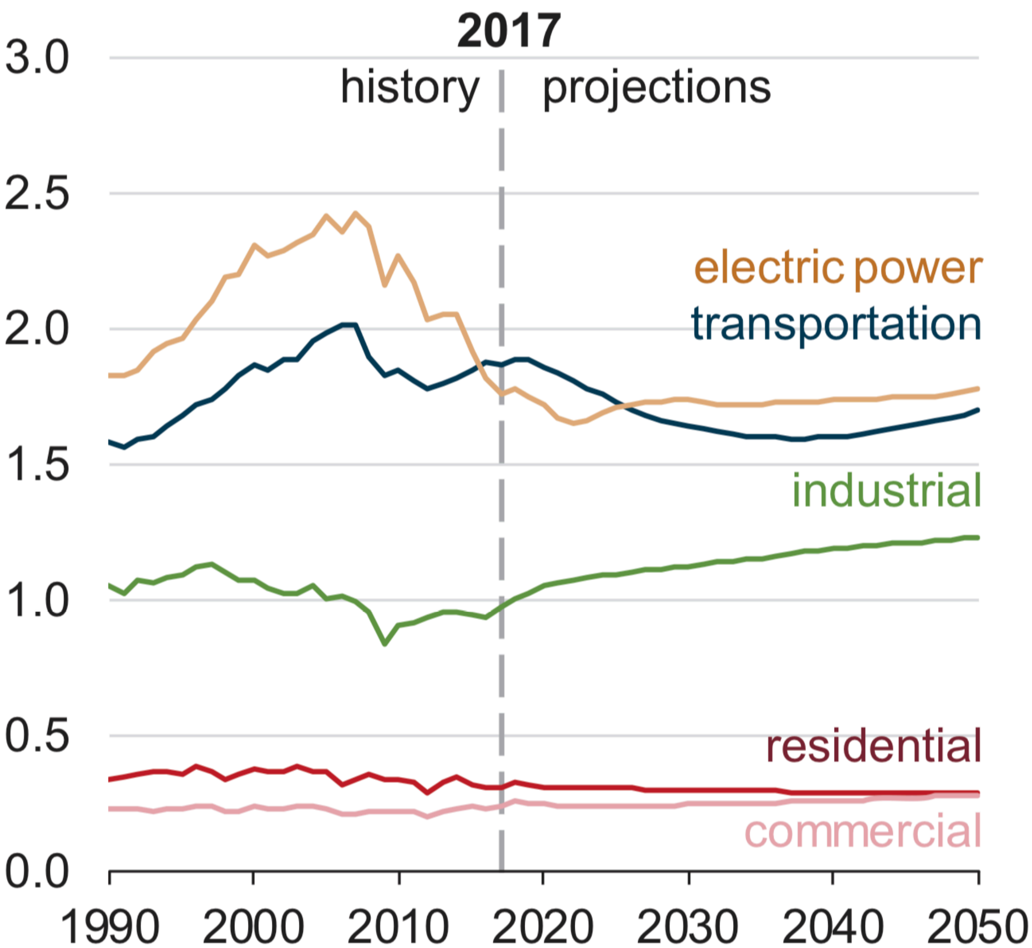
Environmental sustainability implications of Austin's regional growth options

Jay Blazek Crossley
Ashkan Jahangiri
Andrew Mayer
Laura Thomas

Farm & City



Energy-related carbon dioxide emissions by sector (Reference Case)
billion metric tons of carbon dioxide



Growing Cooler

A decade later, the seminal report grows even more important and influential

In 2007, the Urban Land Institute released *Growing Cooler*, a highly-cited landmark publication linking climate change and transportation. It is a good report.

Our work here – to empower communities and elected officials with better information and analysis to help build a sustainable, equitable Austin region – is based upon Growing Cooler.

Carbon emissions from transportation account for over a third of our national emissions, and have been a larger problem than the US energy sector since 2014.

Growing Cooler found transportation emissions can only be meaningfully reduced by reducing vehicle miles traveled (VMT) by choosing compact development. We agree with this general framework.

Many efforts – including the emphasis by the City of Austin – to curb transportation emissions have focused on reducing tailpipe emissions without questioning VMT. The result has been no improvement in the national fuel economy from 1990-2005 and a 50% increase in VMT. 70% of the increased VMT is directly attributable to our sprawl, with only 13 % from growth.

Population growth is generally slightly associated with a reduction in per capita VMT, a reflection of shifting trends towards compact development. Characterized by density & regional diversity of land use, compact development is a low-cost method of reducing VMT. As we grow together, we grow more efficient.

A local push for compact development to manage existing demand could yield a 30% reduction in VMT and a concomitant 10% reduction in vehicle based carbon emission by 2050.

Compact development allows for safe access by all modes of transportation, while meaningful access by transit and other modes are not possible to provide to people living in low density sprawl.

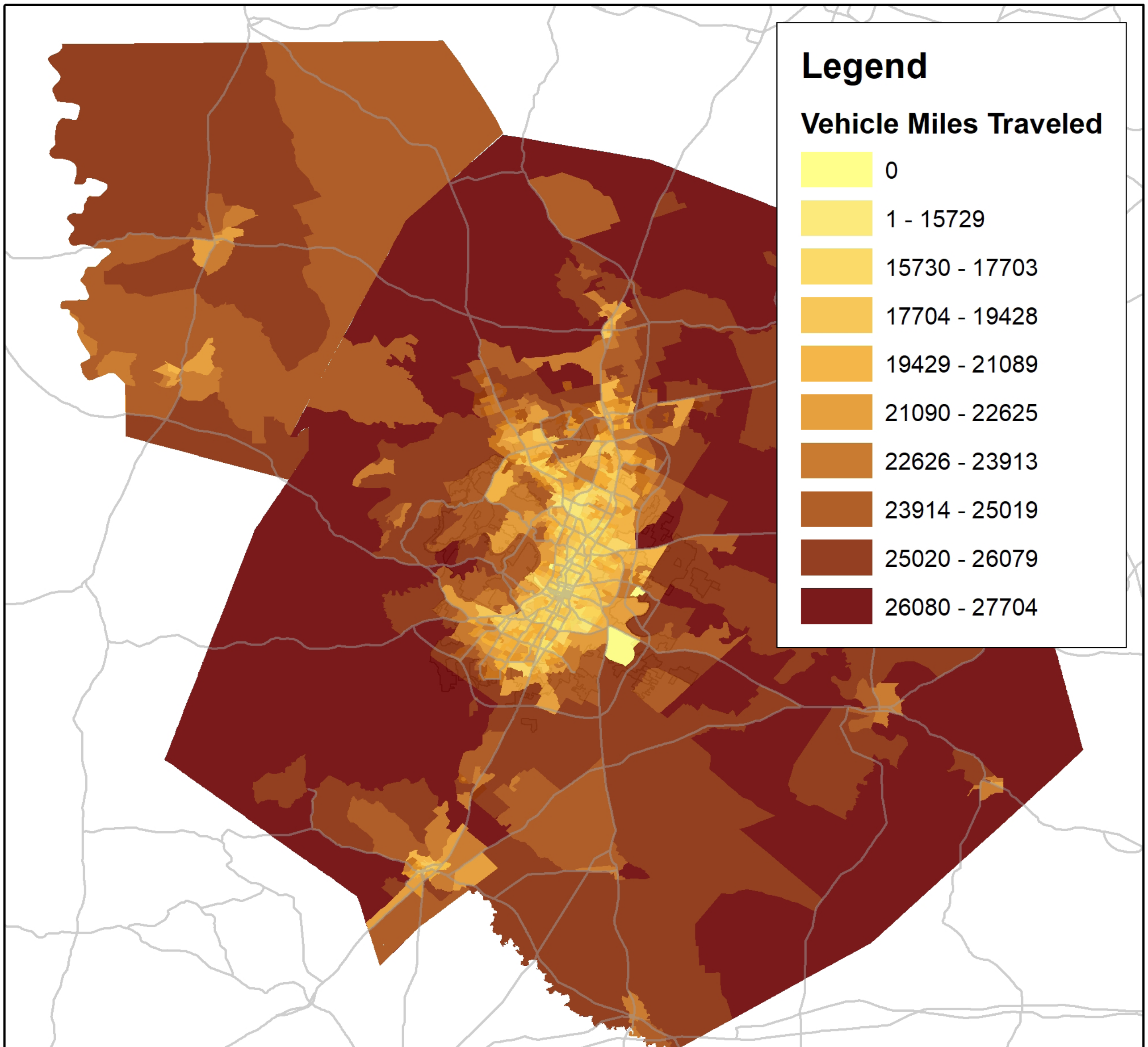
Water quality and existing forestry are protected by compact development. There are also public health benefits through increased access to healthy lifestyles, improved air quality, and reduced pollution.

Growing Cooler promotes compact development and discourages sprawl. Cities, counties, and MPOs can curb transportation emissions by adopting land use codes that promote infill and mixed uses to build complete communities for all.

Our work on Growing Weirder is an attempt to build on *Growing Cooler*'s wisdom and apply it to current policy debates across the Austin region.

We're analyzing vehicle miles traveled, carbon emissions, traffic, and climate emissions costs of various CodeNEXT and regional growth proposals, and seeking solutions.

Preserving the livability of the Austin region requires making these difficult decisions today, based upon the best available data.



Vehicle Miles Traveled (VMT) is a crucial measure of how much individuals, neighborhoods, and entire metropolitan areas travel.

Traditionally, VMT has been regarded as an unavoidable consequence of regional growth. Many elected officials actively work to sustain VMT increases, believing economic growth to be dependent on VMT. Texas transportation planners continue to allocate billions of dollars based on the notion that we must allow VMT growth. However, this assumption is not necessarily correct. Nationwide per capita VMT has a slight negative correlation with growth. TxDOT's own data also suggests economic growth and VMT are decoupling.

VMT does have concrete negative consequences; every additional mile travelled increases traffic and the risk of collisions. Crashes cost Texans $162 billion every year, while congestion drains a further $14 billion in unproductive time spent in cars. With an annual statewide VMT of 258 billion, every mile driven is respon-

Vehicle Miles Traveled

Tell me your address, and I can tell you how much your neighbors drive.

	SuperUrban	Urban	Suburban	Rural
People	11,434	735,639	672,614	592,271
Households	3,296	272,582	251,433	207,080
Total VMT	44,693,190	5,206,634,672	5,568,521,504	5,236,638,780
VMT per capita	3,909	7,078	8,279	8,842
Carbon per capita (tonnes)	1.96	2.93	3.43	3.69
Total carbon (tonnes)	15,923	2,157,910	2,310,421	2,186,908

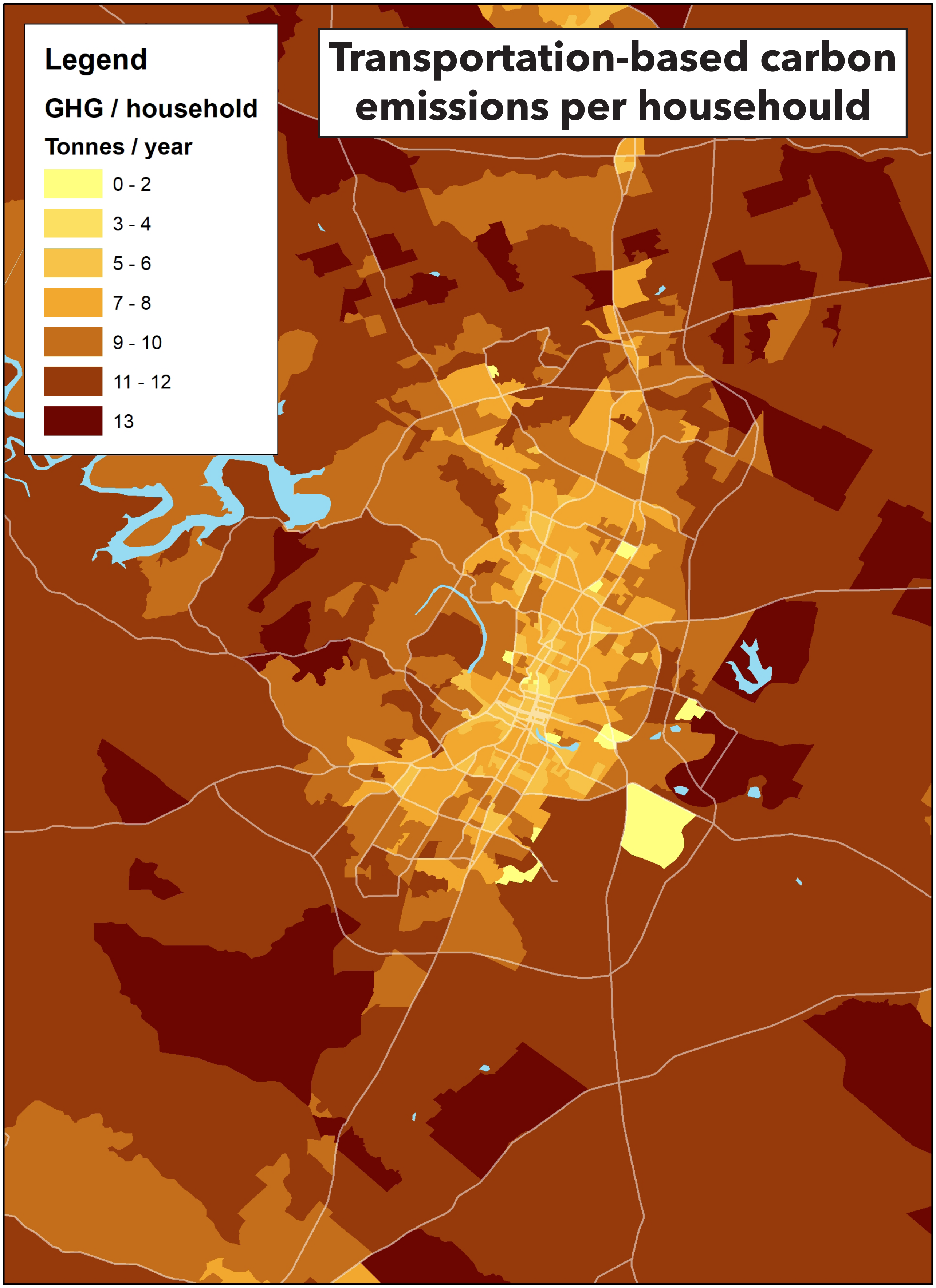
sible for $0.63 of property and vehicle damage. The human cost is also steep; ten people die every day on Texas roads, causing immeasureable pain and suffering.

Our transportation decision-making system also hides the cost of "free" roads, underrepresents people of color, and provides scant data on the true costs of our transportation system. Given the steep risks associated with distances travelled, planners must explicitly aim to reduce VMT.

Transportation is responsible for over one third of carbon emissions in the United States. These emissions are a simple function of fuel efficiency and VMT. The federal government has successfully regulated fuel efficiency through increased mileage standards for vehicles & the gas tax. On an individual and local level, VMT reduction is the most significant way to reduce carbon emissions. VMT can be reduced through use of public transportation and location efficiency, which is achieved by positioning housing, work, and schools in compact, easily-accessible locations.

Unfortunately, the availability of low-carbon lifestyle options depends on our urban environment. As the Austin region grows from two to four million people over the coming decades, the decisions made in CodeNEXT and the 2045 Regional Transportation Plan will determine how many people are allowed affordable access to sustainable, healthy, walkable urban neighborhoods.

The Center for Neighborhood Technology maintains a H+T Affordability Index that provides detailed data on the financial and environmental costs of housing and transportation across the US. It forms the basis of our analysis on VMT and transportation-related carbon emissions.


Transportation-based carbon emissions per househould
Legend
GHG / household
Tonnes / year
0 - 2
3 - 4
5 - 6
7 - 8
9 - 10
11 - 12
13

Carbon Policy

Transportation-based carbon emissions vary by where you live across the region

We must reduce our metropolitan carbon emissions to play a responsible role in the 21st century world community. Unfortunately, many of our public policies continue to increase our carbon footprint--especially land use and transportation policies.

As we grow from a population of two million to four million, we have the oportunity to lower our carbon footprint significantly by allowing existing and new residents better options to live healthy, low-carbon lifestyles, by reducing car dependency.

Austin's urban grid, density, transit and pedestrian access, and multimodal street safety dictate how much it costs to access the benefits of this American metropolis. While environmental costs can be less obvious, they are expressed in carbon emissions, air quality, and loss of trees and open space.

Today's Austin provides low-carbon lifestyles for a very select few, but that select few contains a diverse mix of socio-demographics. Long-standing traditional urban street grids continue to provide both rich and poor Austinites with low-carbon lifestyles. Allowing more housing in the environmentally sound existinurban grid means more people having access to the current benefits, while also reducing the carbon footprint and travel needs of those there today.

More people in your neighborhood will mean more services at your fingertips, including retail, schools, and offices within walking distance as well as allowing for high quality, frequent transit access.

There are areas of our region where the average household emits ten times as much transportation-based carbon than in other, more efficient parts of our region.

A key element of transportation based carbon emissions is that the tailpipe emissions are not the only contirbution to global warming for every mile you drive. A new car - whether it is electric or internal combustion - already has an amount of embedded carbon when you buy it.

The factory, parts, and materials contributed to global warming before the engine was ever turned on. Some estimates show that this amount of embedded carbon is about equal to the amount that a new internal combustion car will release over its life cycle.

But this isn't all. Driving requires roads and parking spots. The Austin region has more lane miles per capita than most Texas metros. All of those miles of road required extensive green house gas emissions through bulldozing the road, bringing the material, paving the road, and ongoing maintenance.

Cutting the Austin region's vehicle miles traveled is a crucial element of climate responsibility, which will primarily be determnined by our regional growth policies, especially CodeNEXT and the 2045 Regional Transportation Plan.

Each additional person allowed to live in the region, but not inside the City of Austin = **0.46 additional tonnes of carbon emissions** annually.

Adopting CodeNEXT V.2 today would mean 108,951,401 less vehicle miles traveled in 2027 compared to currently-used segregation zoning. This would be equivalent to planting **2 million trees** every year.

These are very conservative estimates of the benefits of allowing more people to live within the City of Austin. As more people and jobs are added to our neighborhoods, each one of us actually ends up driving less and emitting less carbon, while gaining greater access to people and opportunities. This proposal is a rare environmental / societal win-win.

Code Impacts on Carbon

Average housing + transportation costs as a percent of regional typical income

We drive a lot in Texas. Americans drive more than most wealthy nations, and Texans in our major metropolitan regions drive more than most Americans in other major metropolitan regions.

Austinites, in particular, drive more than those in most other Texas metros, meaning the region lags behind Houston and Dallas in responsibly addressing climate change.

If you live in the City of Austin, you're responsible for an average of 7,602 vehicle miles traveled every year. However, if you live in the Austin region but outside the City, you're averaging 8,259 miles a year.

Each additional man, woman, & child not allowed to live in the City of Austin, who instead lives in the more car-dependent parts of the region means around 2 miles more of driving every day.

Transportation accounts for more green house gas emissions for Americans than energy. On average, every person living outside the City of Austin accounts for 0.46 more tonnes of transportation based carbon emissions than if they lived inside the city, based upon the VMT differences.

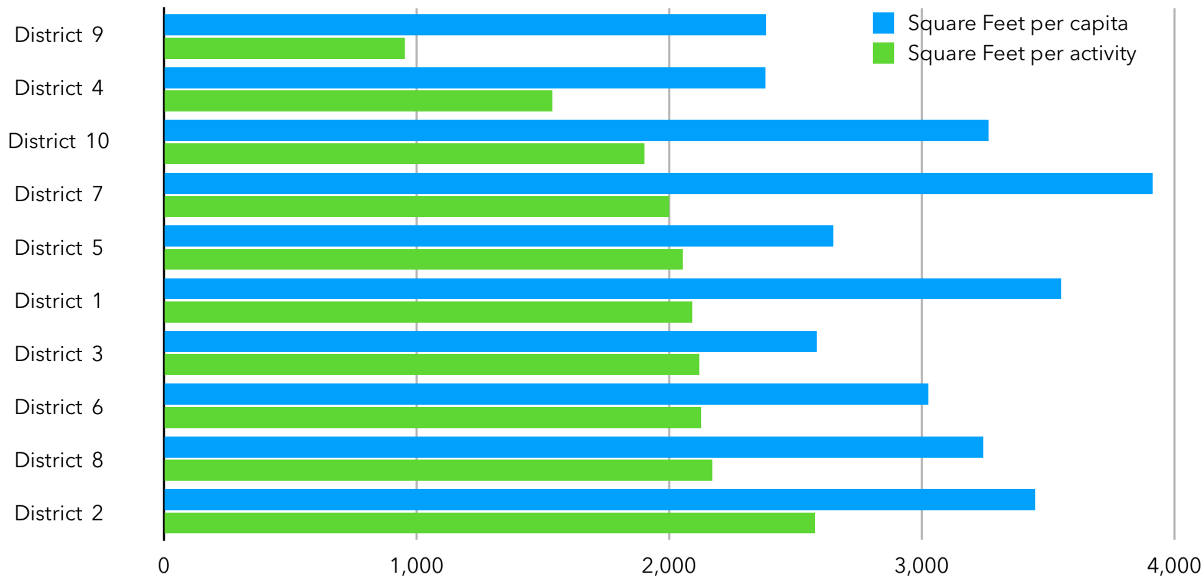
When we analyze potential future growth scenarios, we often underestimate the difference between living in and out of the City. Even so, the distinction is important.

The more people an attractions are nearby, the less people have to drive long distances to get to them. The land development code must be tweaked to allow every neighborhood to develop into a complete community.

A progressive, climate responsible CodeNEXT can meaningfully reduce future carbon emissions and traffic.

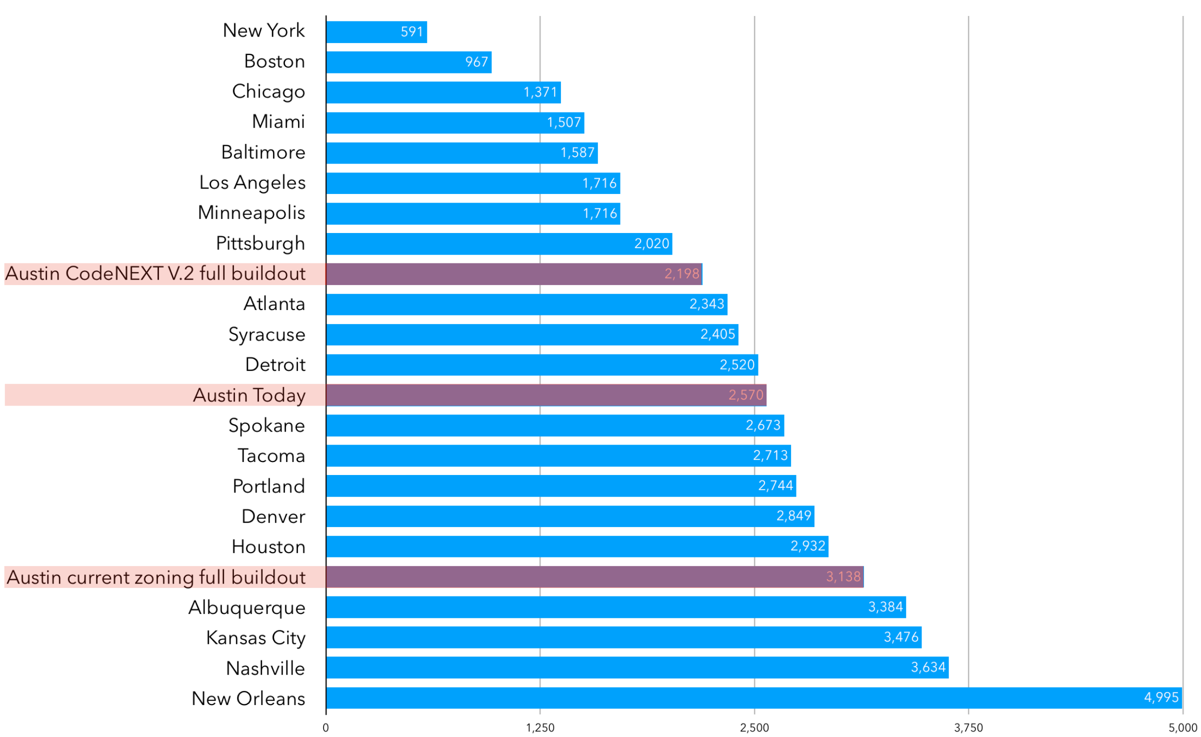
Most calculations herein are based on our analysis of CNT data. as explained in our Affordability report. Please explore the source data here: https://htaindex.cnt.org

Impervious Surface By Austin Council District



Population is 2010 Census estimates as presented by the City of Austin Demographer online. Jobs were derived from the CAMPO Regional Forecasts baseline 2010 data using the percent clip method to extract the data to council districts from TAZs. Activity Intensity is the amount of jobs and population in an area. So an activity means someone lives there or works there.

Square feet of impervious surface per person in major US cities



Impervious Surface

Average housing + transportation costs as a percent of regional typical income

According to numbers from the City of Austin Watershed Department, the proposed CodeNEXT Version 2 would have been a slight improvement over current zoning in terms of the total amount of impervious surface expected in the City of Austin by 2027 - comparing both options using a fantasy scenario where all entitlements are actually used.

However, our potential future development affects impervious surface in part by controlling the number of people allowed to live inside the City of Austin or outside.

Allowing people to live inside the City of Austin helps ease the heavy impervious surface costs of subsidizing growth outside the City, reducing flooding. Allowing higher population densities inside the city – as CodeNEXT V.2 does – would yield environmental benefits for the region.

As far as we know, this analysis has not been redone for the most recent drafts of CodeNEXT, but the impervious surface benefits are likely similar or better in Version 3.5 than Version 2.

Today in the region – according to TXDOT's "FY2005 - 2016 Roadway Data Tables" – the people of Travis County are responsible for 55% of the amount of roads and streets per capita that the people of Hays County are, as shown in the chart to the left.

Low density car dependent neighborhoods require more roads per person, which means more flooding.

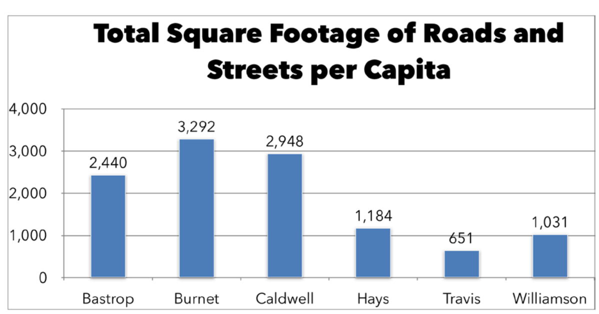
Current projections of impervious surface coverage contradicts anyone citing environmental, flooding, heat island, or water quality fears as reasons to vote against CodeNEXT V.2 (see chart opposite).

A full buildout of CodeNEXT V.2 will result in about 1,000 fewer acres of impervious land than a buildout of current zoning. Each resident of the City of Austin would be responsible for almost 1,000 fewer square feet of impervous surface.

This means roughly 1% of the city would be left open rather than paved, giving clear indication that the new proposal is more environmentally friendly than its alternatives.

In addition, the current zoning code is responsible for many of Austin's localized flooding problems. As we move further into the anthropocene towards an ever-increasing number of unexpected weather events, efficient land development codes are vital in disaster preparedness.

Passing CodeNEXT would reduce future total regional impervious surface, and dramatically reduce impervious surface per capita for residents of the City.



Dedication ceremony for the Rio Grande Protected Bike Lane
Photo Credit: our friends at BikeTexas

UNO: Austin's CodeNEXT Pilot

There's a place in Texas with astounding environmental results of public policy

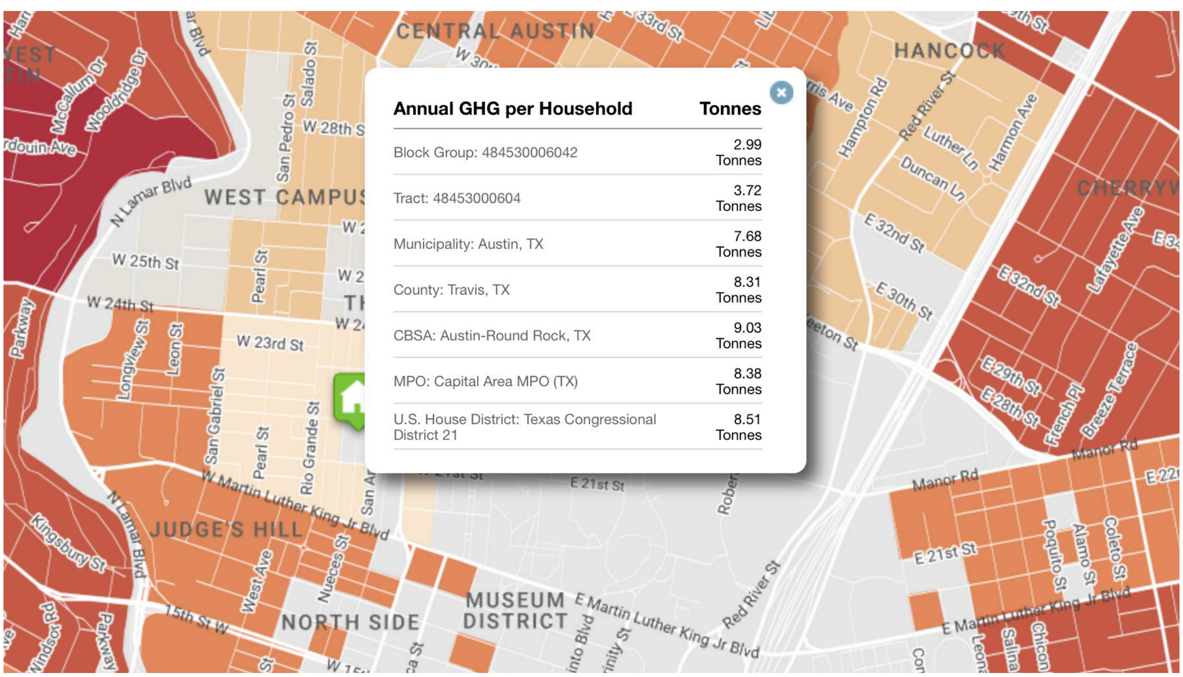
West Campus is a Texas neighborhood that has radically changed since – some of us lived there in – the 90s due to leadership and direction from Austin City Council, with astounding metrics on what has been achieved in terms of people living better.

Clearly the area has gained safe street improvements faster than anywhere else in Texas. According to Dan Keshet's blog *Austin on Your Feet*, the student-rich neighborhood now contains double the apartments that were available 15 years ago.

While rents in West Campus have risen dramatically, its residents are driving less than other Texans. West Campus is easily the most eco-friendly place to live in the Austin region – if not all of Texas – with residents of West Campus emitting just 23% of the regional population's average transportation-based carbon emissions.

For urban planning and climate responsibility purposes, students' trips to class are equal to work commutes. City Council's effort to provide convenient, affordable access by all modes for students demonstrates the power of transit improvements.

We are very well aware of the costs and benefits. These policies have allowed affordable, low-carbon lifestyles to many Texans, and should be spread beyond West Campus.



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We can provide the analysis decision-makers and the public need to optimize our freedoms, our environment, and our quality of life. We can begin to shift our thinking to treat our growth as a shared responsibility and opportunity to complete our communities.

We intend to substantially impact the outcomes of City of Austin's CodeNEXT, Capital Area Metropolitan Planning Organization's Regional Transportation Plan, Capital Metro's Project Connect, City of Austin Strategic Mobility Plan, state legislation, and various related public processes, such as local budgets and bond proposals.

Displacement is real. Profit and abundance are real. Successful mixed-income, mixed-use community building is also real. We need to determine strategies and best practices that will minimize displacement, maximize affordable housing units in accessible and affordable locations, and achieve citizen priorities. The region's policy-makers and finance community need to learn the lexicon of location efficiency.

We need a holistic set of understandings of growth, best practices for equitable policy making, and synergistic transportation policies to produce true affordability.

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We must measure our success by the ability of low income and disadvantaged people to live comfortably and access all the benefits of a modern city. We are trying to change the paradigm of growth, development, and transportation in their favor, but it will take time.

This report is part of a series of in-depth investigations on the various consequences of our major land use and transportation policy decisions. This is necessarily messy- our built environment impacts every aspect of how we live our lives in ways that aren't obvious and that we are only beginning to understand.

Other Growing Weirder reports took a closer look at affordability, how City of Austin policies limit the amount of people allowed to live in the City, and the potential for Equitable Transit Oriented Development strategies to build a more sustainable region.

Growing Weirder

Understanding Austin's Growth and Potential

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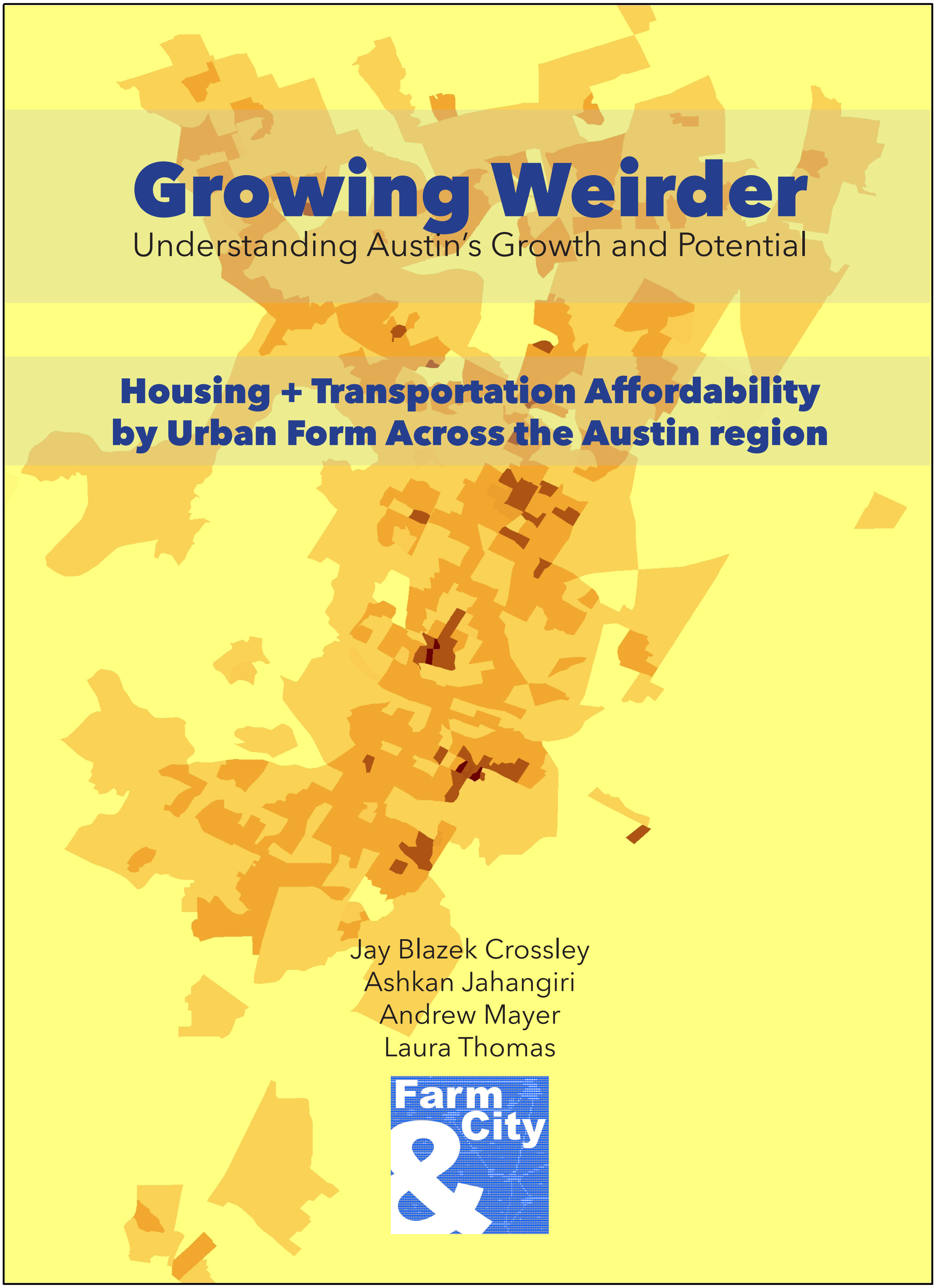


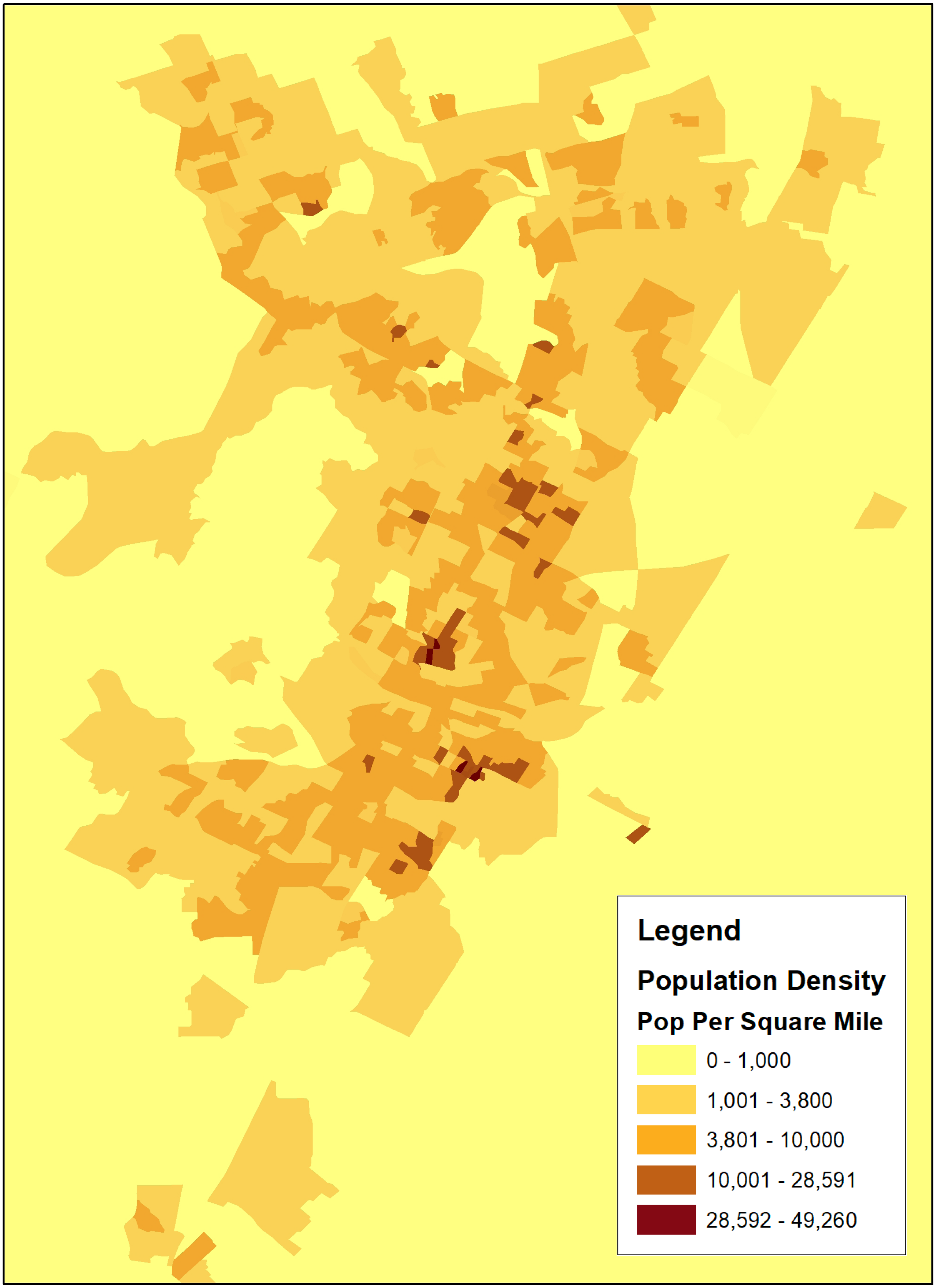
Growing Weirder

Understanding Austin's Growth and Potential

Housing + Transportation Affordability by Urban Form Across the Austin region

Jay Blazek Crossley
Ashkan Jahangiri
Andrew Mayer
Laura Thomas

Farm & City


Legend
Population Density
Pop Per Square Mile
0 - 1,000
1,001 - 3,800
3,801 - 10,000
10,001 - 28,591
28,592 - 49,260

Three Austins

In this report, we examine the relationship between density and affordability

Affordability is often defined by the cost of housing. While housing is the most significant single household expense, transportation is second largest and therefore a significant component of true affordability. Transportation costs are primarily a function of location. Multimodal transportation options are more available in urban areas of higher density. In the Austin region, people can walk, bike, use transit, or take short car trips to their daily destinations primarily in dense urban areas.

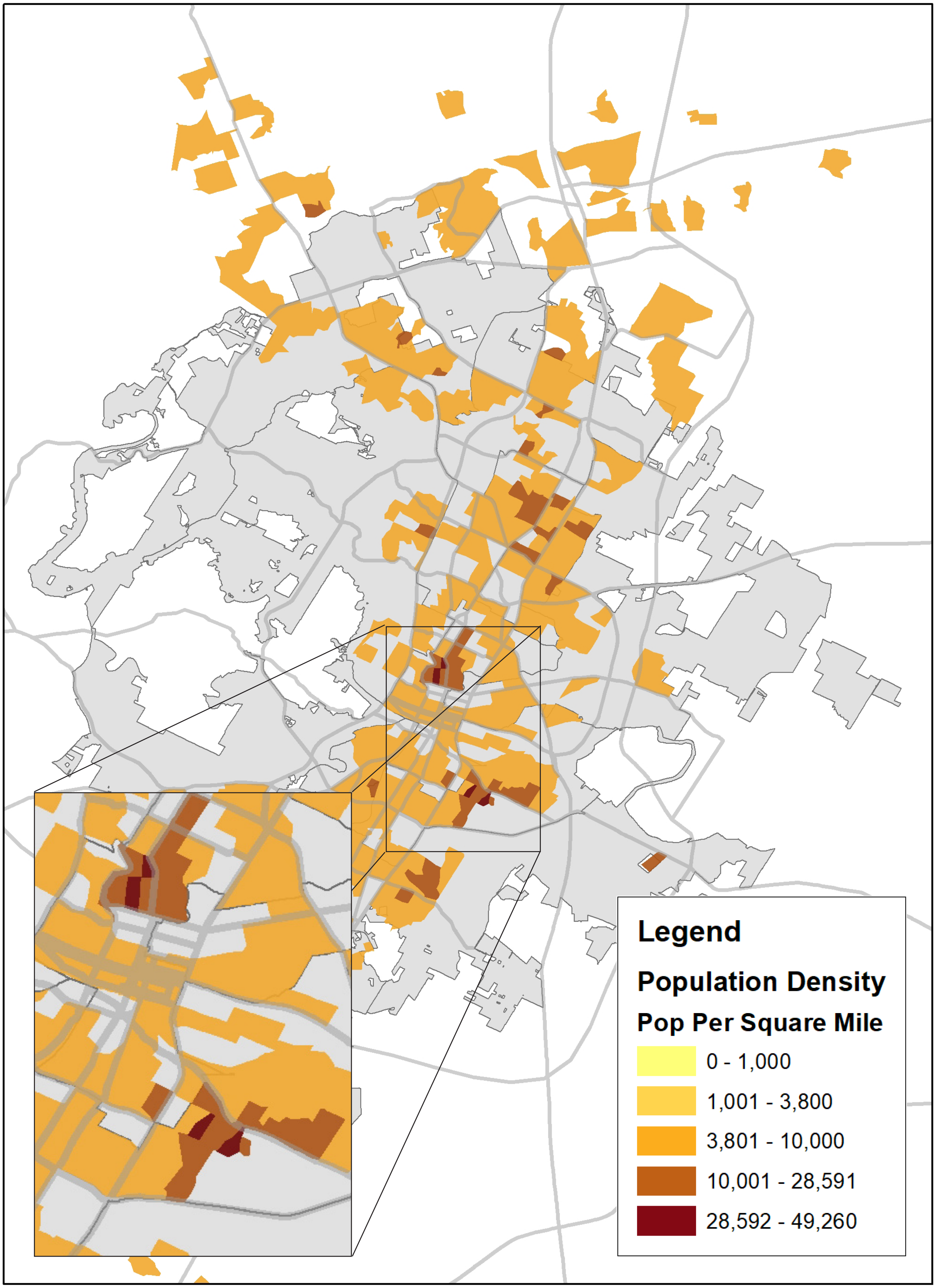
We would expect those living in car-dependent, low density housing to spend more on transportation. The map on the left shows urban, sub-urban, and rural portions of the Austin region as defined by standard density measures.

Our astonishing discovery is that today it is on average more affordable to live in the urban areas of Austin than in suburban and rural, not just in terms of transportation, but also housing costs. Urban Austinites spend 45% of the typical regional median income on housing and transportation. This number rises to 52% in sub-urban Austin, and 55% in the rural, least dense parts of the region. These figures challenge conventional notions of affordability.

Average Housing + Transportation Costs as a Percent of Regional Typical Income in the Three Austins

	H+T	H	T
Urban	45%	25%	20%
Sub-urban	52%	31%	21%
Rural	55%	30%	25%

Many public policy decisions impact the amount of people realistically able to live in these three Austins. We should make those with a better understanding of the housing + transportation affordability implications.



Legend
Population Density
Pop Per Square Mile
0 - 1,000
1,001 - 3,800
3,801 - 10,000
10,001 - 28,591
28,592 - 49,260

Urban Austin

Places that are home to over 3,800 people per square mile

Numbers in black represent all urban areas, followed by particularly dense regions of 10,000-28,590 people per square mile and super urban areas home to over 25,000 per square mile.

People
735,659 109,982 11,434

Households
272,582 33,422 3,296

Average Housing + Transportation Costs as % of Regional Typical Income
45% 36% 39%

Renter-occupied households
154,813 28,097 3,245

% of households that rent
57% 84% 98%

% of city's renters
52% 9% 1%

Average household size
2.7 3.3 3.5

Total Vehicle Miles Traveled (millions)
5,206 534 45

VMT per capita
7,078 4,852 3,909

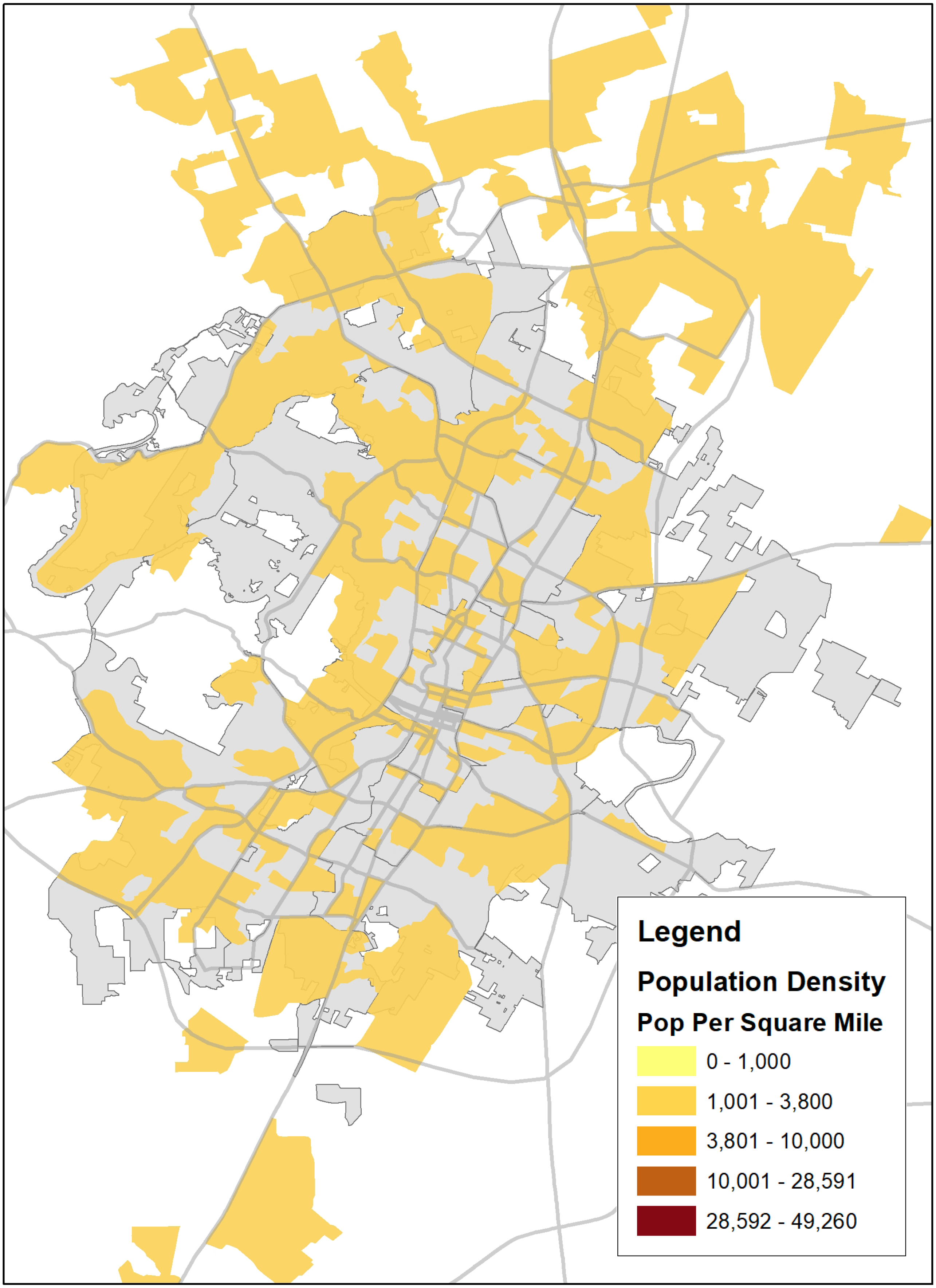
Total Annual CO2 emissions from household transportation use
2,157,910 215,205 15,923

CO2 emissions per capita
2.93 1.96 1.39

Total square miles
118 7.8 0.3

The darkest regions on the map (left) have the highest residential density in Austin, including sections of West Campus and Pleasant Valley. These fare the most green parts of our region, and perhaps of all of Texas, in terms of the greenhouse gas emissions from transportation - one of the elements of the climate change crisis most squarely a responsibility of local government.

In the coming decades, a substantial portion of Austin may graduate into areas of complex, mixed-use, mixed-income high density, but the extent to which many more Austinites of all income levels are allowed options for healthy, low carbon lifestyles will depend upon two as-of-yet undecided major initiatives: CodeNEXT and the 2045 Regional Transportation Plan.


Legend
Population Density
Pop Per Square Mile
0 - 1,000
1,001 - 3,800
3,801 - 10,000
10,001 - 28,591
28,592 - 49,260

Sub-urban Austin

Places that are home to 1,000 - 3,800 people per square mile

People
672,614

Households
251,433

Average Housing + Transportation Costs as % of Regional Typical Income
52%

Renter-occupied households
96,084

% of households that rent
38%

% of city's renters
32%

Average household size
2.7

Total Vehicle Miles Traveled (millions)
5,568,521,504

VMT per capita
8,279

Total Annual CO2 emissions from household transportation use
2,310,421

CO2 emissions per capita
3.43

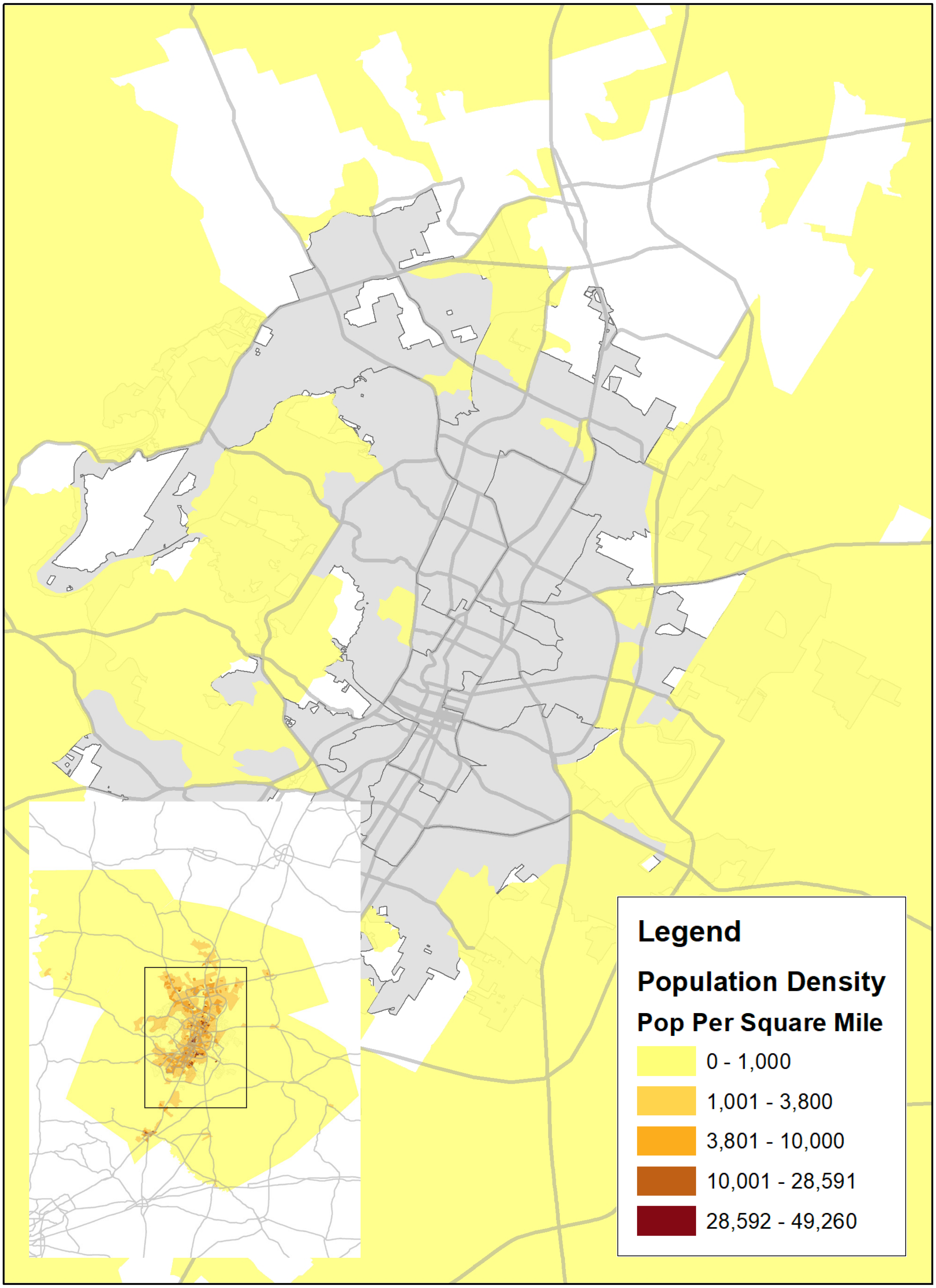
Total square miles
348

Sub-urban Austin is an economically diverse place, with low- and moderate-income neighborhoods alongside the expensive car-dependent neighborhoods of the hill country on the west side. All inhabitants of sub-urban Austin share a high cost of transportation.

A citizen would have to spend 21.47% of their income on transportation to live in sub-urban Austin, compared to 19.65% in urban Austin or 15.31% in super-urban Austin. Interestingly, sub-urban Austin is also more expensive in terms of housing, with average households spending 30.6% of their income on housing compared to 26.2% in urban areas.

Sub-urban Austin also has smaller household sizes, higher carbon footprints, and more vehicle miles traveled than urban Austin.

Austin's sub-urbanites drive twice as much as residents of the very high density areas of West Campus and Pleasant Valley.


Legend
Population Density
Pop Per Square Mile
0 - 1,000
1,001 - 3,800
3,801 - 10,000
10,001 - 28,591
28,592 - 49,260

Rural Austin

Places that are home to fewer than 1,000 people per square mile

People
592,217

Households
207,080

Average Housing + Transportation Costs as a % of Regional Typical Income
55%

Renter-occupied households
96,083

% of households that rent
23%

% of city's renters
16%

Average household size
2.9

Total Vehicle Miles Traveled (millions)
5,236,638,780

VMT per capita
8,842

Total Annual CO2 emissions from household transportation use
2,186,908

CO2 emissions per capita
3.69

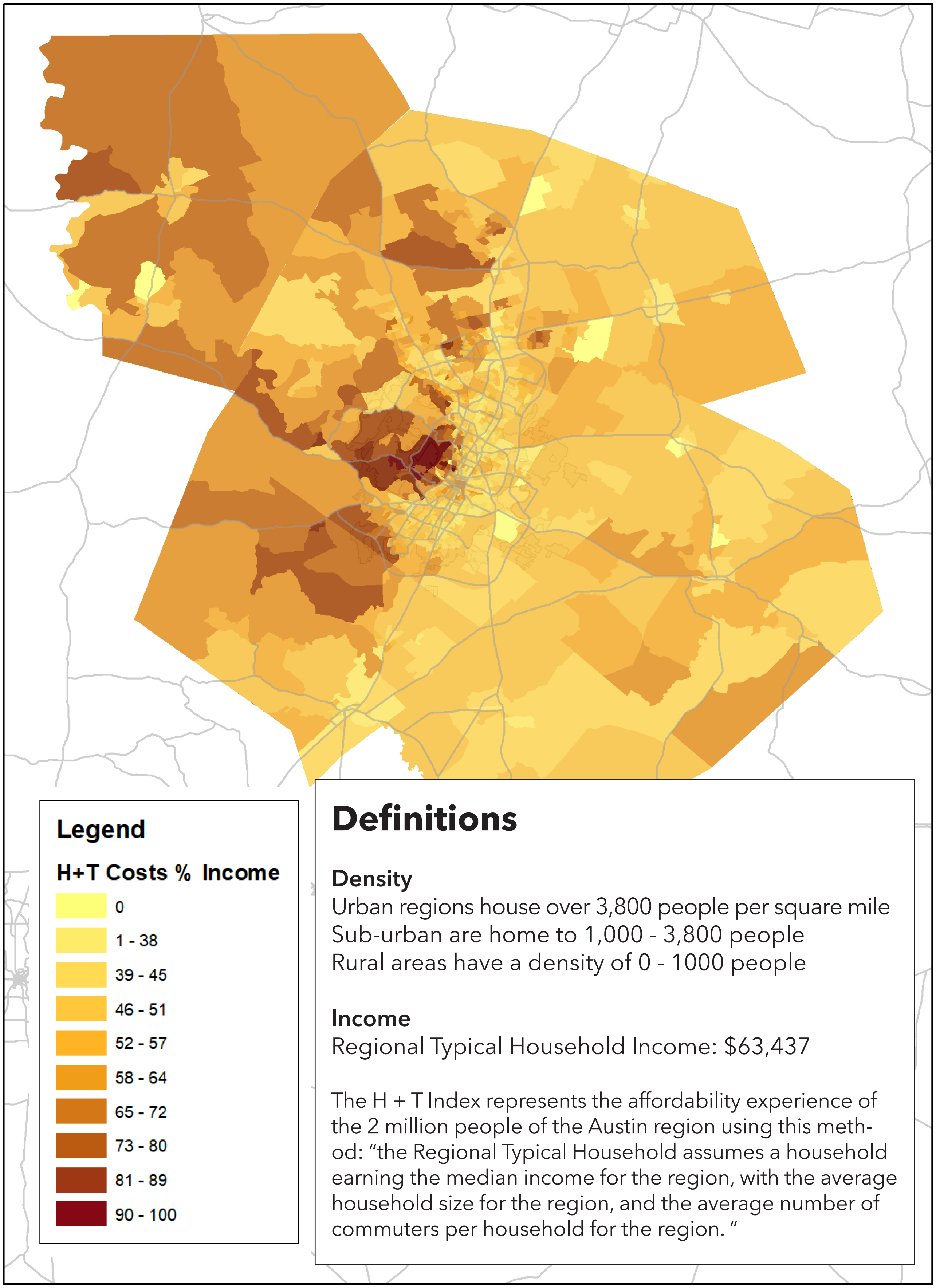
Total square miles
8,747

Rural Austin has equivalent housing costs as sub-urban Austin, requiring roughly 30% of regional typical family income. However, rural Austin has the highest transportation costs at 25.19% of regional typical family income.

Rural Austin drives the most and is responsible for the most carbon emissions per capita from household transportation. The costs of transportation are 65% higher for rural Austin than for the residents of the most dense part of the Austin region.

The proportion of the Austin metro area population who live in these very low density situations seems unique for Texas. Identical analysis was done on the Houston metro region, finding that 14% of Houstonians live in rural settings, compared to 30% of the residents of the Austin region.

This perhaps is a significant explanation for why the Austin region has a much higher rate of vehicle miles traveled and traffic deaths than Houston and most other Texas metros.



Definitions

Density
Urban regions house over 3,800 people per square mile
Sub-urban are home to 1,000 - 3,800 people
Rural areas have a density of 0 - 1000 people

Income
Regional Typical Household Income: $63,437

The H + T Index represents the affordability experience of the 2 million people of the Austin region using this method: "the Regional Typical Household assumes a household earning the median income for the region, with the average household size for the region, and the average number of commuters per household for the region. "

CNT H+T Index

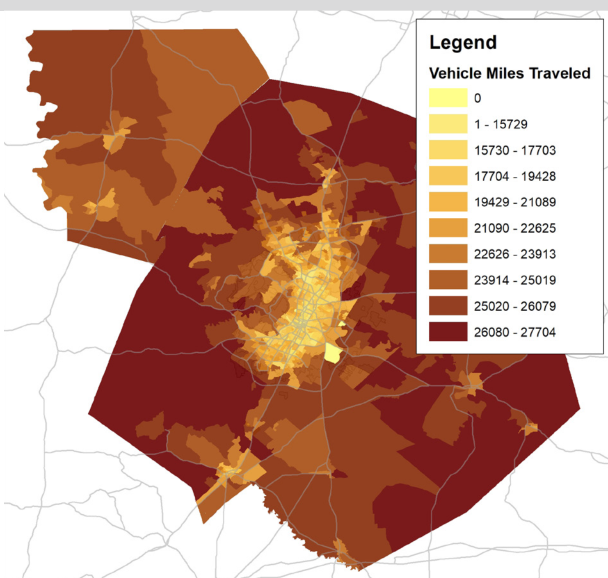
The data this report is based upon is readily available on-line for all to use.

All of the maps and data in this report are derived from the Center for Neighborhood Technology's Housing and Transportation Index project. We believe this index is perhaps one of the most important and underused tool available on the Internet for urban planning, transportation, affordability, and environmental policies in American metropolitan regions.

The map to the left, enlarged on the next page, is the housing + transportation affordability map of the Austin region. Accounting for transportation as well as housing costs presents a dramatically different picture than many of the predominant narratives about affordability. For example, the map reveals no truly affordable neighborhoods in Manor. Most affordable housing in the Austin region remains in the City of Austin, where location efficiency means dramatic reductions in transportation costs.

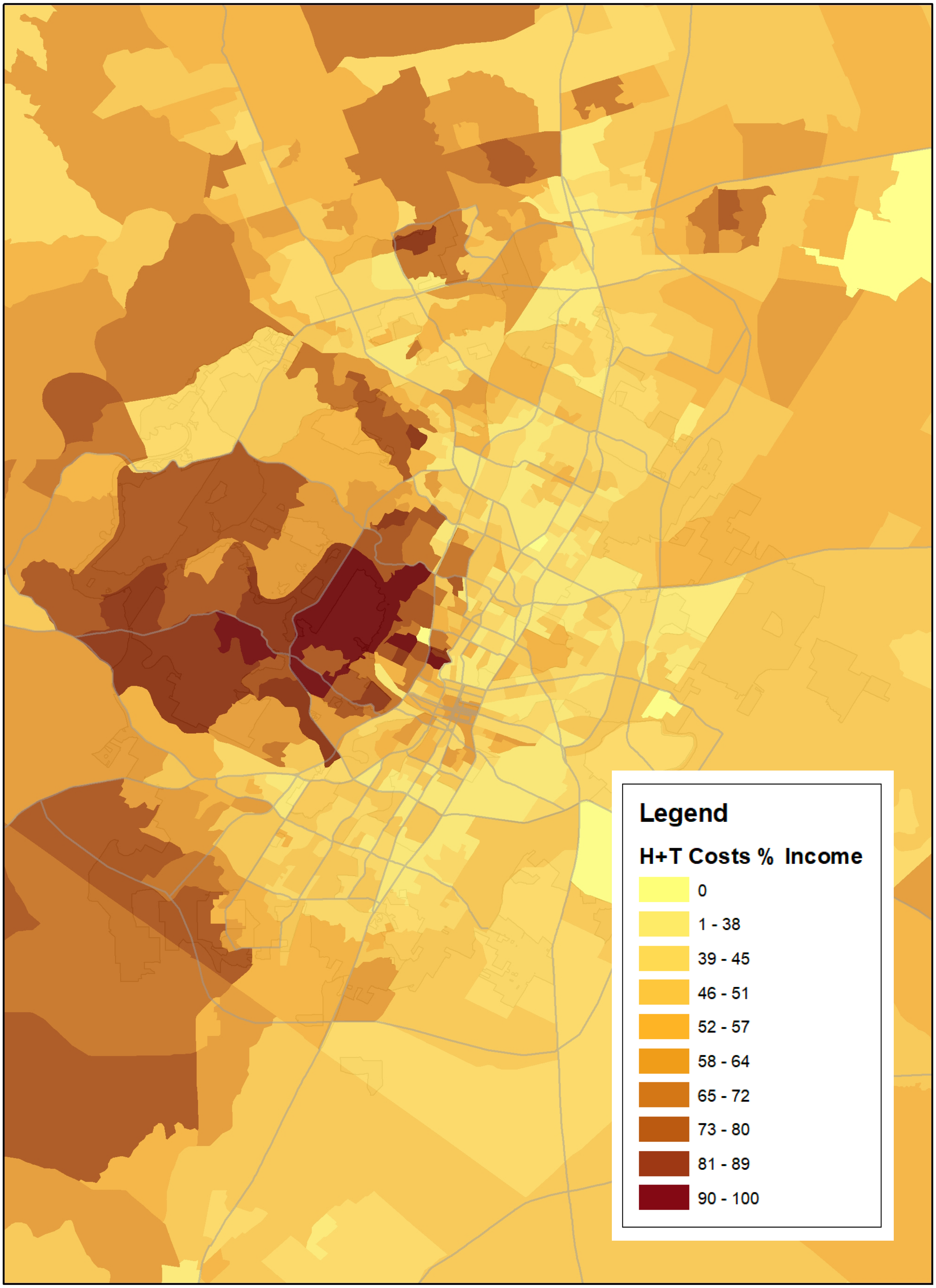
Location efficiency can and should be integrated in all housing and transportation-related public policies as well as private programs, such as websites related to realty and finding new housing. Regional growth policies such as CodeNEXT or the 2045 Regional Transportation Plan should fully integrate this view of affordability to give as many people as possible access to affordable housing options with better access.

Check out the CNT H+T Index yourself here: https://htaindex.cnt.org



The amount people drive is dictated by where they live. It accounts for more than our work commutes, which make up only 15% of total trips. If citizens can't walk to a park, to dinner, or to retail stores from their house, they make another trip in the car.

We can reduce this reliance on driving by improving location efficiency through optimized housing, planning, development, and transportation policy.


Legend
H+T Costs % Income
0
1 - 38
39 - 45
46 - 51
52 - 57
58 - 64
65 - 72
73 - 80
81 - 89
90 - 100

Location-Efficient Solutions

Meaningful affordability will require myriad wise policy choices. Here are some.

Austin is experiencing an affordability crisis. Debate over potential solutions rages at city hall, neighborhood association meetings, and throughout the city. We support the following strategies for regional decision makers to consider to help the people of Austin:

Location-efficient mortgages

As this report details, driving is expensive. Individual consumers feel the immediate financial impact, but the rest of society pays in congestion, reduced air quality, and the immeasurable suffering wrought by traffic injuries and fatalities, not to mention the heavy, and generally unaccounted for public costs.

Foregoing ownership of a single car allows Austinites to afford an estimated additional $100,000 of a mortgage. Explicit policies enabling location-efficient mortgages would allow greater choice in housing location, allowing families to get by with just one car, and to instead invest the fuel and perishable asset budget into housing equity.

Better Transit and More Transit Funding

People without cars still need to get around. People with cars deserve options for safe, multimodal transportation to reduce car trips. High-quality, frequent public transportation makes the city accessible and affordable to all, yet Texas radically limits its cities with poor transportation funding policies.

Allowing more people to live in the City of Austin through CodeNEXT

The region is projected to grow by 699,552 people over next 10 years. Who will be allowed to live in the city, and thus benefit from the affordable multimodal transportation options, is determined by zoning.

The current land use code allows 192,099 additional residents in the city's center; CodeNEXT Draft 3 increased this projection to 369,348. This is more closely examined in another of our Growing Weirder reports.

Funding affordable housing through Tax Increment Finance Zones

As suggested by the Austin nonprofit Community Not Commodity and Council Member Greg Casar, allocating increased tax revenue towards the establishment and maintenance of affordable housing could provide one targeted funding source for improvements. We are working on a TIF proposal to fund light rail on Guadalupe integrated with affordable housing.

Equitable Transit-Oriented Development

Transit-Oriented Development is recognition of the intersecting impacts of different aspects of land use. Our complementary report on an ETOD fund showcases the tremendous potential benefits of planning for equitable growth.

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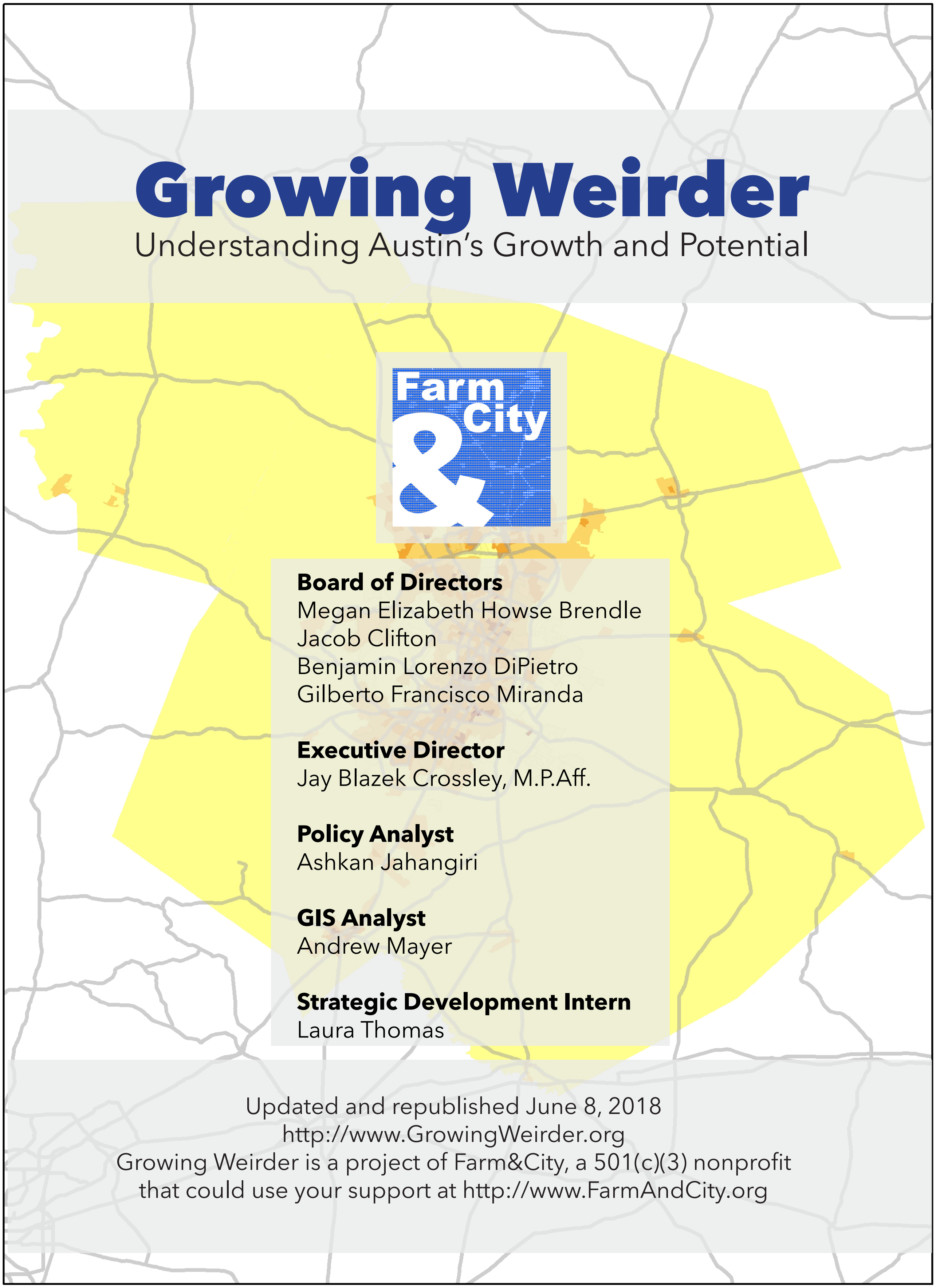

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The high impervious surface costs of Austin's current zoning scheme

February 8, 2018 Ashkan Jahangiri

In December, the City of Austin Watershed Department released a memo that looks at the impervious surface impacts of two alternatives: keeping current zoning or switching to the draft CodeNEXT V.2. They looked at the expected impervious surface in the full buildout scenario – meaning that every entitlement would be used up – something that never happens. But it provides a useful way to compare two plans for future growth.

And so far it seems most discussions of this memo completely miss the powerful findings.

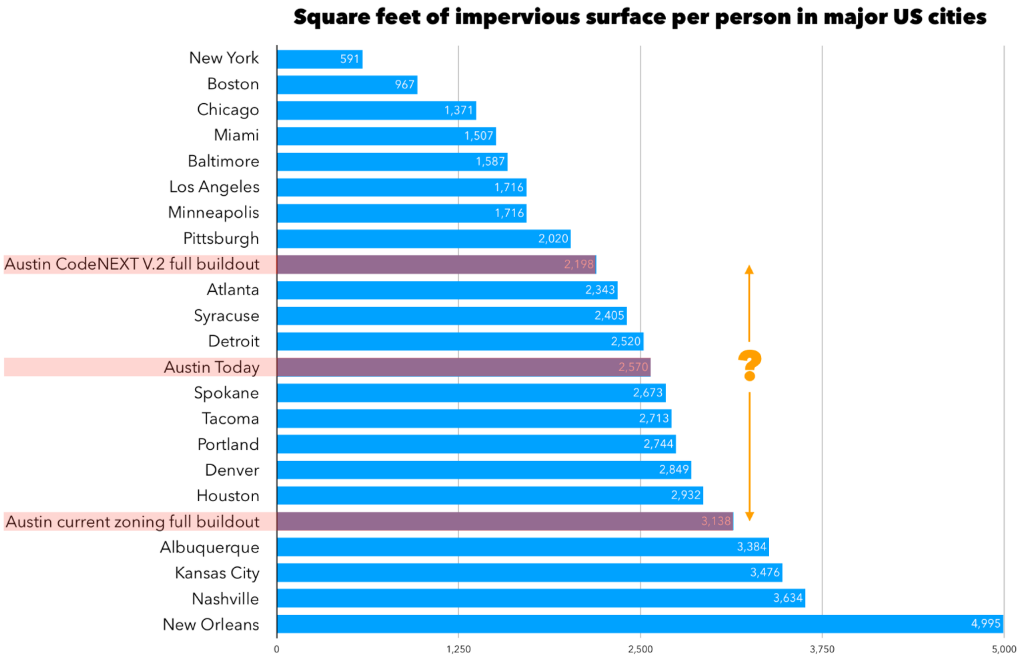
Their conclusion was that the proposed CodeNEXT V.2 was a slight improvement over current zoning, with about 1,200 less acres of land paved over in the city or about 1% of the city left open rather than paved, because of the change.

This is already a very strong rebuke of any claims that keeping the current zoning is good for flooding or environmentally friendly.

However, we can go further, because these two scenarios actually mean quite different things in terms of the numbers of people allowed to live in the City of Austin. Allowing more people to live in the City of Austin not only is the most significant step we can make to counter displacement, but also has a tremendous environmental advantage.

When we take the different future populations into account, we see that these two paths represent dramatically different future impervious surface per capita for the people of the City of Austin and the region. In these two scenarios, the CodeNEXT V.2 future would

mean each resident of the City of Austin were responsible for almost 1,000 less square feet of impervious surface, compared to the future we expect if we keep the current zoning scheme.



There are also regional impervious surface benefits of this shift just inside the City of Austin toward more sustainable compact, connected development. If a lot more people lived inside the City of Austin, thus not living the high impervious surface per capita lifestyle that most new housing in our region outside the city of Austin provides, the total regional effects would be dramatic. And these benefits are not captured in this current analysis. So we could similarly go further with this argument and intend to do so.

But this chart is already a very strong rebuke to anyone pretending to claim environmental or flooding or water quality (or heat island) reasons to argue against CodeNEXT in favor of keeping the current zoning code that has caused so many localized flooding problems for Austin.

Join us Friday, February 16 for the 3rd of 4 events in the Growing Weirder Breakfast Seriesto talk about this and other environmental sustainability issues related to regional growth, CodeNEXT, and the regional transportation plan. Get your tickets today.

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Ashkan Jahangiri

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United States Environmental Protection Agency

EPA 231-R-06-001
January 2006
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PROTECTING WATER RESOURCES WITH HIGHER-DENSITY DEVELOPMENT

Office of Sustainable Communities
Smart Growth Program

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To request additional copies of this report, contact EPA's National Service Center for Environmental Publications at 800-490-9198 or by email at [redacted] and ask for publication number 231-R-06-001.

To access this report online, visit <www.epa.gov/smartgrowth> or <www.smartgrowth.org>.

Front cover photos:

Left: The Snake River flows outside Jackson, Wyoming. Photo courtesy of USDA NRCS.
Top right: Rosslyn-Ballston Corridor, Arlington County, Virginia. Arlington County Department of Community Planning, Housing, and Development received a 2002 National Award for Smart Growth Achievement in the Overall Excellence category for its planning efforts in the Rosslyn-Ballston Corridor. Photo courtesy of Arlington County.
Middle right: People gather at Pioneer Square in Portland, Oregon. Photo courtesy of US EPA.

Back cover photos:

Top left: This hillside in Northern California is covered by wildflowers. This open space provides habitat to wildlife as well as serving important watershed services. Photo courtesy of USDA NRCS.
Middle left: A family enjoys open space in central Iowa. Photo courtesy of USDA NRCS.
Bottom left: A stream flows through western Maryland. Photo courtesy of USDA NRCS.
Right: This redevelopment site in Arlington, Virginia, which includes stores, apartments townhomes, single family homes, parking garages, and a one-acre public park, was formerly a large department store surrounded by surface parking. Photo courtesy of US EPA.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

Dear Colleague:

We are excited to share with you the enclosed report, *Protecting Water Resources with Higher-Density Development*. For most of EPA's 35-year history, policymakers have focused on regulatory and technological approaches to reducing pollution. These efforts have met with significant success. But, the environmental challenges of the 21st century require new solutions, and our approach to environmental protection must become more sophisticated. One approach is to partner with communities to provide them with the tools and information necessary to address current environmental challenges. It is our belief that good environmental information is necessary to make sound decisions. This report strives to meet that goal by providing fresh information and perspectives.

Our regions, cities, towns, and neighborhoods are growing. Every day, new buildings or houses are proposed, planned, and built. Local governments, working with planners, citizen groups, and developers, are thinking about where and how this new development can enhance existing neighborhoods and also protect the community's natural environment. They are identifying the characteristics of development that can build vibrant neighborhoods, rich in natural and historic assets, with jobs, housing, and amenities for all types of people. They are directing growth to maintain and improve the buildings and infrastructure in which they have already invested.

In addition to enjoying the many benefits of growth, communities are also grappling with growth's challenges, including development's impact on water resources. In the face of increasing challenges from non-point source pollution, local governments are looking for, and using, policies, tools, and information that enhance existing neighborhoods and protect water resources. This report gives communities a different perspective and set of information to address the complex interactions between development and water quality.

Protecting Water Resources with Higher-Density Development is intended for water quality professionals, communities, local governments, and state and regional planners who are grappling with protecting or enhancing their water resources while accommodating growing populations. We hope that you find this report informative as your community strives to enjoy the many benefits of growth and development and cleaner water.

For additional free copies, please send an e-mail to [redacted] or call (800) 490-9198 and request EPA publication 231-R-06-001. If you have any questions concerning this study, please do not hesitate to contact Lynn Richards at (202) 566-2858.

Sincerely,

Ben Grumbles
Assistant Administrator
Office of Water

Brian F. Mannix
Associate Administrator
Office of Policy, Economics, and Innovation

Protecting Water Resources with Higher-Density Development

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Executive Summary

Growth and development expand communities' opportunities by bringing in new residents, businesses, and investments. Growth can give a community the resources to revitalize a downtown, refurbish a main street, build new schools, and develop vibrant places to live, work, shop, and play. However, with the benefits come challenges. The environmental impacts of development can make it more difficult for communities to protect their natural resources. Where and how communities accommodate growth has a profound impact on the quality of their streams, rivers, lakes, and beaches. Development that uses land efficiently and protects undisturbed natural lands allows a community to grow and still protect its water resources.

The U.S. Census Bureau projects that the U.S. population will grow by 50 million people, or approximately 18 percent, between 2000 and 2020. Many communities are asking where and how they can accommodate this growth while maintaining and improving their water resources. Some communities have interpreted water-quality research to mean that low-density development will best protect water resources. However, some water-quality experts argue that this strategy can backfire and actually harm water resources. Higher-density development, they believe, may be a better way to protect water resources. This study intends to help guide communities through this debate to better understand the impacts of high- and low-density development on water resources.

To more fully explore this issue, EPA modeled three scenarios of different densities at three scales—one-acre level, lot level, and watershed level—and at three different time series build-out examples to examine the premise that lower-density development is always better for water quality. EPA examined stormwater runoff from different development densities to determine the comparative difference between scenarios. This analysis demonstrated:

- The higher-density scenarios generate less stormwater runoff per house at all scales—one acre, lot, and watershed—and time series build-out examples;
- For the same amount of development, higher-density development produces less runoff and less impervious cover than low-density development; and
- For a given amount of growth, lower-density development impacts more of the watershed.

Taken together, these findings indicate that low-density development may not always be the preferred strategy for protecting water resources. Higher densities may better protect water quality—especially at the lot and watershed levels. To accommodate the same number of houses, denser developments consume less land than lower density developments. Consuming less land means creating less impervious cover in the watershed. EPA believes that increasing development densities is one strategy communities can use to minimize regional water quality impacts. To fully protect water resources, communities need to employ a wide range of land use strategies, based on local factors, including building a range of development densities, incorporating adequate open space, preserving critical ecological and buffer areas, and minimizing land disturbance.

Introduction

Growth and development expand communities' opportunities by bringing in new residents, businesses, and investments. Growth can give a community the resources to revitalize a downtown, refurbish a main street, build new schools, and develop vibrant places to live, work, shop, and play. However, with the benefits come challenges. The environmental impacts of development can make it more difficult for communities to protect their natural resources. Where and how communities accommodate growth has a profound impact on the quality of their streams, rivers, lakes, and beaches. Development that uses land efficiently and protects undisturbed natural lands allows a community to grow and still protect its water resources.

Which is a better strategy to protect water quality: low- or high-density development?

The U.S. Census Bureau projects that the U.S. population will grow by 50 million people, or approximately 18 percent, between 2000 and 2020. Many communities are asking where and how they can accommodate this growth while maintaining and improving their water resources. Some communities have interpreted water-quality research to mean that low-density development will best protect water resources. However, some water-quality experts argue that this strategy can backfire and actually harm water resources. Higher-density development, they believe, may be a better way to protect water resources. This study intends to help guide communities through this debate to better understand the impacts of high- and low-density development on water resources.

Virtually every metropolitan area in the United States has expanded substantially in land area in recent decades. According to the U.S. Department of Agriculture's National Resources Inventory (NRI), between 1954 and 1997, urban land area almost quadrupled, from 18.6 million acres to about 74 million acres in the contiguous 48 states (USDA, 1997b). From 1982 to 1997, when population in the contiguous United States grew by about 15 percent, developed land increased by 25 million acres, or 34 percent. Most of this growth is taking place at the edge of developed areas, on greenfield sites, which can include forestland, meadows, pasture, and rangeland (USDA, 1997a). Indeed, in one analysis of building permits in 22 metropolitan areas between 1989 and 1998, approximately 95 percent of building permits were on greenfield sites (Farris, 2001).

Between 1954 and 1997, urban land area almost quadrupled, from 18.6 million acres to about 74 million acres in the contiguous 48 states.

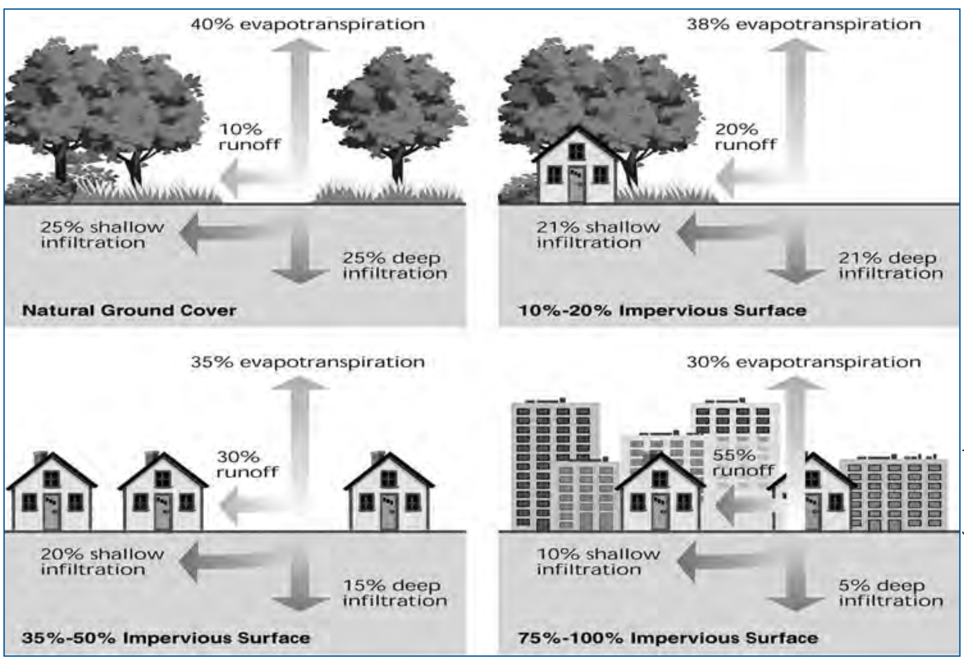
According to the American Housing Survey, 35 percent of new housing is built on lots between two and five acres, and the median lot size is just under one-half acre (Census, 2001). Local zoning may encourage building on relatively large lots, in part because local governments often believe that it helps protect their water quality. Indeed, research has revealed that more impervious cover can degrade water quality. Studies have demonstrated that at 10 percent imperviousness, a watershed is likely to become impaired and grows more so as imperviousness increases (Arnold, 1996; Schueler, 1994). This research has prompted many communities to adopt low-density zoning and site-level imperviousness limits, e.g., establishing a percentage of the site, such as 10 or 20 percent, that can be covered by impervious surfaces such as houses, garages, and driveways. These types of zoning and development ordinances are biased against higher-density development because it has more impervious cover. But do low-density approaches protect our water resources?

This study examines the assumption that low-density development is always better for water quality.[1] EPA modeled stormwater runoff from different development densities at the site level and then extrapolated and analyzed these findings at the watershed level. Modeling results were used to compare stormwater runoff associated with several variations of residential density.

Impacts from Development on Watershed Functions

A watershed is a land area that drains to a given body of water. Precipitation that falls in the watershed will either infiltrate into the ground, evapotranspirate back into the air, or run off into streams, lakes, or coastal waters. This dynamic is described in Exhibit 1.

EXHIBIT 1: Watershed Services



Graphic courtesy of U.S. EPA

As land cover changes, so does the amount of precipitation that absorbs into the ground, evaporates into the air, or runs off.

A watershed may be large or small. The Mississippi River, for example, drains a one-million-square-mile watershed made up of thousands of smaller watersheds, such as the drainage basins of the creeks that flow into tributaries of the Mississippi. In smaller watersheds, a few acres of land may drain into small streams, which flow into larger streams or rivers; the lands drained by these streams or rivers make up a larger watershed. These streams support

[1] Stormwater runoff was used as a proxy for overall water quality. In general, the more stormwater runoff a region experiences, the more associated pollutants, such as total nitrogen, phosphorus, and suspended solids, will enter receiving waterbodies.

diverse aquatic communities and perform the vital ecological roles of processing the carbon, sediments, and nutrients upon which downstream ecosystems depend. Healthy, functioning watersheds naturally filter pollutants and moderate water quality by slowing surface runoff and increasing the infiltration of water into soil. The result is less flooding and soil erosion, cleaner water downstream, and greater ground water reserves.

Land development directly affects watershed functions. When development occurs in previously undeveloped areas, the resulting alterations to the land can dramatically change how water is transported and stored. Residential and commercial development create impervious surfaces and compacted soils that filter less water, which increases surface runoff and decreases ground water infiltration. These changes can increase the volume and velocity of runoff, the frequency and severity of flooding, and peak storm flows.

Moreover, during construction, exposed sediments and construction materials can be washed into storm drains or directly into nearby bodies of water. After construction, development usually replaces native meadows, forested areas, and other natural landscape features with compacted lawns, pavement, and rooftops. These largely impervious surfaces generate substantial runoff. For these reasons, limiting or minimizing the amount of land disturbed and impervious cover created during development can help protect water quality.

Critical Land Use Components for Protecting Water Quality for Both Low- and High-Density Development

What strategies can communities use to continue to grow while protecting their water quality? Watershed hydrology suggests that three primary land use strategies can help to ensure adequate water resource protection:

- Preserve large, continuous areas of absorbent open space;
- Preserve critical ecological areas, such as wetlands, floodplains, and riparian corridors; and
- Minimize overall land disturbance and impervious surface associated with development.

These approaches work because, from a watershed perspective, different land areas have different levels of ecological value. For example, a nutrient-rich floodplain has a higher ecological value than a grass meadow. Communities should view these strategies as basic steps to preserve watershed function and as the framework within which all development occurs.

Preserving Open Space

Preserving open space is critical to maintaining water quality at the regional level. Large, continuous areas of open space reduce and slow runoff, absorb sediments, serve as flood control, and help maintain aquatic communities. To ensure well-functioning watersheds, regions should set aside sufficient amounts of undisturbed, open space to absorb, filter, and store rainwater. In most regions, this undeveloped land comprises large portions of a watershed, filtering out trash, debris, and chemical pollutants before they enter a community's water system. Open space provides other benefits, including habitat for plants and animals, recreational opportunities, forest and ranch land, places of natural beauty, and community recreation areas.

To protect these benefits, some communities are preserving undeveloped parcels or regional swaths of open space. One of the most dramatic examples is the New York City Watershed Agreement. New York City, New York State, over 70 towns, eight counties, and EPA signed the agreement to support an enhanced watershed protection program for the New York City drinking water supply. The city-funded, multi-year, $1.4-billion agreement developed a multi-faceted land conservation approach, which includes the purchase of 80,000 acres within the watershed as a buffer around the city's drinking water supply. This plan allows the city to avoid the construction of filtration facilities estimated to cost six to eight billion dollars (New York City, 2002).

Preserving Ecologically Sensitive Areas

Some types of land perform watershed functions better than others do. Preserving ecologically important land, such as wetlands, buffer zones, riparian corridors, and floodplains, is critical for regional water quality. Wetlands are natural filtration plants, slowing water flow and allowing sediments to settle and the water to clarify. Trace metals bound to clay carried in runoff also drop out and become sequestered in the soils and peat at the bed of the marsh instead of entering waterbodies, such as streams, lakes, or rivers. Preserving and maintaining wetlands are critical to maintain water quality.

Photo courtesy of USDA NRCS

Wetlands, such as this one in Butte County, California, provide critical watershed services for the region.

In addition, strips of vegetation along streams and around reservoirs are important buffers, with wooded buffers offering the greatest protection. For example, if soil conditions are right, a 20- to 30-foot-wide strip of woodland removes 90 percent of the nitrates in stormwater runoff (Trust for Public Land, 1997). These buffer zones decrease the amount of pollution entering the water system. Tree and shrub roots hold the bank in place, preventing erosion and its resulting sedimentation and turbidity. Organic matter and grasses slow the flow of runoff, giving the sediment time to settle and water time to percolate, filter through the soil, and recharge underlying ground water. Research has shown that wetlands and buffer zones, by slowing and holding water, increase ground water recharge, which directly reduces the potential for flooding (Schueler, 1994). By identifying and preserving these critical ecological areas, communities are actively protecting and enhancing their water quality.

Minimizing Land Disturbance and Impervious Cover

Minimizing land disturbance and impervious cover is critical to maintaining watershed health. The amount of land that is converted, or "disturbed," from undeveloped uses, such as forests and meadows, to developed uses, such as lawns and playing fields, significantly affects watershed health. Research now shows that the volume of runoff from highly compacted lawns is almost as high as from paved surfaces (Schueler, 1995, 2000; USDA, 2001). This research indicates that lawns and other residential landscape features do not function, with regard to water, in the same way as nondegraded natural areas. In part, the difference arises because developing land in greenfield areas involves wholesale grading of the site and removal of topsoil, which can lead to severe erosion during construction, and soil compaction by heavy equipment. However, most communities focus not on total land disturbed, but on the amount of impervious cover created.

Photo courtesy of USDA NRCS

Current construction practices generally disturb the entire development site, as shown by this site in Des Moines, Iowa.

Research has revealed a strong relationship between impervious cover and water quality (Arnold, 1996; Schueler, 1994; EPA, 1997). Impervious surfaces collect and accumulate pollutants deposited from the atmosphere, leaked from vehicles, or derived from other sources. During storms, accumulated pollutants are quickly washed off and rapidly delivered to aquatic systems. Studies have demonstrated that at 10 percent imperviousness,[2] a watershed is likely to become impaired (Schueler, 1996; Caraco, 1998; Montgomery County, 2000), the stream channel becomes unstable due to increased water volumes and stream bank erosion, and water quality and stream biodiversity decrease. At 25 percent imperviousness, a watershed becomes severely impaired, the stream channel can become highly unstable, and water quality and stream biodiversity are poor[3] (Schueler, 2000). The amount of impervious cover is an important indicator of watershed health, and managing the degree to which a watershed is developed is critical to maintaining watershed function.

Although the 10 percent threshold refers to overall imperviousness within the watershed, municipalities have applied it to individual sites within the watershed, believing that lower densities better protect watershed functions. Indeed, as mentioned earlier, some localities have gone so far as to create strong incentives for, or even require, low densities—with water resource protection as an explicit goal. These communities are attempting to minimize hard

[2] The 10 percent figure is not an absolute threshold. Recent studies have indicated that in some watersheds, serious degradation may begin well below 10 percent. However, the level at which watershed degradation begins is not the focus of this study. For purposes of our analysis, EPA uses the 10 percent threshold as an indicator that water resources might be impacted.

[3] There are different levels of impairment. In general, when the term is used in EPA publications, it usually means that a waterbody is not meeting its designated water quality standard. However, the term can also imply a decline or absence of biological integrity; for example, the waterbody can no longer sustain critical indicator species, such as trout or salmon. Further, there is a wide breadth of levels of impairment, from waterbodies that are unable to support endangered species to waterbodies that cannot support any of the beneficial-use designations.

surfaces at the site level. They believe that limiting densities within particular development sites limits regional imperviousness and thus protects regional water quality. The next section examines this proposition and finds that low-density development can, in fact, harm water quality.

Low-Density Development—Critiquing Conventional Wisdom

As discussed, studies have demonstrated that watersheds can suffer impairment at 10 percent impervious cover and that at 25 percent imperviousness, the watershed is typically considered severely impaired. Communities have often translated these findings into the notion that low-density development at the site level results in better water quality. Such conclusions often come from analysis such as: a one-acre site has one or two homes with a driveway and a road passing by the property. The remainder of the site is lawn. Assuming an average housing footprint of 2,265 square feet[4] (National Association of Home Builders, 2001), the impervious cover for this one-acre site is approximately 35 percent (Soil Conservation Service, 1986). By contrast, a higher-density scenario might have eight to 10 homes per acre and upwards of 85 percent impervious cover (Soil Conservation Service, 1986). The houses' footprints account for most of the impervious cover. Thus, low-density zoning appears to create less impervious cover, which ought to protect water quality at the site and regional levels. However, this logic overlooks several key caveats.

1. *The "pervious" surface left in low-density development often acts like impervious surface.* In general, impervious surfaces, such as a structure's footprint, driveways, and roads, have higher amounts of runoff and associated pollutants than pervious surfaces. However, most lawns, though pervious, still contribute to runoff because they are compacted. Lawns are thought to provide "open space" for infiltration of water. However, because of construction practices, the soil becomes compacted by heavy equipment and filling of depressions (Schueler, 1995, 2000). The effects of this compaction can remain for years and even increase due to mowing and the presence of a dense mat of roots. Therefore, a one- or two-acre lawn does not offer the same infiltration or other water quality functions as a one- or two-acre undisturbed forest. Minimizing impervious surfaces by limiting the number of houses but allowing larger lawns does not compensate for the loss of watershed services that the area provided before development (USDA, 2001).

   Lawns still contribute to runoff because they are compacted and disturbed.

2. *Density and imperviousness are not equivalent.* Depending on the design, two houses may actually create as much imperviousness as four houses. The impervious area per home can vary widely due to road infrastructure, housing design (single story or multistory), or length and width of driveways. To illustrate, a three-story condominium building of 10 units on one acre can have less impervious surface than four single-family homes on the same acre. Furthermore, treatment of the remaining undeveloped land on that acre can

[4] The average house built in 2001 included three or more bedrooms, two and a half baths, and a two-car garage.

vary dramatically between housing types. For example, in some dispersed, low-density communities, such as Fairfax County, Virginia, some homeowners are paving their front lawns to create more parking for their cars (Rein, 2002).

3. *Low-density developments often mean more off-site impervious infrastructure.* Development in the watershed is not simply the sum of the sites within it. Rather, total impervious area in a watershed is the sum of site developments plus the impervious surface associated with infrastructure supporting those sites, such as roads and parking lots. Lower-density development can require substantially higher amounts of this infrastructure per house and per acre than denser developments. Recent research has demonstrated that on sites with two homes per acre, impervious surfaces attributed to streets, driveways, and parking lots can represent upwards of 75 percent of the total site imperviousness (Cappiella, 2001). That number decreases to 56 percent on sites with eight homes per acre. This research indicates that low densities often require more off-site transportation-related impervious infrastructure, which is generally not included when calculating impervious cover.

> Water quality suffers not only from the increase in impervious surface, but also from the associated activities: construction, increased travel to and from the development, and extension of infrastructure.

   Furthermore, water quality suffers not only from the increase in impervious surface, but also from the associated activities: construction, increased travel to and from the development, extension of infrastructure, and chemical maintenance of the areas in and surrounding the development. Oil and other waste products, such as heavy metals, from motor vehicles, lawn fertilizers, and other common solvents, combined with the increased flow of runoff, contribute substantially to water pollution. As imperviousness increases, so do associated activities, thereby increasing the impact on water quality.

4. *If growth is coming to the region, limiting density on a given site does not eliminate that growth*. Density limits constrain the amount of development on a site but have little effect on the region's total growth (Pendall, 1999, 2000). The rest of the growth that was going to come to the region still comes, regardless of density limits in a particular place. Forecasting future population growth is a standard task for metropolitan planning organizations as they plan where and how to accommodate growth in their region. They project future population growth based on standard regional population modeling practices, where wage or amenity differentials, such as climate or culture (Mills, 1994)—and not zoning practices such as density limits—account for most of a metropolitan area's population gain or loss.[5] While estimates of future growth within a particular time frame are rarely precise, a region must use a fixed amount of growth to test the effects of adopting

> Growth is still coming to a region, regardless of density limits in a particular place.

[5] The most widely-used such model—the REMI® Policy Insight™ model—uses an amenity variable. However, even this is implemented as an additional change in the wage rate. See Remi Model Structure. <www.remi.com/Overview/Evaluation/Structure/structure.html>. The in-house model used by the San Diego Association of Governments is an advanced example of the type used by councils of governments around the country.<www.sandag.cog.ca.us/resources/demographics_and_other_data/demographics/forecasts/index.asp>.

different growth planning strategies because it still must understand the economic, social, and environmental impacts of accommodating a growing population. Absent regional coordination and planning, covering a large part of a region with density limits will likely drive growth to other parts of the region. Depending on local conditions, water quality may be more severely impaired than if the growth had been accommodated at higher densities on fewer sites.

Testing the Alternative: Can Compact Development Minimize Regional Water Quality Impacts?

To more fully understand the potential water quality impacts of different density levels, this section compares three hypothetical communities, each accommodating development at different densities—one house per acre, four houses per acre, and eight houses per acre.[6] To assess regional water quality impacts, EPA modeled the stormwater impacts from different development densities. In general, the more stormwater runoff generated within a region, the more associated pollutants, such as total nitrogen, phosphorus, and suspended solids, will enter receiving waterbodies. The three density levels capture some of the wide range of zoning practices in use throughout the country. All of these densities are consistent with single-family, detached housing. EPA examined the stormwater impacts from each density scenario at various scales of residential development[7]—one-acre, lot, and watershed levels—and through a 40-year time series build-out analysis.

The Model and Data Inputs

The model used to compare the stormwater impact from the scenarios is the Smart Growth Water Assessment Tool for Estimating Runoff (SG WATER), which is a peer-reviewed sketch model that was developed specifically to compare water quantity and quality differences among different development patterns (EPA, 2002). SG WATER's methodology is based on the Natural Resources Conservation Service (NRCS) curve numbers (Soil Conservation Service, 1986), event mean concentrations, and daily rainfall data.[8] The model requires the total number of acres developed at a certain development density. If density is unknown, total percent imperviousness can be used. The model was run using overall percent imperviousness.

EPA believes that the results presented here are conservative. SG WATER uses a general and simple methodology based on curve numbers. One limitation of curve numbers is that they tend to underestimate stormwater runoff for smaller storms (less than one inch). This underestimate

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[6] Densities at one, four, and eight residential units per acre are used here for illustrative purposes only. Many communities now are zoning for one unit per two acres at the low-density end of the spectrum. Low-density residential zoning exists in places as diverse as Franklin County, Ohio, which requires no less than two acres per unit <www.co.franklin.oh.us/development/franklin_co/LDR.html#304.041>) to Cobb County, Georgia, outside of Atlanta, which requires between one and two units per acre in its low-density residential districts (<www.cobb-county.org/community/plan_bza_commission.htm>). By comparison, some communities are beginning to allow higher densities, upwards of 20 units per acre. For example, the high-density residential district in Sonoma County, California permits between 12 and 20 units per acre (<www.sonoma-county.org/prmd/Zoning/article_24.htm>), and the city of Raleigh, North Carolina, allows up to 40 units per acre in planned development districts.

[7] This example and others throughout this study compare residential units, but a similar comparison including commercial development could also be done .

[8] Daily time-step rainfall data for a 10-year period (1992-2001, inclusive) were used.

can be significant since the majority of storms are small storms. In addition, the curve numbers tend to overestimate runoff for large storms. However, curve numbers more accurately predict runoff in areas with more impervious cover.[9] For the analysis here, the runoff from the low-density site is underestimated to a larger degree than the runoff from the higher-density site because the higher-density site has more impervious cover. Simply put, because of methodology, the difference in the numbers presented here is conservative—it is likely that the comparative difference in runoff between the sites would be greater if more extensive modeling were used.

To isolate the impacts that developing at different densities makes on stormwater runoff, EPA made several simplifying assumptions in the modeling:

- EPA modeled only residential growth and not any of the corresponding commercial, retail, or industrial growth that would occur in addition to home building. Moreover, EPA assumed that all the new growth would occur in greenfields (previously undeveloped land). Infill development, brownfield redevelopment, and other types of urban development were not taken into consideration, nor were multifamily housing, apartments, or accessory dwelling units.[10]
- The modeling did not take into account any secondary or tertiary impacts, such as additional stormwater benefits, that may be realized by appropriately locating the development within the watershed. For example, siting development away from headwaters, recharge areas, or riparian corridors could better protect these sensitive areas. Denser development makes this type of protective siting easier since less land is developed. However, these impacts are not captured or calculated within the modeling.
- Whether developed at one, four, or eight houses per acre, when one acre is developed, EPA assumed the entire acre is disturbed land (e.g., no forest or meadow cover would be preserved), which is consistent with current construction practices.
- All the new growth is assumed to be single-family, detached houses.[11] Whether developed at one, four, or eight houses per acre, each home has a footprint of 2,265 square feet, roughly the current average size for new houses (National Association of Home Builders, 2001).

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[9] Most existing stormwater models incorrectly predict flows associated with small rains in urban areas. Most existing urban runoff models originated from drainage and flooding evaluation procedures that emphasized very large rains (several inches in depth). These large storms contribute only very small portions of the annual average discharges. Moderate storms, occurring several times a year, are responsible for the majority of the pollutant discharges. These frequent discharges cause mostly chronic effects, such as contaminated sediment and frequent high flow rates, and the inter-event periods are not long enough to allow the receiving water conditions to recover.

[10] Single-family, detached housing dominates many low-density residential developments. However, higher-density developments support a range of housing types, including townhouses, apartments, and other forms of multifamily housing. These housing types generally have a smaller footprint per house than 2,265 square feet. Therefore, a more realistic situation for the higher-density scenarios would either be a smaller housing footprint or an increase in the number of homes accommodated on one acre. In either case, including these different housing types in the analysis would produce less overall stormwater runoff and less per house runoff for the higher-density scenarios.

[11] It is possible that when additional land uses, such as commercial, transportation, or recreation, are included in the analysis, the low-density scenarios become relatively less dense while the higher-density scenarios become relatively more dense. In general, low-density residential development tends to be associated with low-density commercial development, characterized by large retail spaces, wide roads, large parking lots, and minimal public transportation. Higher-density residential areas are more likely to have high-density commercial options, with smaller retail spaces, mixed land uses, narrower streets, parking garages, on-street parking, and sometimes a well-developed public transportation system, which can reduce parking needs.

- The same percentage of transportation-associated infrastructure, such as roads, parking lots, driveways, and sidewalks, is allocated to each community acre, based on the curve number methodology from the NRCS. For example, each scenario has the same width of road, but because the higher-density scenario is more compact, it requires fewer miles of roads than the lower-density scenarios. So while the same percentage is applied, the amounts differ by scenario. Collector roads or arterials that serve the development are not included.
- The modeled stormwater runoff quantity for each scenario is assumed to come from one hypothetical outfall.
- The model does not take into account wastewater or drinking water infrastructure, slope, or other hydrological interactions that the more complex water modeling tools use.

Summary of Scenarios

Example 1 examines the stormwater runoff impacts on a one-acre lot that accommodates one house (Scenario A), four houses (Scenario B), or eight houses (Scenario C). Example 2 expands the analysis to examine stormwater runoff impacts within a lot-level development that accommodates the same number of houses. Because of different development densities, this growth requires different amounts of land. Scenario A requires eight acres for eight houses, Scenario B requires two acres for eight houses, and Scenario C requires one acre for eight houses.

Examples 3, 4, and 5 explore the relationship between density and land consumption by building in a watershed at different densities. Again, different amounts of land are required to support the same amount of housing. Examples 6, 7, and 8 examine how the hypothetical community grows over a 40-year timeframe with different development densities.

The scenarios and scales of development are summarized in Exhibit 2. EPA expects to capture the differences in stormwater runoff associated with different development densities by using these three scenarios (Scenarios A, B, and C) at four different scales (one acre, lot, watershed, and build-out).

EXHIBIT 2: Summary of Scenarios

Scale of Analysis	Scenario A: One house per acre	Scenario B: Four houses per acre	Scenario C: Eight houses per acre
Example 1: One acre	1 house per acre	4 houses per acre	8 houses per acre
Example 2: Lot—Each development lot accommodates the same number of houses	8 houses built on 8 acres	8 houses built on 2 acres	8 houses built on 1 acre

Example 3: Watershed—Each 10,000-acre watershed accommodates the same number of houses	10,000 houses built on 10,000 acres	10,000 houses built on 2,500 acres or ¼ of the watershed	10,000 houses built on 1,250 acres or ⅛ of the watershed
Example 4: Watershed—Each 10,000-acre watershed is fully built out at different densities	10,000 houses built on 10,000 acres	40,000 houses built on 10,000 acres	80,000 houses built on 10,000 acres
Example 5: Watershed—Each scenario accommodates the same number of houses	80,000 houses consume 8 watersheds	80,000 houses consume 2 watersheds	80,000 houses consume 1 watershed
Example 6: Hypothetical build-out in the year 2000	10,000 houses built on 10,000 acres	10,000 houses built on 2,500 acres	10,000 houses built on 1,250 acres
Example 7: Hypothetical build-out in the year 2020	20,000 houses built on 20,000 acres, or 2 watersheds	20,000 houses built on 5,000 acres, or ½ of 1 watershed	20,000 houses built on 2,500 acres, or ¼ of 1 watershed
Example 8: Hypothetical build-out in the year 2040	40,000 houses built on 40,000 acres, or 4 watersheds	40,000 houses built on 10,000 acres, or 1 watershed	40,000 houses built on 5,000 acres, or ½ of 1 watershed

Before analyzing the impacts of these different scenarios, it is useful to clarify some underlying premises. This analysis assumes that:

1. Metropolitan regions will continue to grow. This assumption is consistent with U.S. Census Bureau projections that the U.S. population will grow by roughly 50 million people by 2020 (Census, 2000). Given this projected population growth, most communities across the country are or will be determining where and how to accommodate expected population increases in their regions.

2. Housing density affects the distribution of new growth within a given region, not the amount of growth. Individual states and regions grow at different rates depending on a variety of factors, including macroeconomic trends (e.g., the technology boom in the 1980s spurring development in the Silicon Valley region in California) and demographic shifts. Distribution and density of new development do not significantly affect these factors.

3. The model focuses on the comparative differences in stormwater runoff between scenarios, not absolute values. As discussed, using the curve number and event mean concentration approach can underestimate the total quantity of stormwater runoff for smaller storm events and in areas of lower densities. Because of this and other model simplifications discussed above, the analysis does not focus on the absolute value of stormwater runoff generated for each scenario but instead focuses on the comparative difference, or the delta, in runoff between scenarios.

Results

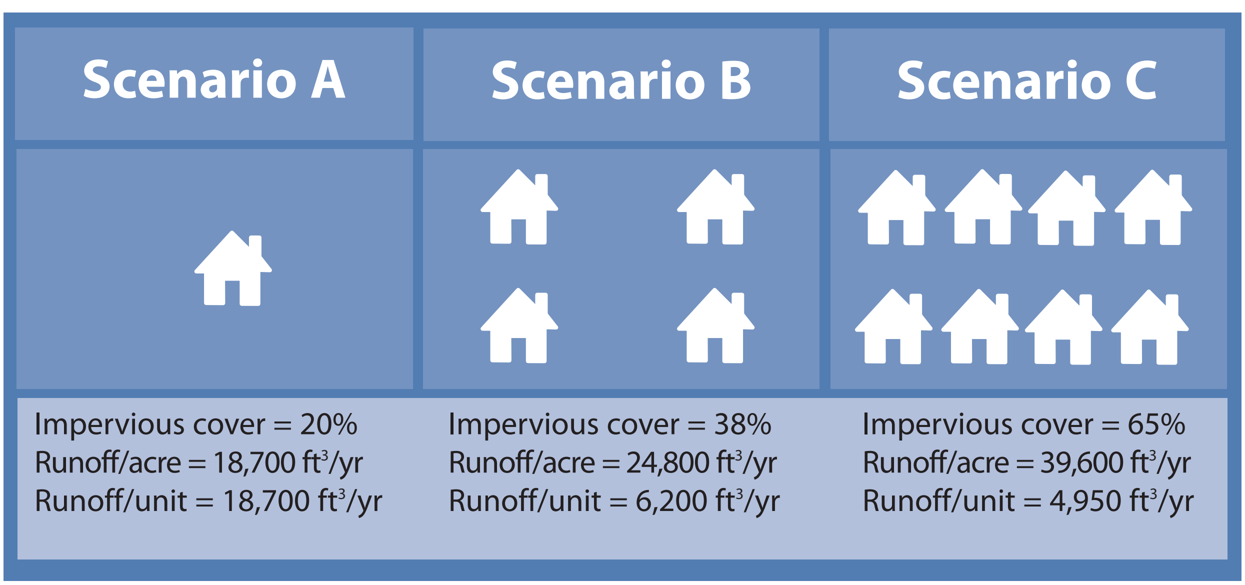
The results from the eight examples for all three scenarios are presented below.

EXAMPLE 1: ONE-ACRE LEVEL

Scale of Analysis	Scenario A	Scenario B	Scenario C
One Acre	1 house	4 houses	8 houses

EPA examined one acre developed at three different densities: one house, four houses, and eight houses. The results are presented in Exhibit 3. As Exhibit 3 demonstrates, the overall percent imperviousness for Scenario A is approximately 20 percent with one house per acre, 38 percent for Scenario B with four houses per acre, and 65 percent for Scenario C with eight houses per acre (Soil Conservation Service, 1986).

EXHIBIT 3: Total Average Annual Stormwater Runoff for All Scenarios



Examining the estimated average annual runoff at the acre level, as illustrated in Exhibit 4, the low-density Scenario A, with just one house, produces an average runoff volume of 18,700 cubic feet per year (ft^3/yr). Scenario C, with eight houses, produces 39,600 ft^3/yr, and Scenario B falls between Scenarios A and C at 24,800 ft^3/yr. In short, looking at the comparative differences between scenarios, runoff roughly doubles as the number of houses increases from one house per acre to eight houses per acre. Scenario C, with more houses on the acre, has the greatest amount of impervious surface cover and thus generates the most runoff at the acre level.

Looking at the comparative difference of how much runoff each individual house produces, in Scenario A, one house yields 18,700 ft^3/yr, the same as the per acre level. In the denser Scenario C, however, each house produces 4,950 ft^3/yr average runoff. The middle scenario, Scenario B, produces considerably less runoff—6,200 ft^3/yr—per house than Scenario A, but more than Scenario C. Each house in Scenario B produces approximately 67 percent less runoff than a house in Scenario A, and each house in Scenario C produces 74 percent less runoff than a house in Scenario A. This is because the houses in Scenarios B and C create less impervious surface per house than the house in Scenario A. Therefore, per house, each home in the higher-density communities results in less stormwater runoff.

Each house in Scenario B produces approximately 67 percent less runoff than a house in Scenario A, and each house in Scenario C produces 74 percent less runoff than a house in Scenario A.

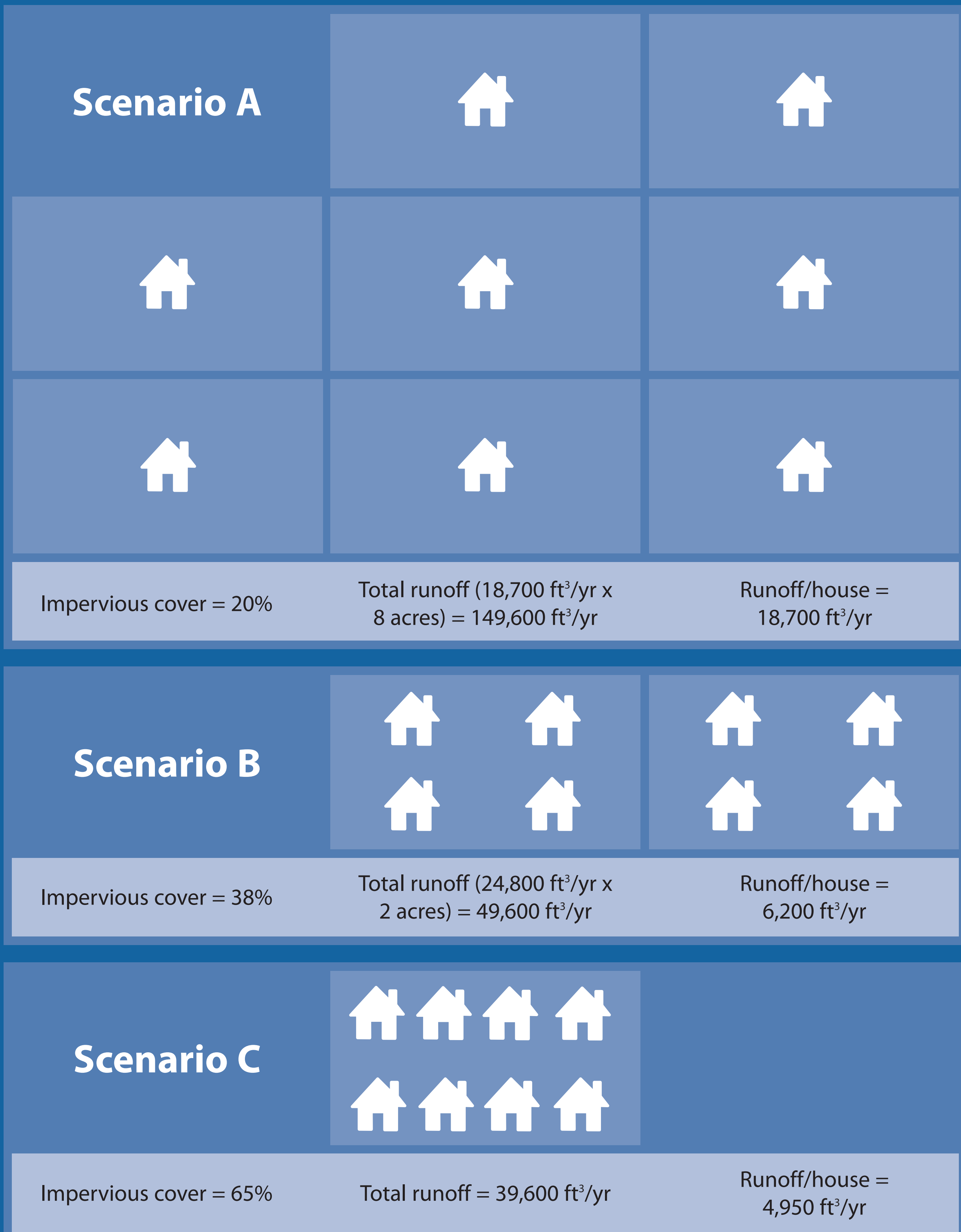
Modeling at the acre level demonstrates that, in this example, when density is quadrupled (from one house to four houses), stormwater runoff increases by one-third per acre, but decreases by two-thirds per house. Moreover, when density increases by a factor of eight—from one house to eight houses—stormwater runoff doubles per acre, but decreases by almost three-quarters per house.

These results indicate when runoff is measured by the acre, limiting density does minimize water quality impacts compared to the higher-density scenarios. However, when measured by the house, higher densities produce less stormwater runoff.

Example 2: Lot Level

Scale of Analysis	Scenario A	Scenario B	Scenario C
Lot	8 houses built on 8 acres	8 houses built on 2 acres	8 houses built on 1 acre

EXHIBIT 4: Each Scenario Accommodates Eight Houses



For each development to accommodate the same number of houses, the lower-density scenarios require more land to accommodate the same number of houses that Scenario C has accommodated on one acre. Specifically, Scenario A must develop seven additional acres, or eight acres total, to accommodate the same number of houses as Scenario C. Scenario B must develop two acres to accommodate the same number of houses. Exhibit 4 illustrates.

The increase in runoff for Scenario A is due to the additional land consumption.

With each scenario accommodating the same number of houses, this analysis shows that total average runoff in Scenario A is 149,600 ft^3/yr (18,700 ft^3/yr x 8 acres), which is a 278 percent increase from the 39,600 ft^3/yr total runoff in Scenario C. Total average runoff from eight houses in Scenario B is 49,600 ft^3/yr (24,800 ft^3/yr x 2 acres), which is a 25 percent increase in runoff from Scenario C. The increase in runoff for Scenario A is due to the additional land consumption and associated runoff. The impervious cover for Scenario A remains the same at 20 percent, but now, seven additional acres have 20 percent impervious cover.

Examining the comparative difference in runoff between scenarios shows that lower densities can create less total impervious cover, but produce more runoff when the number of houses is kept consistent between scenarios. Furthermore, the higher-density scenario produces less runoff per house and per lot.

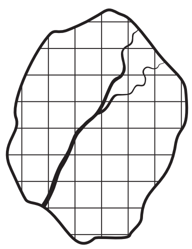
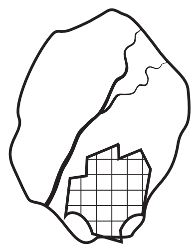
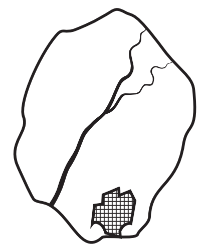
Example 3: Watershed Level

Scale of Analysis	Scenario A	Scenario B	Scenario C
Watershed—Each 10,000-acre watershed accommodates the same number of houses	10,000 houses built on 10,000 acres	10,000 houses built on 2,500 acres	10,000 houses built on 1,250 acres

Taking the analysis to the watershed level, EPA examined the comparative watershed stormwater runoff impacts from accommodating growth at different densities. The watershed used in this analysis is a hypothetical 10,000-acre watershed accommodating only houses. As discussed, the modeling does not include retail, business centers, farms, or any other land uses typically seen in communities, nor does it take into consideration where the development occurs within the watershed. Research has shown that upper sub-watersheds, which contain smaller streams, are generally more sensitive to development than lower sub-watersheds (Center for Watershed Protection, 2001).

Accommodating 10,000 houses at one house per acre in the 10,000-acre watershed would fully build out the watershed. At the higher density of four houses per acre, one-quarter of the watershed would be developed, and at eight houses per acre, one-eighth of the watershed would be developed. Exhibit 5 shows the runoff associated with each of these scenarios.

EXHIBIT 5: 10,000-Acre Watershed Accommodating 10,000 Houses

Scenario A	Scenario B	Scenario C
		
10,000 houses built on 10,000 acres produce:	10,000 houses built on 2,500 acres produce:	10,000 houses built on 1,250 acres produce:
10,000 acres x 1 house x 18,700 ft^3/yr of runoff =	2,500 acres x 4 houses x 6,200 ft^3/yr of runoff =	1,250 acres x 8 houses x 4,950 ft^3/yr of runoff =
187 million ft^3/yr of stormwater runoff	**62 million ft^3/yr of stormwater runoff**	**49.5 million ft^3/yr of stormwater runoff**
Site: 20% impervious cover	**Site: 38% impervious cover**	**Site: 65% impervious cover**
Watershed: 20% impervious cover	**Watershed: 9.5% impervious cover**	**Watershed: 8.1% impervious cover**

As Exhibit 5 illustrates, if development occurs at a lower density, e.g., one house per acre, the entire watershed will be built out, generating 187 million ft^3/yr of stormwater runoff. Scenario B, at four houses per acre, consumes less land and produces approximately 62 million ft^3/yr of stormwater runoff, while Scenario C, at the highest density, consumes the least amount of land and produces just 49.5 million ft^3/yr of stormwater runoff. Looking at the comparative differences, Scenario A generates approximately three times as much runoff from development as Scenario B, and approximately four times as much stormwater runoff as Scenario C.

Exhibit 5 also illustrates that, in this example, overall impervious cover for the watershed decreases as site density increases. Scenario C, which has a lot-level imperviousness of 65 percent, has a watershed-level imperviousness of only 8.1 percent, which is lower than the 10

Overall impervious cover for the watershed decreases as site density increases.

percent threshold discussed earlier. Scenario B, with a density of four houses per acre, has a site-level impervious cover of 38 percent, but a watershed imperviousness of 9.5 percent, which is still lower than the 10 percent threshold. Finally, Scenario A, at a lot-level imperviousness of 20 percent, has the same overall imperviousness at the watershed level. **Both of the higher-density scenarios consume less land and maintain below-the-threshold imperviousness.**

This simplistic illustration demonstrates a basic point of this analysis—higher-density developments can minimize stormwater impacts because they consume less land than their lower-density counterparts. For example, imagine if Manhattan, which accommodates 1.54 million people on 14,720 acres (23 square miles) (Census, 2000), were developed not at its current density of 52 houses per acre, but at one or four houses per acre. At one house per acre, Manhattan would need approximately 750,000 more acres, or an additional 1,170 square miles, to accommodate its current population at two people per household. That's approximately the size of Rhode Island. At four houses per acre, Manhattan would need approximately 175,000 more acres, or an additional 273 square miles.

At one house per acre, Manhattan would need approximately 750,000 more acres, or an additional 1,170 square miles, to accommodate its current population at two people per household.

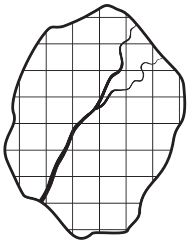
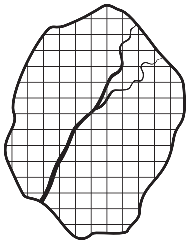
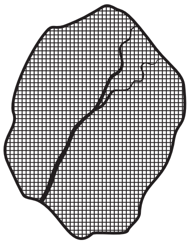
Reducing land consumption is crucial to preserving water quality because, as discussed previously, preserving large, continuous areas of open space and sensitive ecological areas is critical for maintaining watershed services. In addition, because of their dense development pattern, Scenarios B and C may realize additional stormwater benefits if the developed land is appropriately sited in the watershed to protect sensitive ecological areas, such as headwaters, wetlands, riparian corridors, and floodplains.

Example 4: Remaining Land in the Watershed Developed

What happens if the remaining undeveloped parts of the watershed in Scenarios B and C are developed? Exhibit 6 considers this situation.

Scale of Analysis	Scenario A	Scenario B	Scenario C
Watershed—Each 10,000-acre watershed is fully built out at different densities	10,000 houses built on 10,000 acres	40,000 houses built on 10,000 acres	80,000 houses built on 10,000 acres

EXHIBIT 6: 10,000-Acre Watershed Accommodating Different Numbers of Houses

Scenario A	Scenario B	Scenario C
		
The watershed is fully built out at *1 house per acre*. 10,000 acres accommodates **10,000 houses**, translating to:	The watershed is fully built out at *4 houses per acre*. 10,000 acres accommodates **40,000 houses**, translating to:	The watershed is fully built out at 8 *houses per acre*. 10,000 acres accommodates **80,000 houses**, translating to:
10,000 acres x 1 house x 18,700 ft^3/yr of runoff =	10,000 acres x 4 houses x 6,200 ft^3/yr of runoff =	10,000 acres x 8 houses x 4,950 ft^3/yr of runoff =
187 million ft^3/yr stormwater runoff	**248 million ft^3/yr stormwater runoff**	**396 million ft^3/yr stormwater runoff**
Site: 20% impervious cover	**Site: 38% impervious cover**	**Site: 65% impervious cover**
Watershed: 20% impervious cover	**Watershed: 38% impervious cover**	**Watershed: 65% impervious cover**

Each watershed is fully built out, and the watershed developed at the highest density (Scenario C) is generating approximately double the total stormwater runoff of Scenario A. Scenario B is generating approximately one-third more runoff than Scenario A. Similar to the acre-level and lot-level results, Scenario C has the highest degree of impervious cover at 65 percent, while Scenario A maintains the lowest level at 20 percent.

Scenarios A and B accommodate only a small portion of the expected growth. The rest will have to be built in other watersheds.

The higher densities found in Scenario B and C are degrading their watershed services to a greater extent than Scenario A. However, the number of houses accommodated in each community is not the same. Scenario B is accommodating **30,000 more houses** (four times the number of Scenario A), and Scenario C is accommodating **70,000 more houses** (eight times the number of Scenario A). Recall that density limits shift growth and do not generally affect the total amount of growth in a given time period. Therefore, this is not a fair comparison. Scenarios A and B accommodate only one-eighth and one-half, respectively, of the 80,000 houses accommodated in Scenario C. Where do the other houses, households, and families go? To get a true appreciation for the effects of density, Scenarios A and B must also show where those homes will be accommodated. It is likely that they would be built in nearby or adjacent watersheds. Our hypothetical community that develops at one house per acre (Scenario A) is able to accommodate only 10,000 houses. For the community that develops at that density to accommodate the same number of houses that Scenario C contains, it must disturb and develop land from nearby or adjacent watersheds.

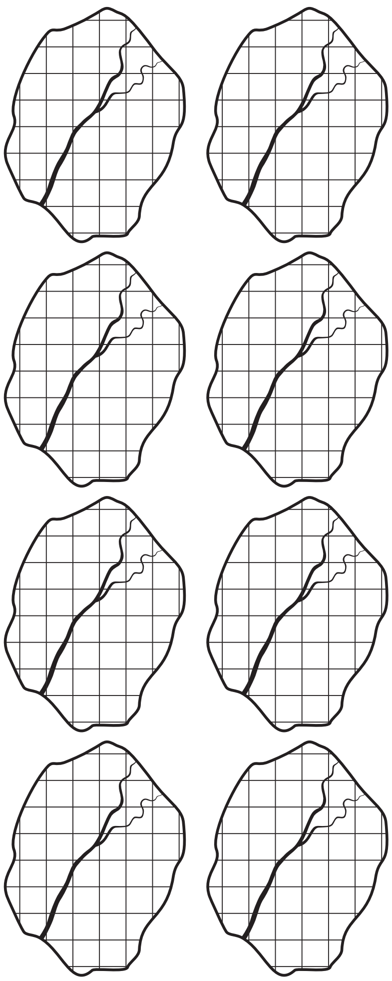
Example 5: Accommodating the Same Number of Houses

Scale of Analysis	Scenario A	Scenario B	Scenario C
Watershed—Each scenario accommodates the same number of houses	1 house per acre—80,000 houses consume 8 watersheds	4 houses per acre—80,000 houses consume 2 watersheds	8 houses per acre—80,000 houses consume 1 watershed

As discussed, the U.S. population will increase by an estimated 50 million people by 2020. Different areas of the country will grow at different rates in the future. Whether a region anticipates 1,000 or 80,000 new households to come to the region over the next 10 years, comparisons between build-out scenarios must keep the number of homes consistent. In this case, if Scenario C is developed so that its entire watershed is built out to 80,000 houses, then for a fair comparison, Scenarios A and B must also include 80,000 houses. Exhibit 7 illustrates this situation.

EXHIBIT 7: 80,000 Houses Accommodated

Scenario A



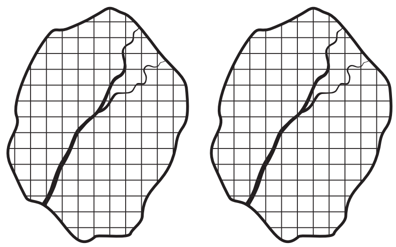
At 1 house per acre, 80,000 houses require 80,000 acres, or *8 watersheds*, translating to:

80,000 acres x 1 house x 18,700 ft^3/yr of runoff =

1.496 billion ft^3/yr of stormwater runoff

8 watersheds at 20% impervious cover

Scenario B



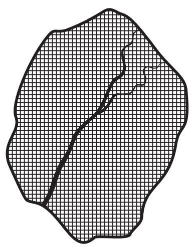
At 4 houses per acre, 80,000 houses require 20,000 acres, or *2 watersheds*, translating to:

20,000 acres x 4 houses x 6,200 ft^3/yr of runoff =

496 million ft^3/yr of stormwater runoff

2 watersheds at 38% impervious cover

Scenario C



At 8 houses per acre, 80,000 houses require 10,000 acres, or *1 watershed*, translating to:

10,000 acres x 8 houses x 4,950 ft^3/yr of runoff =

396 million ft^3/yr of stormwater runoff

1 watershed at 65% impervious cover

When the number of houses is kept consistent, Scenario A would need to develop an *additional seven watersheds* (assuming the same size watersheds) and Scenario B would need to develop *one additional watershed* to accommodate the same growth found in Scenario C.

As Exhibit 7 demonstrates, for Scenario A to accommodate the additional 70,000 homes already accommodated in Scenario C, it must develop another seven watersheds. This generates 1.496 billion ft^3/yr of stormwater runoff. Scenario C, with a development density of eight houses per acre, has still developed just one watershed and is generating approximately 74 percent less stormwater runoff than Scenario A—or 396 million ft^3/yr. Scenario B, at four houses per acre, is generating 496 million ft^3/yr runoff, or two-thirds less runoff than Scenario A, but 100 million ft^3/yr more than Scenario C.

Scenario A would need to develop an *additional seven watersheds* and Scenario B would need to develop *one additional watershed* in order to accommodate the same growth found in Scenario C.

Example 6: Time Series Build-out Analysis: Build-out in 2000

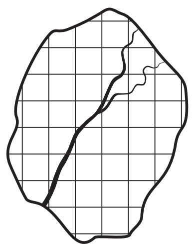
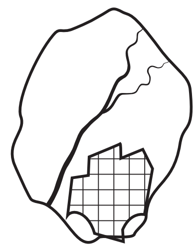
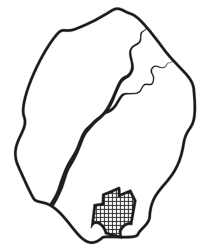
Scale of Analysis	Scenario A	Scenario B	Scenario C
Hypothetical build-out in the year 2000	10,000 houses built on 10,000 acres	10,000 houses built on 2,500 acres	10,000 houses built on 1,250 acres

Another way to examine this issue is to look at what happens to build-out of the three scenarios over time. A basic assumption for EPA's modeling is that growth is coming to the hypothetical community, and that growth will be accommodated within a fixed time horizon. But what happens to growth in the hypothetical community over several, sequential time horizons?

Given the dynamic nature of population growth, what will build-out look like in the hypothetical community in 2000, 2020, and 2040 at different development densities? The next several examples examine the amount of land required to accommodate increasing populations within a watershed that develops at different densities. The purpose of this time series build-out is to examine how much land is consumed as the population grows in 20-year increments.

Starting in the year 2000, the three watersheds each begin with 10,000 homes. The only difference between the watersheds is the densities at which the building occurs. In 2000, they might look something like Exhibit 8.

EXHIBIT 8: Time Series Build-out Analysis: Build-out in 2000

Scenario A	Scenario B	Scenario C
		
10,000 houses on 10,000 acres at a density of *1 house per acre* consume 1 entire watershed.	10,000 houses on 2,500 acres at a density of *4 houses per acre* consume ¼ of 1 watershed.	10,000 houses on 1,250 acres at a density of *8 houses per acre* consume ⅛ of 1 watershed.

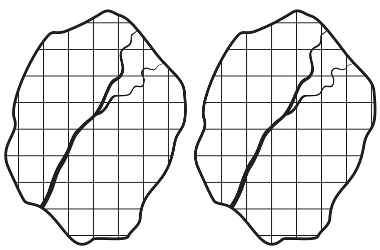
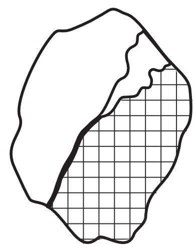
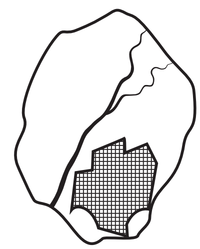
As previously demonstrated in Example 3, building at higher densities consumes, or converts, less land within the watershed. Scenario A, developing at one unit per acre, requires the entire 10,000-acre watershed to accommodate 10,000 houses. Scenario C, on the other hand, developing at eight units an acre, requires significantly less land to accommodate the same amount of development.

EXAMPLE 7: TIME SERIES BUILD-OUT ANALYSIS: BUILD-OUT IN 2020

Scale of Analysis	Scenario A	Scenario B	Scenario C
Hypothetical build-out in the year 2020	20,000 houses built on 20,000 acres, or 2 watersheds	20,000 houses built on 5,000 acres, or ½ of 1 watershed	20,000 houses built on 2,500 acres, or ¼ of 1 watershed

Fast-forwarding 20 years, the population in the hypothetical community has doubled from 10,000 houses to 20,000 houses. Each scenario must accommodate this additional growth at different development densities. Exhibit 9 demonstrates how this development might look.

EXHIBIT 9: Time Series Build-out Analysis: Build-out in 2020

Scenario A	Scenario B	Scenario C
		
20,000 houses accommodated on 20,000 acres at a density of *1 house per acre* will consume 2 watersheds.	20,000 houses accommodated on 5,000 acres at a density of *4 houses per acre* will consume ½ of 1 watershed.	20,000 houses accommodated on 2,500 acres at a density of *eight houses per acre* will consume ¼ of 1 watershed.

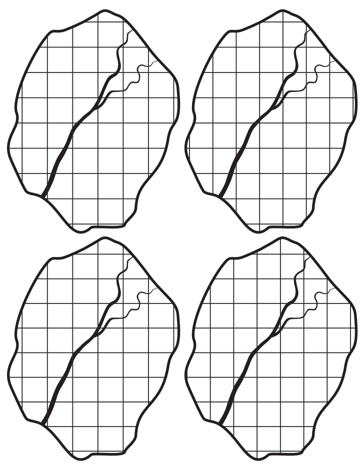
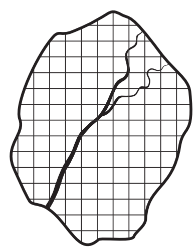
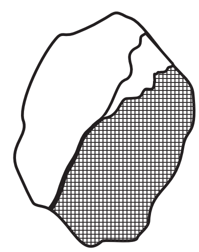
As Exhibit 9 demonstrates, Scenario A, developing at one house per acre, requires another whole watershed to accommodate the additional growth. Scenarios B and C, developing at higher densities, can accommodate the additional growth within the same watershed. Moreover, by developing at higher densities within the watershed, ample open space or otherwise undeveloped land remains to perform critical watershed functions. No such land exists in Scenario A, and, as previously discussed, lawns typically associated with one house per acre are not able to provide the same type of watershed services as forests, meadows, or other types of unconverted land.

EXAMPLE 8: TIME SERIES BUILD-OUT ANALYSIS: BUILD-OUT IN 2040

Scale of Analysis	Scenario A	Scenario B	Scenario C
Hypothetical build-out in the year 2040	40,000 houses built on 40,000 acres, or 4 watersheds	40,000 houses built on 10,000 acres, or 1 watershed	40,000 houses built on 5,000 acres, or ½ of 1 watershed

The hypothetical community continues to grow and, in another 20 years, population has doubled again, requiring each scenario to accommodate 20,000 more homes at different development densities. Exhibit 10 demonstrates how this development might look.

EXHIBIT 10: Time Series Build-out Analysis: Build-out in 2040

Scenario A	Scenario B	Scenario C
		
40,000 houses on 40,000 acres at a density *of 1 house per acre* will consume 4 watersheds.	40,000 houses on 10,000 acres at a density of *4 houses per acre* will consume 1 watershed.	40,000 houses on 5,000 acres at a density of *8 houses per acre* will consume ½ of 1 watershed.

As Exhibit 10 demonstrates, Scenario A, developing at one house per acre, must develop land in four watersheds, or 40,000 acres, to accommodate all its houses. Scenario B, developing at a slightly higher density, uses its remaining land to accommodate the additional growth. Scenario C is still developing within the same watershed and still has additional land available to provide watershed services. Scenario A and B do not. Any land for watershed services would need to come from additional watersheds.

Lower-density development always requires more land than higher densities to accommodate the same amount of growth.

This build-out analysis can continue indefinitely with the same result: lower-density development always requires more land than higher densities to accommodate the same amount of growth. Because more land is required, more undeveloped land is converted.

Findings/Discussion

The results indicate when runoff is measured *by the acre*, limiting density does produce less stormwater runoff when compared to the higher-density scenarios. However, when measured *by the house*, higher densities produce less stormwater runoff. So, which is the appropriate measure?

Typically, a planning department analyzes the projected stormwater runoff impacts of a developer's proposal based on the acreage, not the number of houses being built. Based on the results from the one-acre level example, communities might conclude that lower-density development would minimize runoff. Runoff from one house on one acre is roughly half the runoff from eight houses. However, where did the other houses, and the people who live in those houses, go? The answer is almost always that they went somewhere else in that region—very often somewhere within the same watershed. Thus, those households still have a stormwater impact. To better understand the stormwater runoff impacts from developing at low densities, the impacts associated with those houses locating elsewhere need to be taken into account. This approach has two advantages:

- It acknowledges that the choice is not whether to grow by one house or eight but is instead where and how to accommodate the eight houses (or whatever number by which the region is expected to grow).
- It emphasizes minimization of total imperviousness and runoff within a region or watershed rather than from particular sites—which is more consistent with the science indicating that imperviousness within the watershed is critical.

To more fully explore this dynamic, EPA modeled scenarios at three scales—one acre, lot, and watershed—and at three different time series build-out examples to examine the premise that lower-density development better protects water quality. EPA examined stormwater runoff from different development densities to determine the comparative difference between scenarios. The higher-density scenarios generated less stormwater runoff per house at all scales and time series build-out examples. Exhibit 11 summarizes these findings.

EXHIBIT 11: Summary of Findings

Scenario	Number of Acres Developed	Impervious Cover (%)	Total Runoff (ft³/yr)	Runoff Per Unit (ft³/yr)	Savings Over Scenario A: runoff per unit (%)
One-Acre Level: Different densities developed on one acre					
A: One house/acre	1	20.0	18,700	18,700	0
B: Four houses/acre	1	38.0	24,800	6,200	67
C: Eight houses/acre	1	65.0	39,600	4,950	74
Lot Level: Eight houses accommodated at different density levels					
Scenario A	8	20.0	149,600	18,700	0
Scenario B	2	38.0	49,600	6,200	67
Scenario C	1	65.0	39,600	4,950	74
Watershed Level: 10,000 houses accommodated in one 10,000-acre watershed					
Scenario A	10,000	20.0	187 M	18,700	0
Scenario B	2,500	9.5	62 M	6,200	67
Scenario C	1,250	8.1	49.5 M	4,950	74
Scenario	**Summary of Build-out Examples**				
Watershed Level: Time Series Build-out Analysis: Build-out in 2000					
Scenario A	10,000 houses built on 10,000 acres: 1 watershed is consumed				
Scenario B	10,000 houses built on 2,500 acres: ¼ of 1 watershed is consumed				
Scenario C	10,000 houses built on 1,250 acres: ⅛ of 1 watershed is consumed				
Watershed Level: Time Series Build-out Analysis: Build-out in 2020					
Scenario A	20,000 houses built on 20,000 acres: 2 watersheds are consumed				
Scenario B	20,000 houses built on 5,000 acres: ½ of 1 watershed is consumed				
Scenario C	20,000 houses built on 2,500 acres: ¼ of 1 watershed is consumed				
Watershed Level: Time Series Build-out Analysis: Build-out in 2040					
Scenario A	40,000 houses built on 40,000 acres: 4 watersheds are consumed				
Scenario B	40,000 houses built on 10,000 acres: 1 watershed is consumed				
Scenario C	40,000 houses built on 5,000 acres: ½ of 1 watershed is consumed				

Specifically, this analysis demonstrates:

- With more dense development (Scenario C), runoff rates per house decrease by approximately 74 percent from the least dense scenario (Scenario A);
- For the same amount of development, denser development produces less runoff and less impervious cover than low-density development; and
- For a given amount of growth, lower-density development uses more of the watershed.

EPA found that the higher-density scenarios generate less stormwater runoff per house at all scales—one acre, lot, watershed—and time series build-out examples.

Taken together, these findings indicate that low-density development may not always be the preferred strategy for reducing stormwater runoff. In addition, the findings indicate that higher densities may better protect water quality—especially at the lot and watershed levels. Higher-density developments consume less land to accommodate the same number of houses as lower density. Consuming less land means less impervious cover is created within the watershed. To better protect watershed function, communities must preserve large, continuous areas of open space and protect sensitive ecological areas, regardless of how densely they develop.

However, while increasing densities on a regional scale can, on the whole, better protect water resources at a regional level, higher-density development can have more site-level impervious cover, which can exacerbate water quality problems in nearby or adjacent waterbodies. To address this increased impervious cover, numerous site-level techniques are available to mitigate development impacts. When used in combination with regional techniques, these site-level techniques can prevent, treat, and store runoff and associated pollutants. Many of these practices incorporate some elements of low-impact development techniques (e.g., rain gardens, bioretention areas, and grass swales), although others go further to include changing site-design practices, such as reducing parking spaces, narrowing streets, and eliminating cul-de-sacs. Incorporating these techniques can help communities meet their water quality goals and create more interesting and enjoyable neighborhoods.

Photo courtesy of the City of Portland, Oregon

The city of Portland, Oregon, is developing urban stormwater strategies, such as these curb extensions that can absorb the street's runoff from large storm events.

A University of Oregon study, *Measuring Stormwater Impacts of Different Neighborhood Development Patterns* (University of Oregon, 2001), supports this conclusion. The study, which included a study site near Corvallis, Oregon, compared stormwater management strategies in three common neighborhood development patterns. For example, best management practices, such as disconnecting residential roofs and paved areas from the stormwater system, introducing swales and water detention ponds into the storm sewer system, and strategically locating open space, considerably reduced peak water runoff and improved infiltration. The study concluded that "some of the most effective opportunities for reducing stormwater runoff and decreasing peak flow are at the site scale and depend on strategic integration with other site planning and design decisions." The study also found that planting strips and narrower streets significantly reduced the amount of pavement and, as a result, runoff in developed areas.

A development in Tacoma, Washington, demonstrates that increasing densities and addressing stormwater at the site level can work effectively. The Salishan Housing District was built on Tacoma's eastern edge in the 1940s as temporary housing for ship workers. It is currently a public housing community with 855 units.

Redevelopment of Salishan will increase densities to include 1,200 homes (public housing, affordable and market rate rentals, and for-sale units), local retail, a farmers market, a senior housing facility, a daycare center, a health clinic, commercial office space, and an expanded community center. Among the most important priorities for the redevelopment is restoring the water quality of Swan Creek, which forms the eastern edge of Salishan. The creek is a spawning ground for indigenous salmon populations that feed into the Puyallup River and Puget Sound. The site plan seeks to restore 65 percent of the land to forest and pervious landscape. In addition, the streets will be narrowed to reduce impervious surfaces and also make the neighborhood more inviting for walking. Some streets may be eliminated and replaced with pedestrian paths. The remaining streets will be bordered by rain gardens that would accept, filter, and evapotranspire runoff. Most existing street surfaces would be reused, although some may be replaced with pervious pavers.

Salishan Housing District is replacing 855 public housing units with 1,200 units. Numerous site-level strategies, such as integrating uses, narrowing the streets, installing rain gardens, and daylighting a stream, are used to restore the water quality of Swan Creek and revitalize an existing neighborhood.

Communities can enjoy a further reduction in runoff if they take advantage of underused properties, such as infill, brownfield, or greyfield[12] sites. For example, an abandoned shopping center (a greyfield property) is often almost completely impervious cover and is already producing high volumes of runoff (Sobel, 2002). If this property were redeveloped, the net runoff increase would likely be zero since the property was already predominately impervious cover. In many cases, redevelopment of these properties breaks up or removes some portion of the impervious cover, converting it to pervious cover and allowing for some stormwater infiltration. In this case, redevelopment of these properties can produce a net improvement in regional water quality by decreasing total runoff. Exhibit 12 illustrates this opportunity.

[12] Greyfield sites generally refer to abandoned or underutilized shopping malls, strip malls, or other areas that have significant paved surface and little or no contamination.

EXHIBIT 12: Redevelopment of a Greyfield Property

Before Redevelopment

After Redevelopment

Photos courtesy of Juan Ayala, Invisioneering, for the New Jersey Office of State Planning

Redevelopment of a former shopping mall in Boca Raton, Florida, provides an example of this type of opportunity. The Mizner Park shopping mall was redesigned from its original pattern of a large retail structure surrounded by surface parking lots; the 29-acre site now includes 272 apartments and townhouses, 103,000 square feet of office space, and 156,000 square feet of retail space. Most parking is accommodated in four multistory parking garages. Designed as a village within a city, the project has a density five times higher than the rest of the city and a mix of large and small retailers, restaurants, and entertainment venues (Cooper, 2003). Most significantly, the final build-out of Mizner Park decreased overall impervious surface on the site by 15 percent through the addition of a central park plaza, flower and tree planters, and a large public amphitheater.

Redeveloping brownfield and greyfield sites can reduce regional land consumption. A recent George Washington University study found that for every brownfield acre that is redeveloped, 4.5 acres of open space are preserved (Deason, 2001). In addition to redeveloping brownfield sites, regions can identify underused properties or land, such as infill or greyfield sites, and target those areas for redevelopment. For example, a recent analysis by King County, Washington, demonstrated that property that is vacant and eligible for redevelopment in the county's growth areas can accommodate 263,000 new houses—enough for

Photo courtesy of U.S. EPA

The redevelopment of Mizner Park, a former shopping mall, decreased impervious cover by 15 percent through the addition of this central plaza.

500,000 people (Pryne, 2002). Redeveloping this property is an opportunity to accommodate new growth without expanding into other watersheds. As Kurt Zwikl, executive director of the Pottstown, Pennsylvania-based Schuylkill River Greenway Association, said, "Certainly, if we can get redevelopment going in brownfields and old industrial sites in older riverfront boroughs like Pottstown and Norristown, that's a greenfield further out in the watershed that has been preserved to absorb more stormwater" (Brandt, 2004).

Redeveloping brownfield and greyfield sites can reduce regional land consumption.

Other Research

Current research supports the findings of this study. Several site-specific studies have been conducted across the United States and in Australia that examine stormwater runoff and associated pollutants in relation to different development patterns and densities. Several case studies approach the research question with varying levels of complexity. Studies of Highland Park, Australia; Belle Hall, South Carolina; New Jersey; Chicago, Illinois; and the Chesapeake Bay each analyze the differences in runoff and associated water pollution from different types of development patterns.

Queensland University of Technology, Gold Coast City Council, and the Department of Public Works in Brisbane, Australia, examined the relationship between water quality and six different land uses to offer practical guidance in planning future developments. When comparing monitored runoff and associated pollutants from six areas, they found the most protective strategy for water quality was high-density residential development (Goonetilleke, 2005).

The Belle Hall study, by the South Carolina Coastal Conservation League, examined the water quality impacts of two development alternatives for a 583-acre site in Mount Pleasant, South Carolina. The town planners used modeling to examine the potential water quality impacts of each site design. In the "Sprawl Scenario," the property was analyzed as if it developed along a conventional suburban pattern. The "Town Scenario" incorporated traditional neighborhood patterns. In each scenario, the overall density and intensity (the number of homes and the square feet of commercial and retail space) were held constant. The results found that the "Sprawl Scenario" consumed eight times more open space and generated 43 percent more runoff, four times more sediment, almost four times more nitrogen, and three times more phosphorous than the "Town Scenario" development (South Carolina Coastal Conservation League, 1995).

These findings hold at a larger, state scale. New Jersey's State Plan calls for increasing densities in the state by directing development to existing communities and existing infrastructure. Researchers at Rutgers University analyzed the water quality impacts from current development trends and compared them to water quality impacts from the proposed compact development. The study found that compact development would generate significantly less water pollution than current development patterns, which are mostly characterized by low-density development, for all categories of pollutants (Rutgers University, 2000). The reductions ranged from over 40 percent for phosphorus and nitrogen to 30 percent for runoff. These conclusions supported a similar statewide study completed in 1992 that concluded that compact development would result in 30 percent less runoff and 40 percent less water pollution than would a lower-density scenario (Burchell, 1995).

Researchers at Purdue University examined two possible project sites in the Chicago area (Harbor, 2000). The first site was in the city; the second was on the urban fringe. The study found that placing a hypothetical low-density development on the urban fringe would produce 10 times more runoff than a higher-density development in the urban core.

Finally, a study published by the Chesapeake Bay Foundation in 1996 comparing conventional and clustered suburban development on a rural Virginia tract found that clustering would convert 75 percent less land, create 42 percent less impervious surface, and produce 41 percent less stormwater runoff (Pollard, 2001). These studies suggest that a low-density approach to development is not always the preferred strategy for protecting water resources.

Conclusions

Our regions, cities, towns, and neighborhoods are growing. Every day, new buildings or houses are proposed, planned, and built. Local governments, working with planners, citizen groups, and developers, are thinking about where and how this new development can enhance existing neighborhoods and also protect the community's natural environment. They are identifying the characteristics of development that can build vibrant neighborhoods, rich in natural and historic assets, with jobs, housing, and amenities for all types of people. They are directing growth to areas that will maintain and improve the buildings and infrastructure in which they have already invested. In addition to enjoying the many benefits of growth, communities are also grappling with growth's challenges, including development's impact on water resources.

Many communities assume that low-density development automatically protects water resources. This study has shown that this assumption is flawed and that pursuit of low-density development can in fact be counterproductive, contributing to high rates of land conversion and stormwater runoff and missing opportunities to preserve valuable land within watersheds.

The purpose of this study is to explore the effects of development density on stormwater runoff and to illustrate the problems with the assumption that low-density development is automatically a better strategy to protect water quality. To that end, three different development densities were modeled at the one-acre, lot, and watershed levels, as well as in the time series build-out examples. The modeling results suggest that low-density development is not always the preferred strategy for protecting water resources. Furthermore, the results seem to suggest that higher-density development could better protect regional water quality because it consumes less land to accommodate the same number of homes.

However, while this study shows that low-density development does not automatically better protect water resources, it does not conclude that high-density development is therefore necessarily more protective. This study has not considered all factors, such as location of development within the watershed, varying soil types, slope, advanced post-construction controls (and their performance over time), and many other factors. In that sense, this study concludes that there are good reasons to consider higher-density development as a strategy that can better protect water resources than lower-density development. However, any bias toward either is inappropriate from a water perspective. A superior approach to protect water resources locally is likely to be some combination of development densities, based on local factors, incorporating adequate open space, preserving critical ecological and buffer areas, and minimizing land disturbance.

These conclusions have implications for how communities can enjoy the benefits of growth and development while also protecting their water quality. Additional relevant information can be found in other resources, such as *Protecting Water Resources with Smart Growth* and *Using Smart Growth Techniques as Stormwater Best Management Practices.*[13] Both publications draw on the experience of local governments, which has shown that regional and site-specific strategies are most effective when implemented together. In addition, *Creating Great Neighborhoods: Density in Your Community*, by the Local Government Commission and the National Association of Realtors, can provide information on some of the other benefits from density that communities can enjoy.

Additional relevant information can be found in these resources:

- *Protecting Water Resources with Smart Growth,* available at: www.epa.gov/smartgrowth/pdf/waterresources_with_sg.pdf.
- *Creating Great Neighborhoods: Density in Your Community,* available at: www.epa.gov/smartgrowth/pdf/density.pdf.

Nationwide, state and local governments are considering the environmental implications of development patterns. As low-density development and its attendant infrastructure consume previously undeveloped land and create stretches of impervious cover throughout a region, the environment is increasingly affected. In turn, these land alterations are not only likely to degrade the quality of the individual watershed, but are also likely to degrade a larger number of watersheds. EPA believes that increasing development densities is one strategy communities can use to minimize regional water quality impacts.

[13] Forthcoming EPA publication.

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