GROWING GREENER

The Environmental Benefits of a Compact and Connected Boulder

FRONTIER GROUP

SWEEP
SOUTHWEST ENERGY EFFICIENCY PROJECT

CoPIRG Foundation

ENVIRONMENT COLORADO
RESEARCH & POLICY CENTER

GROWING GREENER

The Environmental Benefits of a Compact and Connected Boulder

WRITTEN BY:

ABIGAIL BRADFORD AND JAMES HORROX
FRONTIER GROUP

DANNY KATZ
COPIRG FOUNDATION

TRAVIS MADSEN AND MATHEW FROMMER
SOUTHWEST ENERGY EFFICIENCY PROJECT (SWEEP)

AUGUST 2019

ACKNOWLEDGMENTS

The authors thank Will Toor, executive director of the Colorado Energy Office; Chris Hagelin, senior transportation planner at the City of Boulder; Michael Leccesse, executive director at Urban Land Institute Colorado; and John Tayer, president and CEO at Boulder Chamber, for their review of drafts of this document, as well as their insights and suggestions. The authors also thank Rachel Meier, GIS Specialist for drafting the map used in the report. The authors thank those who contributed to the production of the Frontier Group/Environment Texas Research & Policy Center report *Growing Greener: The Environmental Benefits of a Compact and Connected Austin*, which informed this report. Thanks also to Tony Dutzik, Susan Rakov and Elizabeth Ridlington of Frontier Group for editorial support.

Environment Colorado Research & Policy Center, CoPIRG Foundation and Southwest Energy Efficiency Project (SWEEP) thank Innovo Foundation for making this report possible. The authors bear responsibility for any factual errors. The recommendations are those of CoPIRG Foundation, Environment Colorado Research & Policy Center and Southwest Energy Efficiency Project (SWEEP). The views expressed in this report are those of the authors and do not necessarily reflect the views of our funders or those who provided review.

Environment Colorado Research & Policy Center is a 501(c)(3) organization. We are dedicated to protecting Colorado's air, water and open spaces. We investigate problems, craft solutions, educate the public and decisionmakers, and help Coloradans make their voices heard in local, state and national debates over the quality of our environment and our lives. For more information about Environment Colorado Research & Policy Center or for additional copies of this report, please visit www.environmentcoloradocenter.org.

With public debate around important issues often dominated by special interests pursuing their own narrow agendas, CoPIRG Foundation offers an independent voice that works on behalf of the public interest. CoPIRG Foundation, a 501(c)(3) organization, works to protect consumers and promote good government. We investigate problems, craft solutions, educate the public, and offer Coloradans meaningful opportunities for civic participation. For more information about CoPIRG Foundation or for additional copies of this report, please visit www.copirgfoundation.org.

The Southwest Energy Efficiency Project (SWEEP) is a public-interest organization promoting greater energy efficiency in Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming. For more information about our programs and other work, please visit swenergy.org.

Frontier Group provides information and ideas to help citizens build a cleaner, healthier, and more democratic America. We address issues that will define our nation's course in the 21st century – from fracking to solar energy, global warming to transportation, clean water to clean elections. Our experts and writers deliver timely research and analysis that is accessible to the public, applying insights gleaned from a variety of disciplines to arrive at new ideas for solving pressing problems. For more information about Frontier Group, please visit www.frontiergroup.org.

Layout: Alec Meltzer, meltzerdesign.net

Cover photo: The Red Oak Park neighborhood in North Boulder. Dennis Schroeder, National Renewable Energy Laboratory (NREL) via Flickr CC BY-NC-ND 2.0.

CONTENTS

EXECUTIVE SUMMARY

BOULDER IS KNOWN FOR BEING AN environmentally conscious city. Boulder is surrounded by a ring of parks, open spaces and preserved land in the mountains. The city strives to promote water conservation and reduce personal vehicle travel and has ambitious climate goals.[1]

However, Boulder's positive contributions to the environment are undermined by housing policies that contribute to regional sprawl and increase global warming pollution.

Boulder has many policies in place that have caused housing to be scarce and expensive. For example, Boulder reserves most of its residentially zoned land for single-family homes, the least efficient type of housing.[2]

By combining policies that encourage compact development, sustainable transportation and green building practices, Boulder can help to address global warming, improve the quality of our air and water, and protect Colorado's undeveloped areas from sprawling development.

The inability of people who work in Boulder to find or afford housing in the city encourages long commutes that contribute to regional air pollution and global warming. Three out of five jobs in Boulder are held by people who live outside the city.[3]

- Inbound commuters drive about 29 miles roundtrip into Boulder each day on average and 77 percent are alone in their vehicles.[4]
- Nonresident commuters alone in their cars make up most of the vehicle traffic entering Boulder during the morning rush hour.[5]
- Boulder's inbound commuters collectively drive up to 245 million more miles each year than they would if they were Boulder residents.[6] This results in over 99,000 metric tons of additional carbon dioxide emissions each year – equivalent to putting over 21,000 more cars on the road.[7]
- Vehicle travel emits 31 percent of Boulder County's nitrogen oxide (NO_x) emissions and 24 percent of the county's volatile organic compound (VOC) emissions, which react with one another to form ozone, which is at unsafe levels in Boulder County.[8]

Enabling more people who work in Boulder to live in the city would allow them to drive less and walk, bike and take transit more, reducing air pollution and greenhouse gas emissions.

- If one-third of Boulder's nonresident employees moved into the city and drove as much as current residents, there would be up to 6,392 fewer vehicles on Boulder's streets during commute times carrying only one passenger.[9]

- This would also prevent up to 81 million miles of driving each year, which would reduce greenhouse gas emissions by over 33,000 metric tons of carbon dioxide – equivalent to taking over 7,000 cars off the road.[10] Those reductions would get Boulder over 10 percent of the way to its 2050 transportation climate goal.[11]

Enabling more compact development, particularly along transit corridors like Broadway and near commercial centers, could further reduce driving and associated emissions within Boulder.

- People drive less and walk, bike and use transit more in compact neighborhoods than in sprawling developments. For example, Boulder residents who live in detached single-family homes are nearly twice as likely to drive alone to work as those living in attached multi-family dwelling units, who are more likely to walk, bike or take transit.[12]

- Increasing the number of total housing units in Boulder's most populous neighborhoods in North Boulder, South Boulder, Southeast Boulder and Gunbarrel by 15 to 30 percent, focusing this growth around existing transit corridors, and pairing it with mixed-use development, could trigger a large community-wide modal shift away from car-travel and toward the clean and efficient transportation alternatives the city already provides.[13]

- Boulder has many initiatives to minimize vehicle emissions by encouraging walking, biking, transit and electric vehicles, such as extensive networks of bike paths.[14] Increasing infill development – the redevelopment of already developed land – would allow more Boulder residents to live close enough to jobs and recreation opportunities to walk or bike and take transit, helping to support infrastructure expansions and improvements.[15]

Increasing compact development within Boulder would not only reduce driving and associated emissions, but also environmentally damaging sprawling development across the region. A wealth of evidence from dozens of studies by academics, government agencies and nonprofit organizations shows that compact development has less overall environmental impact than low-density development.

Compact development in Boulder would benefit the environment in many ways, including:

- **Reduced emissions:** A 2011 U.S. Environmental Protection Agency (EPA) study found that shifting from conventional suburban development to compact, transit-oriented development is just as important as shifting to the most energy efficient building designs and fuel-efficient vehicles for reducing household energy use and emissions.[16]

- **Land preservation:** Housing more people within the already developed areas of Boulder can help reduce the development of regional open space, farmland and wildlands treasured by Boulder residents.

- **Healthier air:** A study published in the *Journal of Environmental Management* in 2008 found that compact cities experience up to 62 percent fewer high ozone days than sprawling cities.[17] This is crucial for Boulder County, which is in violation of federal air quality standards for ozone pollution.[18] In 2018, there were 52 ozone action days in the Front Range region when residents were warned that exercising outdoors could harm their health.[19]

- **Improved water quality:** Compact residential development minimizes the amount of impervious surface cover, such as roads and buildings, in a watershed, resulting in less runoff pollution in the region. A 2009 study published in the *Journal of the American Water Resources Association* concludes that compact development may be "the single most important practice any city can undertake to improve the surrounding environment."[20]

- **Reduced flood risk:** A multidisciplinary review of scientific literature published in the *Journal of Urbanism* in 2008 concluded that compact development patterns can mitigate the enhanced flood risk that comes with urban development.[21]

- **Lower water consumption:** In Boulder, residents who live in single-family homes use more than twice as much water as those who live in multi-family homes.[22]

Increasing compact development can help Boulder to meet its goals to reduce greenhouse gas emissions, increase affordable housing availability and much more.

In 2015, Boulder drafted *A Toolkit of Housing Options* that could increase housing in the city, but has not implemented most of those suggestions.[23] To create a more connected community with less environmental impact, Boulder should:

- **Re-zone areas to allow for more compact, mixed-use development – which incorporates homes, jobs and recreational opportunities – particularly along transit corridors and near commercial centers.**

- **Encourage accessory dwelling units (ADUs),** which are additional housing units within existing homes or on the same property, such as basement, attic, above-garage and detached, guest house apartments. Rented ADUs can provide a source of income for households – as well as assistance for aging households.

- **Increase home occupancy limits for unrelated people,** which are currently three people in low-density residential areas and four people in medium- to high-density areas.[24]

- **Consider parking maximums instead of parking minimums** for homes and businesses and implement the parking principles from the city's Access Management and Parking Strategy (AMPS).

- **Raise height limits for buildings in key locations, particularly along transit corridors and near commercial zones to the east of Folsom Street, and allow buildings above 35 feet in height but below 55 feet by right.**

To enable new growth without additional traffic, Boulder should also:

- **Expand Boulder's transportation demand management (TDM) programs** like the EcoPass, parking cash-outs, carshare, and bikeshare programs, which encourage residents and employees to get around by means other than driving.

By increasing compact commercial and residential development, such as duplexes and low-rise apartment buildings, Boulder can create neighborhoods where homes, jobs and recreational opportunities coexist, connected by a transportation system that enables and encourages walking, biking, transit, shared modes of transportation and electric vehicles. By prioritizing infill development and maximizing the housing potential of existing buildings, Boulder can create a more compact community while preserving open spaces. These changes would reduce overall energy use and greenhouse gas emissions, land consumption, air and water pollution, flood risk and water consumption in the region.

Increasing compact development is a critical step for Boulder to take to tackle climate change and protect the environment.

Introduction

BOULDER IS A BEAUTIFUL CITY that strives for harmony with nature. Above the sandstone and terracotta buildings of the University of Colorado Boulder, the majestic Flatirons rise up out of the mountains, forming one of the most distinctive skylines you'll find anywhere.

Boulder has preserved more than 45,000 acres of open space, including a buffer of meadows and fields surrounding the city. The city is crisscrossed with bike paths and greenways. And at the center of town, locals and tourists mingle on the pedestrian-only Pearl Street Mall, visited by 2 million people each year.[25]

Boulder's present-day beauty and high quality of life is the result of decades of visionary leadership. In 1959, voters approved a "blue line" on the mountainside, above which city water would not be supplied, helping to keep development down on the plains. In 1967, Boulder voters approved the nation's first city sales tax increase specifically focused on open space preservation, a tax that voters have extended and increased multiple times. Over the years, the city has attracted people who share many similar values – protecting the environment, minimizing human impacts, and creating a community with a high quality of life.

View of the Flatirons beyond Boulder. Credit: Paul Haberstroh via Wikimedia Commons, CC-BY-SA-4.0.

However, when it comes to managing growth and minimizing climate change impacts, Boulder has adopted policies that have led to unintended consequences. In 1976, Boulder voters approved a plan to limit growth in the city, followed by additional policies intended to preserve neighborhood character, minimize traffic, and protect mountain views. Unfortunately, these policies are now making it harder for Boulder to address climate change by fueling driving and traffic, challenging Boulder's status as a beacon of sustainability.

Growth is a fact of life across Colorado. New people are coming to the state, attracted by our high quality of life, mountains and recreational opportunities.

Boulder's well-intentioned attempt to manage growth has not worked to the benefit of Colorado's environment. By limiting new housing opportunities in Boulder, city policies have driven up the cost of housing, forcing new growth to happen in nearby towns and counties, many of them with less environmentally sound policies than Boulder. People are coming to Boulder to work. When they cannot live here, they drive in from out of town – fueling sprawl, increasing driving and traffic, and pollution.

It is time to reconsider Boulder's growth management policies. As this report shows, by enabling compact development in key locations – such as near transit corridors, near jobs and opportunities, and near commercial centers – Boulder can direct growth in productive ways. Smart growth decisions can help people live more sustainable lives and get Boulder closer to its overall sustainability goals.

In 2018, Boulder's City Council identified housing growth as a planning priority:

> "The city's residential neighborhoods are experiencing a dramatic demographic and economic shift with the replacement of modest more-affordable homes with larger more-expensive homes. These large homes are often inconsistent with the existing character of the neighborhoods, and are an inefficient use of land that has exacerbated the city's housing / jobs imbalance and the high-cost of housing. In addition, large homes do not align with the city's energy conservation goals and policies as they consume greater amounts of energy, both in operation and construction, than do modest-sized homes. To address these shortcomings, smaller home sizes and creative infill solutions that consider the potential for multiple smaller-homes in large lot areas (where appropriate), should be encouraged to foster a more efficient use of land, energy and resources, and to support a broader housing and economic diversity in the city's residential neighborhoods."[26]

It is time for the city to implement policies and programs to make sustainable, compact development a reality.

Most of Boulder's residents support increasing compact residential development. In 2016, Boulder residents were surveyed

The Pearl Street Mall is a pedestrian-only commercial center in Boulder. Credit: Lee Coursey via Flickr, CC BY 2.0.

on their opinions of the Boulder Valley Comprehensive Plan – the city's guide to long-term planning – and 62 to 79 percent of respondents supported allowing "more housing in locations like BVRC [the Boulder Valley Regional Center], Neighborhood Centers, Light Industrial areas, and residential infill."[27] Almost two-thirds specifically supported residential infill such as accessory dwelling units and small detached homes in single-family neighborhoods.[28]

By increasing compact residential and commercial development, Boulder can create neighborhoods where homes, jobs and recreational opportunities coexist, connected by a transportation system that enables and encourages walking, biking, transit, shared modes of transportation and electric vehicles. By prioritizing infill development – the redevelopment of already developed land – and maximizing the housing potential of existing buildings, Boulder can increase density while continuing its wise tradition of open-space preservation and livable neighborhood design. In the consulting firm

Mercer's 2019 Quality of Living Ranking, all of the top 50 global cities have compact settlement patterns, good transit and principally walkable neighborhoods.[29]

Evidence from dozens of studies, conducted around the United States and beyond, shows that enabling smart growth can reduce regional energy use and greenhouse gas emissions, slow land consumption, prevent air and water pollution, mitigate flood risk and reduce water consumption. Encouraging compact development can make Boulder an even greater leader in sustainability.

To truly be green, Boulder needs to welcome new neighbors. Increasing compact residential development is the next step for Boulder to take to protect the environment.

WHAT IS COMPACT DEVELOPMENT?

Compact development is a land-use pattern that seeks to minimize the loss of undeveloped land, such as parks and farmland, while enabling population and job growth. To do so, compact development concentrates people and jobs in mixed-use neighborhoods. Compact development can feature housing of many types – from detached single-family homes on small lots and townhomes to duplexes and low-rise apartment buildings. Successful compact development also yields a high quality of life, creating walkable neighborhoods with open spaces, affordable housing, public transit and pedestrian- and bicycle-friendly street design. To minimize the impact of development on the natural environment, compact growth should focus on redeveloping previously developed property, and limit the conversion of undeveloped land on the metropolitan edge. Compact development does not require towering skyscrapers and can result in tight-knit communities that Boulder already has in some of its neighborhoods, such as Boulder Junction, the Holiday Neighborhood and Red Oak Park (see page 13).

Boulder's Lack of Housing Contributes to Sprawl and Environmental Damage

Boulder does not have enough housing to meet demand. The resulting high cost of housing and low availability force many who would choose to live in the city to move to outlying communities and make long commutes into Boulder every day. Boulder's lack of housing also contributes to regional sprawl, which uses more energy and generates more greenhouse gas emissions than compact development in Boulder would, consumes more undeveloped land, increases regional flood risk, uses more water, and worsens regional air and water quality.

For reference throughout the report, Figure 2 on page 8 is a map of the land uses and maximum housing densities allowed in Boulder neighborhoods based on current zoning, as well as bus routes and neighborhood and regional centers identified in the Boulder Valley Comprehensive Plan.

Boulder Does Not Have Enough Housing to Meet Demand

There is not enough housing – particularly affordable housing – in Boulder to meet demand and adequate housing is not being added to accommodate the city's growing workforce

Vacancy rates in the city are low and housing costs are high. From 2007 to 2017, rental vacancy rates in Boulder were consistently lower than statewide and national averages, as shown in Figure 1.[31]

Partly due to the lack of availability, housing is more expensive in Boulder than in surrounding areas. As of June 2019, the median listed price of homes on the real estate database Zillow was $849,450 in Boulder, compared with surrounding communities Louisville ($611,950), Lafayette ($537,000), Erie

FIGURE 1. RENTAL VACANCY RATES IN BOULDER, THE U.S. AND COLORADO FROM 2007 TO 2017[32]

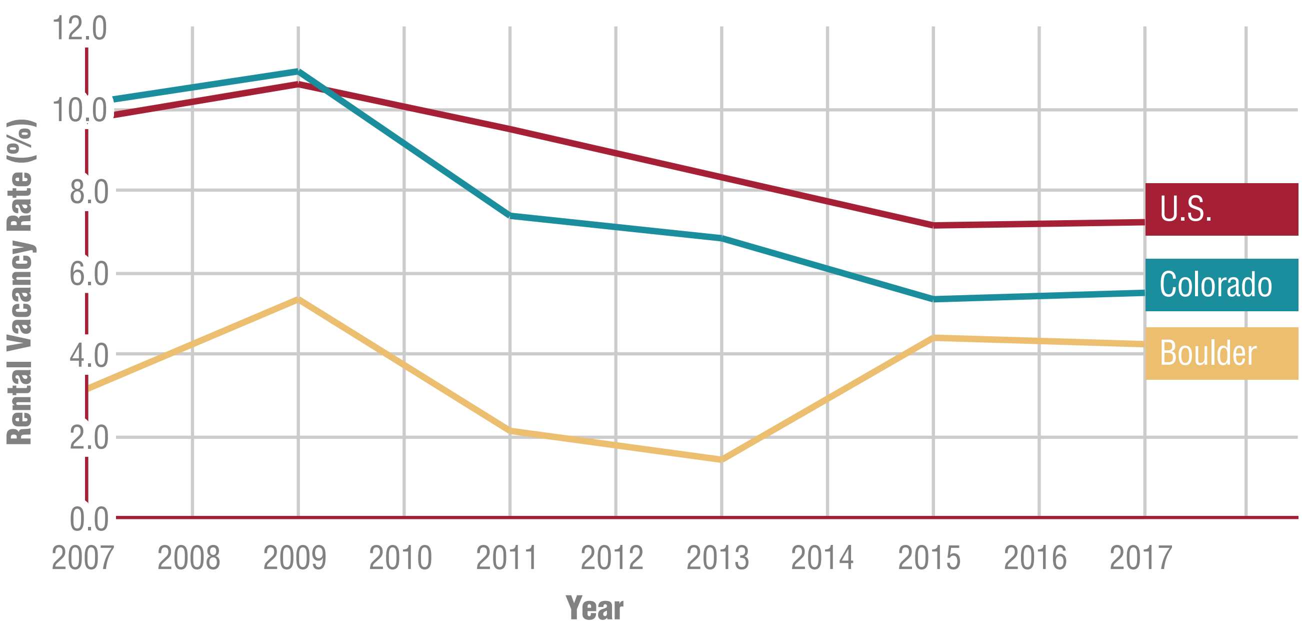


FIGURE 2. MAXIMUM RESIDENTIAL DENSITIES AND LAND USES ALLOWED BY CURRENT ZONING IN BOULDER NEIGHBORHOODS[30]

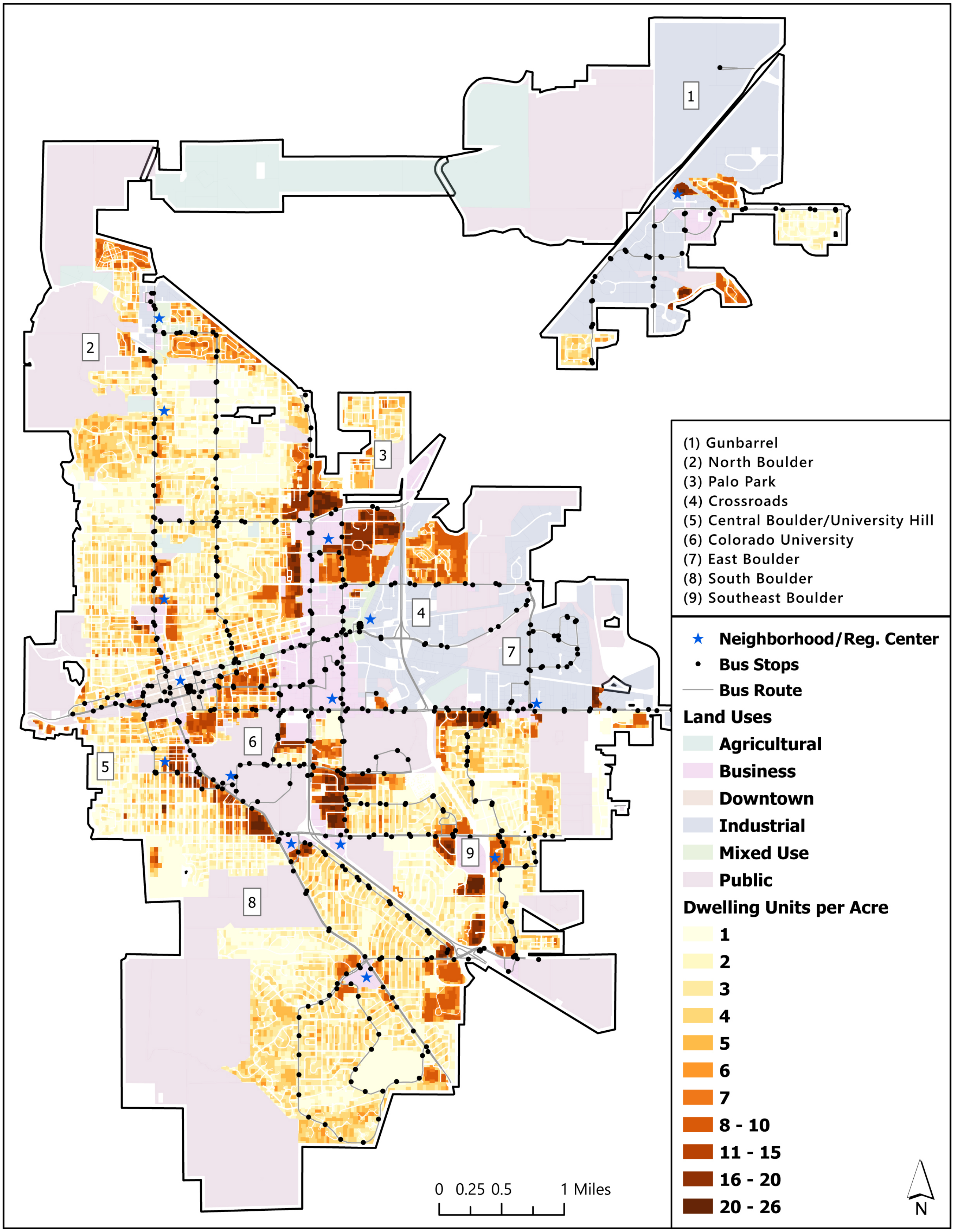
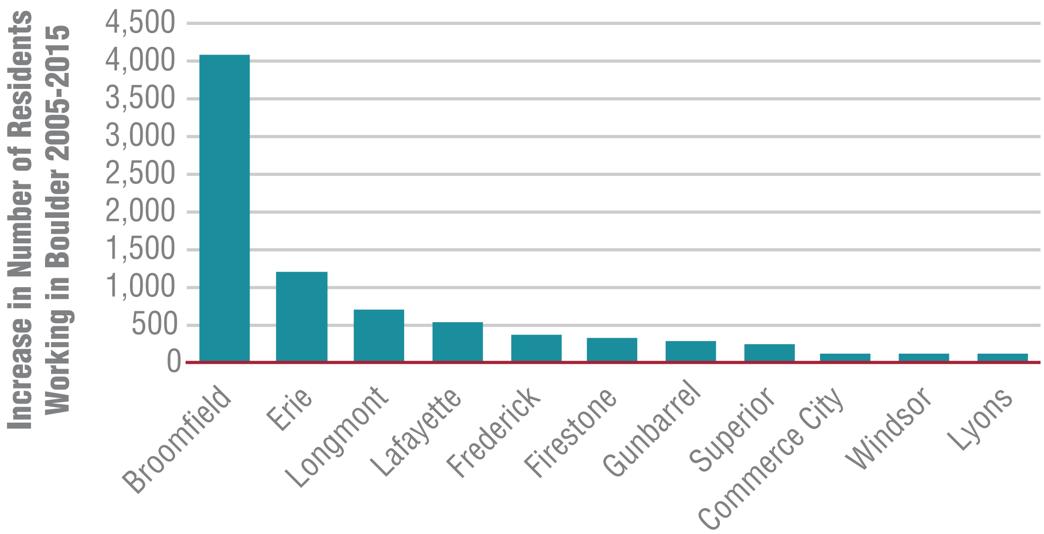


FIGURE 3. COMMUNITIES WITH THE GREATEST INCREASE IN RESIDENTS WHO WORK IN BOULDER, 2005 TO 2015[35]



($549,600) and Brighton ($387,990). Median rent prices are also the highest in Boulder at $2,400.[33] From 2014 to 2017, the median price of detached homes increased by 25 percent and the median price of attached homes increased by 38 percent in Boulder.[34]

In part because of the lack of housing and high housing costs in Boulder, the number of people who work in Boulder is increasing in some surrounding communities as shown in Figure 3.

Between 2017 and 2018, Boulder's population dropped by 0.5 percent, but population increased in Broomfield, Erie, Longmont, Lafayette, Frederick, Firestone and Dacono between 1.5 and 6.3 percent.[36]

Boulder has not been adding enough housing to accommodate its growing workforce and this trend is projected to continue. From 2010 to 2017, Boulder added 4.2 new jobs for each new housing unit.[37] The gap between employment and housing will continue to widen with current zoning. Based on the city's current zoning, Boulder has the capacity to add 54,760 new jobs, but only 19,270 new residents in the city. At this rate, the city's employment to housing ratio will grow from 2.2 in 2015 to 2.9 in the coming decades, adding tens of thousands of inbound commuters to the region's transportation system.[38]

Boulder's Lack of Housing Fuels Vehicle Travel

Boulder's lack of housing is one of the factors contributing to regional vehicle traffic, air pollution and greenhouse gas emissions. Three out of five jobs in Boulder are held by people living in surrounding communities. Many of those communities lack policies, programs and services that encourage sustainable transportation habits, exacerbating the environmental impacts of sprawl.

More than 63,900 jobs in Boulder are held by nonresidents and 77 percent of those employees commute into the city alone in their vehicles each day.[39] These solo inbound commuters contribute significantly to local traffic, making up most of the vehicles entering Boulder during the morning rush hour, and contribute to global warming and regional air pollution.[40]

Transportation is America's number one source of carbon dioxide emissions, the leading global warming pollutant.[41] Boulder has done a lot to encourage transit and other sustainable transportation methods, but in spite of Boulder County's inter-city Regional Transportation District (RTD) network annual ridership increasing 67 percent between 2006 and 2016, inbound commuter vehicle miles travelled (VMT) continues to increase.[42] Commuting – especially long-distance commuting – accounts for a large share of Boulder's contribution to global warming. Boulder residents drive an average of 12.8 miles per day in total, while nonresident employees drive about 29 miles roundtrip on average in commuting distance alone.[43] Boulder's inbound commuters collectively drive up to 245 million more miles each year than they would if they were Boulder residents.[44] This results in over 99,000 metric tons of additional carbon dioxide emissions each year – equivalent to putting over 21,000 more cars on the road.[45]

Driving fueled by long commutes also contributes to dangerous air pollution in the Boulder region. The counties in the Front Range, including Boulder County, are in violation of federal air quality standards for ozone pollution.[46] Ground-level ozone can cause respiratory problems, such as chronic obstructive pulmonary disease (COPD) and lung damage and aggravate lung diseases such as asthma.[47] Vehicle travel in Boulder County emits 31 percent of the county's nitrogen oxide (NO_x) emissions and 24 percent of the county's volatile organic compound (VOC) emissions, which react with one another to form ozone.[48]

Boulder has done a lot to reduce vehicle travel within the city, including through its Community Transit Network, programs like EcoPass – a yearly, unlimited pass for all local and regional buses that can be purchased by a company and its employees or by a neighborhood, and the city's extensive walking and biking networks. However, the lack of compact development in Boulder has pushed many people to live in areas too far from transit stops and without the ability to walk or bike to work or other destinations. Only 26 percent of Boulder residents live in "15-minute walking neighborhoods" – close enough to parks, restaurants and other destinations to walk – versus the city's goal of 80 percent.[49] Boulder residents who live in detached single-family homes are nearly twice as likely to drive alone to work than those living in attached multi-family dwellings units, who are more likely to walk, bike or take transit.[50]

MEASURING CLIMATE IMPACTS

The way greenhouse gas emissions are measured impacts decisions regarding how to reduce them. For example, setting a goal to reduce a community's overall emissions instead of its per capita emissions may encourage steps to cap or reduce population. But global warming is not a local problem – it is a global problem. All of the emissions caused by a city's actions matter – not just those that occur within city limits. In the case of Boulder, the city has made great progress in reducing pollution from community residents, but by limiting housing, the city is also causing inbound commuting from far-away communities, which has a large global warming impact.

Fortunately, Boulder has recognized this and incorporated reducing per capita VMT, including for nonresident commuters into its *2014 Transportation Master Plan*.[54] While VMT per capita for Boulder residents is generally declining, VMT for inbound commuters has increased by about five percent since 2008 as regional sprawl continues to push more nonresident commuters further away from their jobs in Boulder.[55]

Boulder's Lack of Housing Contributes to Sprawling Development Elsewhere

Boulder's lack of housing not only contributes to vehicle travel but also to regional sprawl which degrades water quality, contributes to the urban heat island effect and results in the loss of natural lands. Boulder has limited land consumption within its jurisdiction by preserving a ring of undeveloped land around the city, but Boulder's lack of housing has contributed to the loss of undeveloped land in the greater region. Of jobs in Boulder held by nonresidents, 45 percent are held by people who live elsewhere in Boulder County and 55 percent live in Denver, Broomfield, Adams, Jefferson, Arapahoe, Larimer, Weld, Douglas and El Paso counties.[51] Undeveloped land is being lost in these counties at a faster rate than in Colorado as a whole and the American West on average, as shown in Figure 4.[52] Undeveloped land is being lost fastest in Broomfield County and Broomfield is the community which had by far the greatest increase in the number of residents who work in Boulder from 2005 to 2015 (see Figure 3 on page 9).

How Boulder Limits Housing

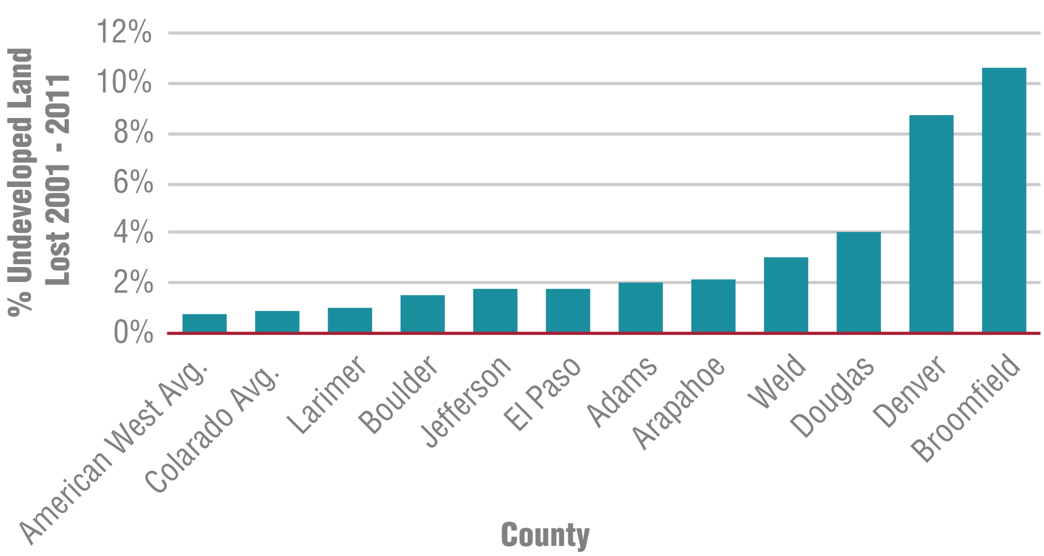
Boulder has many policies that limit housing development, including the following.[56]

Single-family home zoning: Over 56 percent of Boulder's residential area is reserved for detached single-family homes at low densities. Some estimate that about 80 percent of Boulder's residential area is effectively limited to single-family homes due to additional policies and practices.[235] This limits the potential for multi-family housing that is more affordable, more energy efficient and can contribute to the development of walkable, mixed-use neighborhoods, which include both housing, jobs and recreational opportunities.[57]

Accessory dwelling unit (ADU) limits: ADUs are additional housing units within existing homes or on the same property, such as basement, attic, above-garage or detached guest house apartments. Boulder limits the creation of ADUs in several ways:

1. No more than 20 percent of the housing lots or parcels in a given neighborhood can have ADUs in RL-1 and RL-2 (low-density residential) zoning districts.

FIGURE 4. PERCENT OF UNDEVELOPED LAND LOST FROM 2001 TO 2011 IN COUNTIES WHERE BOULDER WORKERS LIVE VERSUS COLORADO AND AMERICAN WEST AVERAGES[53]



2. There must be an additional off-street parking spot for each ADU.

3. The lot must be 5,000 square feet or more to have an ADU.

4. Detached ADUs can't exceed 550 square feet in area or 25 feet in height.

5. Attached ADUs can't be more than 1,000 square feet or one-third the area of the principal home, whichever is less.

These requirements are less restrictive for affordable housing and in designated historic properties.[58] In contrast, many communities and even some states permit ADUs by right.[59]

Occupancy limits: Boulder limits the number of unrelated people who can live together in one household to three people in low-density residential areas and four people in medium- to high-density areas.[60] This limits how many people can be housed in the city's existing housing units. Occupancy limits are much higher in other cities, such as Portland and Seattle, and multiple state supreme courts have ruled that such limits are unconstitutional.[61]

Parking requirements: Boulder requires housing units to have a certain number of off-street parking spaces, which varies by zoning district and the number of bedrooms or occupants in multi-unit homes. The city also requires businesses and other institutions to provide a certain amount of parking, except in the downtown area.[62] These parking requirements can drive up the cost of new construction, especially in redevelopment areas where land costs are high, and can make it more difficult to build multi-unit buildings.[63] Under current requirements, it would be impossible to develop car-free housing, which other communities have demonstrated can attract residents with very low levels of car ownership, essentially eliminating impacts of population growth on local traffic. Because parking encourages vehicle ownership and use, one of the city's goals in its *Transportation Master Plan* is to reduce the number of parking spaces per housing unit.[64] The city has already begun to implement this policy by reducing parking requirements for the Boulder Junction development, which has helped to successfully limit vehicle travel in the development.

Residential growth cap: Boulder's Residential Growth Management System (RGMS) limits residential growth to 1 percent per year. This limit has never been reached because exemptions have been added for certain types of housing, such as mixed-use and affordable housing and because other policies have limited growth.[65]

Building height limits: In 1971, Boulder adopted a 55-foot height limit for all buildings and structures in the city.[66] In the last few years, the city council has adopted a moratorium on buildings over 35 to 40 feet in most of the city.[67] This limits how many housing units can be constructed per acre.

Lengthy permitting process: According to home builders, Boulder's lengthy and expensive review processes are barriers to development.[68] The City of Boulder's website estimates that permits to construct new homes and businesses take 40 to 60 business days, but wait times could be longer.[69] Other communities in the U.S. have taken steps to reduce permitting times to one or two weeks.[70]

Incentives for large, expensive homes: Boulder requires each housing unit to be built on a lot of a certain size with a certain amount of open space. Because these requirements apply to each housing unit, rather than the floor area of the building, multi-unit buildings require larger lot sizes and more open space than single-family homes of the same

MINNEAPOLIS IS INCREASING COMPACT DEVELOPMENT TO EXPAND AFFORDABLE HOUSING AND TACKLE CLIMATE CHANGE

In December 2018, the Minneapolis city council approved *Minneapolis 2040* – the city's comprehensive, long-term plan, which includes ambitious goals for compact development across Minneapolis. With 14 goals and nearly 100 individual policies, the plan aims to use land-use policy oriented toward compact development to combat the city's affordable housing shortage and help the city reach its carbon emissions goals, among other objectives.[73]

There has already been a significant increase in compact development in Minneapolis in recent years, particularly on the edge of the downtown area and in the University and Uptown districts. Between 2010 and 2016, an uptick in urban infill development led to the construction of apartments and townhomes significantly outpacing that of single-family homes.[74]

The 2040 plan includes a radical overhaul of zoning guidelines to allow taller buildings with more units to be constructed in areas that previously only allowed single-family residences, allowing triplexes to be built across much of the city and enabling more compact zoning along transit lines.[75]

The plan acknowledges that a 37 percent reduction in car trips will be necessary for Minneapolis to meet its goal to reduce greenhouse gas emissions by 80 percent below 2006 levels by 2050.[76] So, the plan emphasizes the development of multi-family housing in areas close to transit, retail services and employment hubs to give people the opportunity to live without a car, or with fewer cars per household. The plan also pairs compact development with improvements to pedestrian and cycling infrastructure.[77]

size. This encourages developers to build large, expensive single-family homes rather than multi-unit buildings.[71]

These policies all effectively limit housing development in Boulder, contributing to increased vehicle travel and regional sprawl, which increase greenhouse gas emissions and exacerbate air pollution in the region, among other impacts.

Boulder has started to take steps to increase housing availability. For example, in January 2017 Boulder approved a cooperative housing ordinance, which allows 10 new co-op projects to be licensed each year and raises the caps on the number of residents to 12 per household in low-density neighborhoods and 15 per household in medium and high-density neighborhoods.[72] Cooperative housing offers Boulder residents a more affordable and efficient alternative to single-family homes and adds modest density to Boulder's walkable neighborhoods. These housing types are a small fraction of the total housing supply in Boulder, but in the year since the ordinance was passed, the number of co-ops in Boulder has increased from three to 11. Boulder can take similar steps to remove the barriers to housing development discussed above.

Examples of Compact, Mixed-Use Communities in Boulder

Boulder already has some compact, mixed-use developments that demonstrate the benefits that Boulder could gain by enabling compact growth throughout the city.

Boulder Junction is a 160-acre area on the east side of Boulder that is being transformed into one of the city's flagship mixed-use, pedestrian- and transit-oriented neighborhoods.[78] Boulder Junction has more than 900 residential units, of which 175 are permanently affordable, in addition to retail and office space. Boulder Junction also incorporates a range of sustainability features, including LED street lighting, permeable pavement, trees and other green stormwater infrastructure that combat the urban heat island effect and mitigate stormwater runoff.[79]

A key goal of Boulder Junction is to reduce single occupancy vehicle travel by making the development walkable and by expanding alternative transportation options. The area's zoning stipulates that no more than 45 percent of trips be in single occupancy vehicles. An early evaluation in 2017 found that roughly 58 percent of afternoon peak-time trips were in single occupancy vehicles, meaning the neighborhood is already outperforming almost every other area of the city, though still short of the goal.[80] This figure is expected to fall as transit service increases and new transportation demand management (TDM) programs are put in place, which encourage residents and employees to get around by means other than driving.

Boulder Junction incorporates many TDM strategies. All residents and employees are given an RTD EcoPass, subsidized bikeshare membership and application fee waiver for membership to carshare services.[81] The neighborhood puts into practice Boulder's Access Management and Parking Strategy (AMPS), which uses SUMP (shared, unbundled, managed and paid) parking principles to maximize the use of the infrastructure while decreasing the need for new facilities.

- *Shared*: Parking spaces are shared between commercial, residential and visitor uses at different times of the day.
- *Unbundled:* Spaces are leased separately from the unit and priced at market rates.
- *Managed:* All parking is managed by time and/or cost and regularly enforced.
- *Paid:* No free parking is provided.

The Holiday Neighborhood project is another example of a compact, mixed-use community in Boulder. Developed on the vacant 27-acre site of the former Holiday Drive-in Theater in North Boulder, the neighborhood consists of 333 residential units, as well as parks and community gardens, designed around the principles of walkability and community integration. The homes are built with environmentally friendly materials and the community is connected by bike, transit and pedestrian routes, with shopping and jobs within walking distance.[82]

Red Oak Park in North Boulder is another example. The development consists of 59 duplexes, triplexes and single-family homes, plus a green space, playground and community center. Opened in 2011, the neighborhood is pedestrian-oriented, close to downtown, and has easy access to bike lanes, bus routes, schools and shopping. Its homes are designed to be sustainable and energy-efficient, featuring solar panels and energy-efficient heating and cooling systems.[83]

The Red Oak Park neighborhood in North Boulder is an example of a compact community. Credit: Dennis Schroeder, National Renewable Energy Laboratory via Flickr, CC BY-NC-ND 2.0.

Compact Development Delivers Environmental Benefits

BY PROMOTING COMPACT, MIXED-USE development, Boulder can allow more of its workforce to live within the city and enable residents to commute by taking transit, walking, biking or using shared modes of transportation. Compact development reduces energy use and global warming pollution – both from transportation and from the construction and use of buildings. It also slows land consumption, improves regional air and water quality, reduces flood risk, and lowers water consumption.

Extensive research across a variety of disciplines suggests that compact development is the environmentally sound choice for Boulder's future.

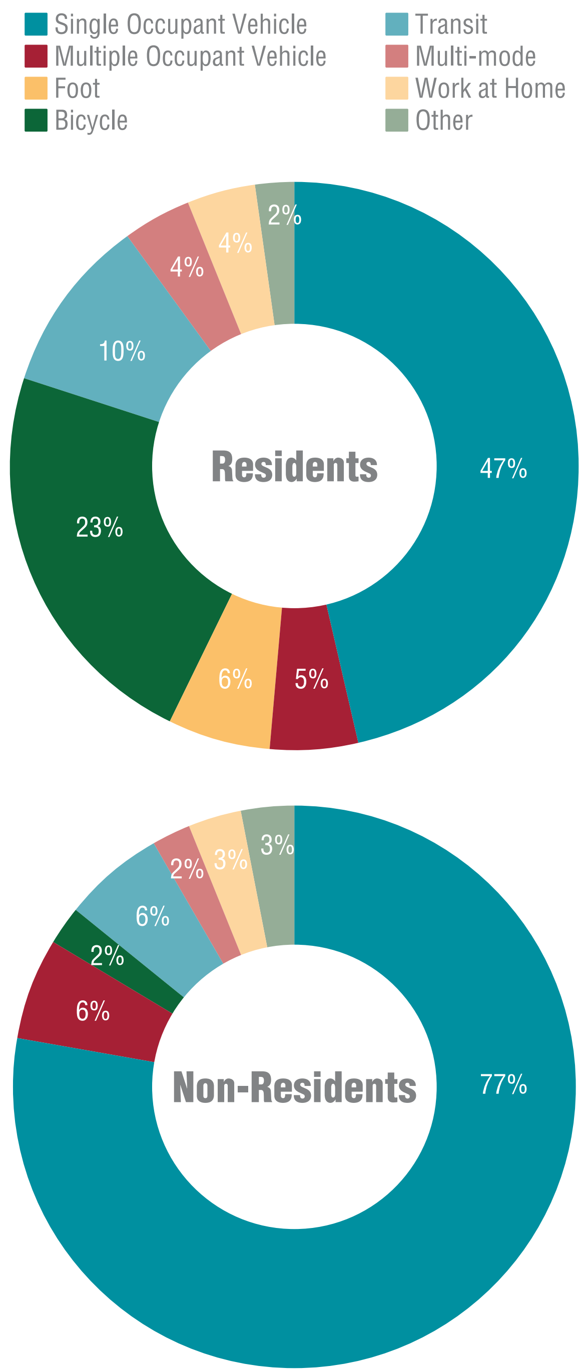
Compact Development Reduces Energy Use and Global Warming Pollution

Planning compact cities can cut urban energy use and greenhouse gas emissions from transportation, as well as from the construction and use of buildings. Creating compact, mixed-use neighborhoods will be key for Boulder and Colorado to meet commitments to cut energy use and greenhouse gas emissions.

People in Compact Urban Neighborhoods Drive Less

Boulder residents drive less and walk, bike and take transit more for their commutes than nonresidents who work in Boulder, as shown in Figure 5. If just one-third of Boulder's inbound commuters lived in the city and drove as much as current residents, there would be up to 6,392 fewer single-occupant vehicles on Boulder's streets during commute times.[84] This would prevent up

FIGURE 5. COMMUTE MODE SPLIT FOR BOULDER EMPLOYEES[87]



to 81 million miles of driving each year, reducing greenhouse gas emissions by over 33,000 metric tons of carbon dioxide – equivalent to taking over 7,000 cars off the road.[85] Those reductions would get Boulder over 10 percent of the way to its goal to reduce greenhouse gas emissions from transportation by 305,000 metric tons of carbon dioxide equivalent by 2050.[86]

Enabling more people who work in Boulder to live in the city would not only cut down on their commutes, but would also reduce the rest of their vehicle travel and emissions as Boulderites drive less than residents of surrounding communities. The Center for Neighborhood Technology's *Housing and Transportation Index* tool measures the relationship between density, transit access, proximity to jobs, and walkability to calculate the average vehicle-related GHG emissions per household for communities across the U.S. Vehicle-related emissions per household are lower in Boulder than in any other community in the region except for Denver, thanks to Boulder's density and efforts to reduce vehicle travel. The other cities and towns within Boulder County are more car-centric and produce about 20 percent more carbon pollution per household than Boulder, just from vehicle use. Of the jobs in Boulder held by nonresidents, more than half – or over 35,000 jobs – are held by people who live in communities outside of Boulder County, such as Broomfield and Thornton, where household GHG emissions from car travel are about 30 percent higher than among Boulder households.[88] These statistics are based on local transportation and land-use characteristics and do not take into account the long daily commutes to Boulder for work.

Southbound traffic on Foothills Parkway in Boulder, Colorado.
Credit: Xnatedawgx via Wikimedia Commons, CC BY-SA 4.0.

By increasing compact development, Boulder can also allow current residents to live closer to transit and the places they need to go, enabling them to walk, bike and use shared modes of transportation more, reducing energy use and greenhouse gas emissions. According to Boulder's *2018 Transportation Report on Progress,* the city has not succeeded in its goal to house 80 percent of its residents in complete, walkable neighborhoods because, though the city has extensive routes for walking and biking, residents do not live close enough to commercial destinations to walk. Creating compact, mixed-use neighborhoods could help address this challenge.[89] The city is also not on track to reduce VMT or greenhouse gas emissions from transportation. The report cites creating more compact, mixed-use, walkable neighborhoods that integrate transit, like Boulder Junction, as a promising strategy to reduce VMT. The report also notes that decreasing trips in single-occupant vehicles will be much harder for nonresident employees, so allowing these employees to live within the city could help the city meet that goal, too.[90]

Extensive research from the United States and beyond shows that people drive less in more compact communities.

- In the April 2017 issue of the *Journal of American Planning Association*, devoted to the question of land form and driving, researcher Mark R. Stevens analyzed 46 studies of compact development and driving.[91] His analysis found that when housing density doubles – for example from single-family homes to duplexes, people drive 22 percent less.[92] He also found that if a household moved 50 percent closer to downtown, for example from 10 miles away to 5 miles away, they would drive 32 percent fewer miles.[93]

- A national-level 2013 study from the University of California Transportation Center determined that a household in an urban area (approximately six dwelling units per acre) drives 21 percent less and consumes approximately 20 percent less fuel than a household living in a suburban area (approximately two to three dwelling units per acre). The study also found that a 50 percent increase in housing density leads to about a 7 percent decrease in mileage and fuel consumption.[94] (See page 8 for a map of the maximum residential densities allowed in Boulder by current zoning.)

- A 2019 study of neighborhoods in San Francisco found a dramatic decrease in auto dependence with neighborhood density. People who live in neighborhoods with 50 residents or more per acre were found to walk, bike, take transit or travel by other means other than driving more than 60 percent of the time.[95]

- A 2010 historical analysis of sprawl by the Lincoln Institute of Land Policy found that higher levels of density are associated with lower car ownership.[96]

- The 2007 study *Growing Cooler* from the Urban Land Institute found that people living in compact neighborhoods drive 20 to 40 percent less than those living in sprawling neighborhoods.[97]

People are more likely to walk, bike, take transit and use shared-transportation options if they live in compact communities where they are close to their destination.[98] Boulder residents are much more likely to walk or bike if they are one mile or less from their destination than if they are further than a mile, as shown in Figure 6.

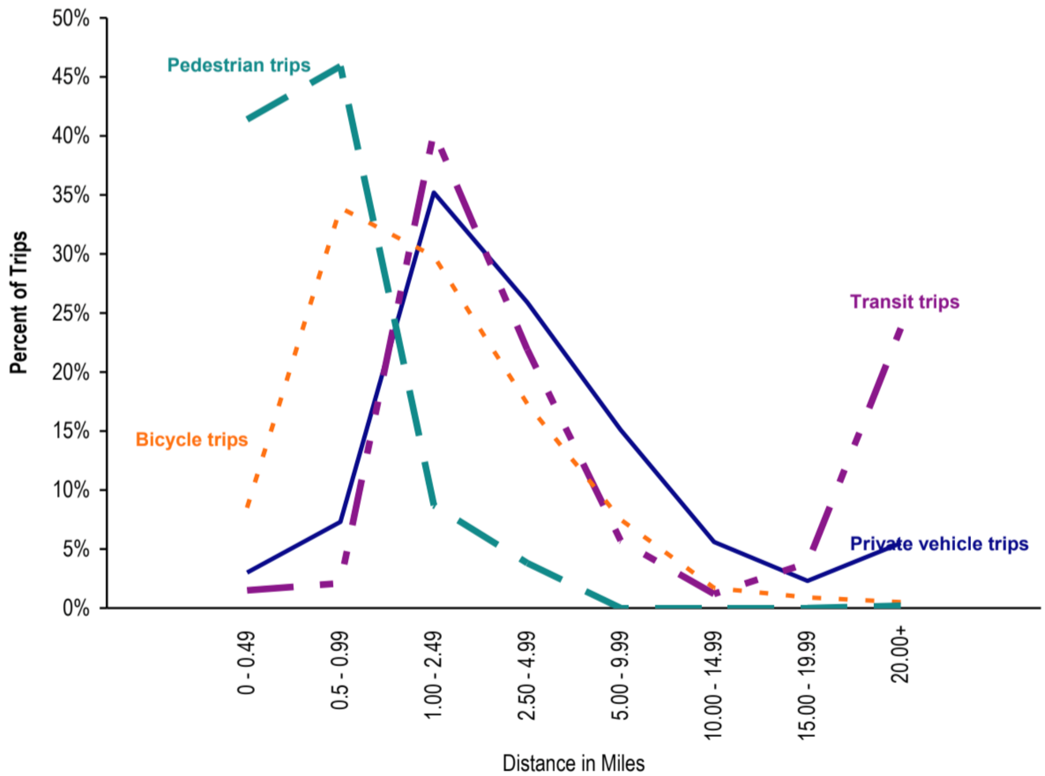
- A 2016 study published in the *Journal of Physical Activity and Health* found that residents of dense neighborhoods (more than 10,000 people per square mile, or approximately 16 people per acre) were almost three times more likely to bike for transportation than those living in low-density neighborhoods (fewer than 500 people per square mile, or fewer than one person per acre).[100]

- A white paper prepared for the 2007 Conference on Transit-Oriented Development in Connecticut concludes that people begin to shift from using single-occupancy vehicles to public transit and walking when certain density thresholds are reached. When housing densities reach 12 dwelling units per acre, dependence on cars begins to decline and people begin to walk, cycle or take public transit. Increasing employment density to 25-50 jobs per acre also leads to a shift from single-occupancy vehicles to walking and transit for work trips.[101]

- A 2006 study in the *Journal of Physical Activity and Health* affirmed that distance to destination and route directness consistently affected the likelihood of walking for transportation.[102]

- Multiple studies show that increasing the density of jobs and residents near

FIGURE 6. TRAVEL MODE OF BOULDER RESIDENTS BY LENGTH OF TRIP, 2018 (CHART: CITY OF BOULDER TRANSPORTATION DIVISION)[99]



transit stops increases transit demand, and makes the expansion of transit service more cost-effective.[103]

- A 2005 report published by the Transit Cooperative Research Project identified high-density, mixed land uses and limited availability of parking as factors in the early success of roundtrip carsharing programs.[104] Carsharing can reduce both VMT and overall vehicle ownership; for example, in a San Francisco car-sharing program, members saw their daily VMT decrease from 2.80 to 1.49 miles, and nearly a quarter of participants gave up a primary or secondary vehicle.[105]

Boulder cites reducing nonresident commuter trips alone in personal vehicles as one of the greatest challenges to meeting its greenhouse gas emission reduction goals.[106] Compact, mixed-use development is a prerequisite for successful strategies to reduce transportation-related energy use and emissions.

- A 2011 U.S. Environmental Protection Agency (EPA) study found that shifting from conventional suburban development to compact, transit-oriented development is just as important as shifting to the most energy efficient building designs and fuel-efficient vehicles for reducing household energy use and emissions.[107]

- The 2009 update of Urban Land Institute's study *Moving Cooler* concluded that if 60 to 90 percent of new development in the U.S. were shifted from continued urban sprawl to compact development, U.S. carbon dioxide emissions from transportation would be 7 to 10 percent lower by 2050.[108]

- A study published in the *Journal of Urban Economics* in 2010 found that suburban households in the Austin metro area emit 4,106 pounds more carbon dioxide per year from driving than households in the city center, or the equivalent of filling up a 15-gallon tank with gasoline 14 more times.[109]

- Since 2008, the state of California has required metropolitan planning organizations to demonstrate how integrated land-use, housing and transportation planning will meet regional greenhouse gas emissions reduction goals.[110] Under this law, the San Diego Regional Planning Agency (SANDAG) has worked closely with local municipalities to reform land-use policies and development patterns, and focus future jobs and housing growth in urbanized areas around existing or planned transit corridors. The agency's 2015 *Regional Growth Forecast* compared the greenhouse gas emissions projections under the 1999 growth plan against the 2013 plan, and found that smart growth policies developed in the last 10 years will account for an estimated 30 percent reduction in regional greenhouse gas emissions. These reductions are largely a result of compact development – in 2050, 80 percent of new housing will be attached multifamily, 87 percent of all housing and 79 percent of all jobs will be within a half-mile of public transit, and the percentage of households within a half-mile of frequent public transit will increase from 35.3 percent in 2012 to 62.3 percent.[111]

It would not require a large increase in density for Boulder to shift residents from vehicle travel to more sustainable transportation methods, reducing air pollution and greenhouse gas emissions.

- A study of residents' travel habits in 28 California communities varying widely in residential density found that the biggest shift from driving to sustainable transportation methods occurred between large-lot, sprawling communities and those with densities of 10 to 20 units per acre – neighborhoods consisting of apartments, row houses and some single-family homes.[112]

- The Puget Sound Regional Council incorporated transit-supportive density goals into its growth plan, citing that, "[e]xtensive national research has shown that residential densities exceeding 7 or 8 homes per gross acre support efficient and reliable local transit service. Household densities should reach, at minimum, 10 to 20 dwelling units per gross acre close to transit stations."

TABLE 1. RESIDENTIAL DENSITY FOR THE FIVE MOST POPULATED NEIGHBORHOODS IN BOULDER (WHICH ACCOUNT FOR 80 PERCENT OF THE TOTAL POPULATION)[113]

	Central Boulder	South Boulder	Southeast Boulder	North Boulder	Gunbarrel
Population	29,335	15,381	22,739	12,291	10,731
Total Dwelling Units (DU)	13,312	7,312	9,385	5,847	5,110
Density (DU/Res Acre)	8.87	6.52	6.93	5.96	6.46

Increasing the number of housing units in Boulder's most populous neighborhoods in North Boulder, South Boulder, Southeast Boulder, and Gunbarrel by 15 to 30 percent could achieve 7 dwelling units per acre and enable a large community-wide modal shift away from car-travel and toward clean and efficient transportation alternatives.[114] (See page 8 for a map of the maximum residential densities allowed throughout Boulder by current zoning.) By co-locating compact residential and commercial growth in these neighborhoods, Boulder can create the necessary conditions for transit to thrive to thrive including a critical mass of potential transit patrons and all-day travel demand with a mix of travel schedules to maximize transit efficiency.[115]

Building more compactly enables residents to switch from driving their cars to walking, biking, taking transit and using shared modes of transportation, such as bikesharing and carsharing. This helps cities reduce energy use, air pollution and greenhouse gas emissions.

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

Compact development can also cut energy use and greenhouse gas emissions from the construction and use of buildings.

A study published in *Energy Policy* in 2014 examined how density in three Austin neighborhoods and one suburb influenced life-cycle energy use for buildings, transportation and infrastructure – from resource extraction and construction to everyday use.[116] The study found that:

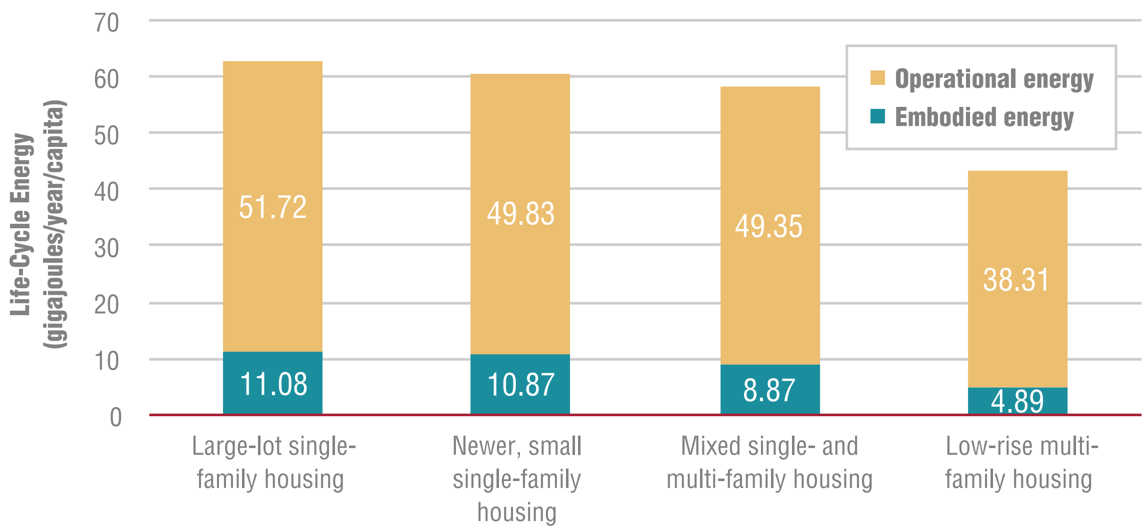
- In the Austin metro area, compact neighborhoods composed of low-rise multi-family homes consume up to 37 percent less energy in total than more suburban neighborhoods dominated by detached single-family homes.[117]
- Not including transportation, an average household in a compact neighborhood consumes up to 26 percent less energy on a day-to-day basis than a similar household in a sprawling neighborhood.
- An average home in a compact neighborhood requires less than half the energy to build than a similar home in a sprawling neighborhood, including the energy expended in producing the raw materials.[118]

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

- In New York, building more compactly was found to decrease the amount of energy per person that was needed to heat, light, cool and power buildings.[120]
- 2011 figures from Statistics Canada show that apartment dwellers consumed 70 percent less energy than those living in single detached homes.[121]
- A study of household energy use in Sydney, Australia, found that multi-unit buildings are 30 percent more energy efficient for heating and cooling than detached homes due to shared walls.[122]
- A 2006 study published in the *Journal of Urban Planning and Development* found that in Toronto, annual energy use was systematically lower in low-rise multi-family buildings than in detached single-family homes – 53 percent lower per person and 12 percent lower per unit of floor area.[123]

Compact communities can also use energy-saving technologies that might be more difficult to apply in more spread-out areas. For example, district energy systems provide heating and cooling for groups of buildings, which is more effi-

FIGURE 7. THE BUILDING AND INFRASTRUCTURE LIFE-CYCLE ENERGY IMPACTS OF FOUR AUSTIN NEIGHBORHOODS VARY BY HOUSING TYPE[119]



** Embodied energy refers to the energy required to produce and deliver the materials used to construct the buildings, operation energy refers to the energy used by the buildings.*

cient than each home operating its own energy system.

- The city of Saint Paul, Minnesota, extended its district heating and cooling system during the construction of a new light rail line. The Saint Paul system is powered in part by a large solar installation, and will be phasing out its use of coal by 2021, cutting more than a quarter of the system's greenhouse gas emissions.[124]

- Austin's electric utility operates a 17-megawatt district cooling system that provides at least 32 buildings with chilled water through a network of underground pipes.[125]

Compact neighborhoods use less energy and emit fewer greenhouse gases than their sprawling counterparts – both from transportation and from building construction and use – particularly when placed near transit corridors and near commercial centers.

Compact Development Slows the Loss of Undeveloped Land

Across Colorado, sprawling development has converted open space, agricultural lands and ecologically important landscapes into roads, buildings and parking lots. With rapid population growth in recent decades, around 250,000 acres of rural land in Colorado is being lost every year to development.[126]

In Boulder, various measures implemented since the late 1950s have aimed to create a clear boundary between urban and rural development, controlling urban sprawl and preserving rural land outside the city, notably through 45,000 acres of open space and parks in and around the city.[127] However, limitations on residential expansion in Boulder itself have led to three-fifths of the city's jobs being held by people living in surrounding communities and counties, contributing to land development there. Between 2001 and 2011, the counties in which much of Boulder's workforce lives lost undeveloped land at much higher rates than Colorado as a whole (see page 11.)[128]

Increasing infill housing development in Boulder can help reduce development pressure on land in Boulder County and surrounding areas, and help preserve open space, farmland and wildlands.

Compact Development Improves Regional Air Quality

There is less air pollution in compact cities than in sprawling areas due to smaller urban heat islands and less transportation-related emissions.

Ozone pollution is a serious concern in Colorado and in the Denver Metro/North Front Range region specifically, with ozone levels frequently exceeding the EPA ozone standard.[133] In 2018, there were 52 ozone action days in the Front Range region when residents were warned that exercising outdoors could harm their health.[134] The American Lung Association's 2019 *State of the Air* report awarded Boulder County an 'F' grade for ground-level ozone, denoting "unhealthy levels" of the pollutant.[135] Air pollution is associated with a higher mortality risk and

View of the Flatirons across the undeveloped ring of land surrounding Boulder. Credit: Scott McLeod via Flickr, CC BY 2.0.

HEALTH EFFECTS OF AIR POLLUTION

Air pollution kills thousands of Americans each year. The higher the concentration of ozone or fine particulate matter, the greater the risk of death. Between 2013 and 2015, high levels of air pollution directly led to an estimated 73 premature deaths and 153 additional illnesses in Colorado.[129]

Small particles of 10 micrometers or less in diameter, approximately the size of a single red blood cell, can affect both the lungs and the heart. Numerous studies have linked small particles to asthma, coughing, difficulty breathing, irregular heartbeat and nonfatal heart attacks. In Colorado, 9 percent of the adult population suffers from asthma.[130] Particle pollution is also the main cause of haze, reducing visibility in many parts of the U.S.[131]

Ozone in the upper atmosphere protects us from ultraviolet rays, but it can be dangerous on the ground. On hot sunny days, air pollutants like nitrogen oxides (NO_x) and volatile organic compounds (VOCs) react in the presence of sunlight to produce ozone, and the concentration of ozone in the air can reach unhealthy levels. Overexposure to ozone can cause or contribute to shortness of breath, inflammation, lung infections, and lung diseases like asthma or chronic bronchitis.[132]

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

detrimental everyday health effects. Boulder's 2018 *Transportation Report on Progress* finds that the city is not on track to reduce air pollution emissions from transportation.[136]

Residents living in compact cities are exposed to lower levels of ozone than in sprawling communities.

- A study published in the *Journal of Environmental Management* in 2008 studied the relationship between urban spatial structure and exceedances of national ozone standards in 45 large metro areas across the U.S. The study found that compact cities experience up to 62 percent fewer high ozone days than sprawling cities.[137]

- In 2008, researchers from the University of Texas at Austin and the Molina Center for Energy and the Environment found that compact development in neighborhoods with mixed-used zoning will produce less exposure to high levels of ozone than sprawling development.[138]

One reason that air pollution levels – including ozone – are lower in compact cities than in sprawling cities is that compact urban forms lead to smaller urban heat islands and fewer extreme heat events, which increase air pollution.

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

- Increase emissions of volatile organic compounds (VOCs) from vehicles and other sources,[139]

- Increase emissions of ozone precursors from power plants in response to greater demand for air conditioning,[140]

- Intensify ground-level ozone formation.[141]

Denver's heat island is the third most intense in the country, with an average temperature differential of 4.9° Fahrenheit between the city's center and outlying rural areas.[142] The relative abundance of open space in the region has helped keep Boulder from becoming a heat island, but continued conversion of undeveloped land in the suburbs could change that – more so than infill development in Boulder would.[143]

- A 2010 study published in *Environmental Health Perspectives* analyzed the frequency of extreme heat events in major U.S. cities, and found that the most sprawling cities experienced 14.8 more extreme heat events on average each year in 2005 than they did in 1956, whereas the most compact cities added just 5.6 extreme heat events.[144]

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

- Compact urban forms, with high household and employment density, high street connectivity and urban public transportation systems, are associated with lower vehicle travel and tailpipe emissions, and with relatively lower emissions of carbon monoxide, nitrogen oxides and VOCs from vehicles.[145]

- The Autumn 2007 issue of the *Journal of the American Planning Association* contained a study that found that a 3.5 percent reduction in household vehicle travel and emissions may be expected with a 10 percent increase in population density in metropolitan areas.[146]

- A 2010 study published in *Transportation Research Record* indicates that combining compact development with transportation policies such as congestion pricing on freeways can cut approximately 15 percent of predicted 2030 emissions of VOCs, NO_x and carbon monoxide relative to a business-as-usual scenario of development.[147]

Building more compactly in Boulder can help combat the development of an urban heat island, cut transportation emissions, and improve regional air quality, with real health benefits.[148] Compact development is key to fighting air pollution and safeguarding public health in Boulder.

Compact Development Results in Better Regional Water Quality

Compact residential development slows the rate of land conversion from agricultural or natural uses to impervious surfaces like roads and buildings, resulting in less regional runoff pollution.[149]

- A 2009 study by John S. Jacob of Texas A&M University and Ricardo Lopez of the Baylor College of Medicine found that while compact development increases runoff locally, it leads to "dramatically lower" levels of overall runoff pollution in the larger area. The authors conclude that compact development may be "the single most important practice any city can undertake to improve the surrounding environment."[150] Green stormwater infrastructure can reduce the impact of compact development on local runoff as well. See page 31.

- A study published in *Proceedings of the National Academy of Sciences* in 2016 found that losing natural land cover to development in cities' source watersheds can increase water treatment costs up to 50 percent in impacted cities.[151]

Diagonal Court is an example of affordable, compact housing in Boulder with easy access to transit and commercial centers. Credit: Dennis Schroeder, National Renewable Energy Laboratory via Flickr, CC BY-NC-ND 2.0.

Choosing to build more compactly mitigates the impact of urban growth on water quality, and may be considered a stormwater best management practice (BMP) in its own right.[152] Consolidating urban growth in already developed areas such as Boulder, instead of developing surrounding undeveloped land, helps to protect urban watersheds and results in cleaner water and healthier aquatic environments.

Compact Development Reduces Flood Risk

Urban floods are increasingly frequent, costly and dangerous in Colorado. Following the devastation caused by the Big Thompson Canyon flood in 1976, Boulder invested heavily in flood mitigation strategies. Rapid population growth along the Front Range and urban and suburban development have exacerbated the risks associated with urban flooding.[153] To address this, Boulder has taken steps to prohibit new development in highly hazardous zones.

When permeable soil is covered by impervious surfaces, like roofs and roads, more rainwater flows as runoff into ditches and streams, potentially leading to downstream flooding.[154] Building more compactly would not prevent large floods like the 2013 Colorado Front Range Flood from causing damage, but can help reduce flood risks during smaller, more frequent events.[155]

- A multidisciplinary review of scientific literature published in the *Journal of Urbanism* in 2008 concluded that compact development patterns minimize the area of impervious surfaces at a regional level, which mitigates the enhanced flood risk that comes with urban development. Single-family housing units tend to have larger houses and longer driveways, which translates to more impervious surface per household. [156]

- A 2010 study published in the *Journal of Water Resources and Planning* found that low-density development resulted in 72 percent more impervious cover than high- and medium-density development.[157] The high- and medium-density sites experienced approximately 8 percent less total on-site runoff and smaller peak flows than the low-density sites.[158]

By increasing compact development and minimizing impervious surface cover, Boulder can help minimize regional flood risk from small, more frequent events.

Compact Development Results in Lower Water Consumption

Colorado has experienced drought conditions in at least one area of the state for most of the last two decades. The state continuously experienced drought conditions for over seven years from October 30, 2001 to May 19, 2009; for over four years from September 28, 2010 to June 9, 2015; and most recently for 20 months from September 5, 2017 to May 14, 2019. During the most recent period of drought, areas of the state experienced "Exceptional Drought" – the most severe designation – for about 10 months from April 17, 2018 to February 19, 2019. [159] Due to global warming, these trends are projected to continue as a result of increasing temperatures and decreasing winter snowpack.[160]

Boulder has implemented many water conservation efforts. For example, the city budgets how much water customers can use each month and charges them more or less based on the percentage of the budget they use.[161] Thanks to these efforts, water consumption has generally been decreasing in Boulder since 2002.[162]

By increasing housing density, Boulder could further reduce water consumption. Boulder residents who live in single-family homes use more than twice as much water as those who live in multi-family homes – 123 gallons of water per day on average versus 58 gallons.[163]

Compact development can decrease water consumption by maximizing building-to-lot ratios, which lowers landscape irrigation needs, particularly when combined with provisions to capture rainwater for use within buildings and for residential lawn watering and commercial landscape irrigation.[164]

- A 2018 study by the Sonoran Institute and the Babbitt Center for Land and Water Policy finds that more compact development results in less water consumption.[165]

- A 2010 study published in the *Journal of the American Water Resources Association* estimating the effect of urban form on residential water use in Hillsboro, Oregon, in the Portland metro area found that compact development can result in lower overall water demand than sprawling development.[166] According to the researchers' analysis, new, large homes with high property values used the most water for external uses like lawn watering, including during droughts.[167]

- A study published in 2007 in the *Journal of the American Planning Association* showed that in Phoenix, water use in single-family units increased by 1.8 percent for each 1,000-square foot increase in average lot size.[168] The study also found that water use in single-family units increased 1.7 percent for every 1°F rise in the average daily temperature low due to the urban heat island effect, which is stronger in sprawling cities than in compact cities.[169] Household water demand and outdoor space are also correlated in both arid and temperate climates due to landscaping.[170]

Compact development, associated with smaller urban heat islands, smaller lots and fewer landscaping needs, is associated with lower household water demand.[171] Building more compactly and reducing lot sizes would help bolster the city's efforts to minimize water consumption in Boulder by minimizing demand.

Smart Policies Can Address Housing Needs While Keeping Boulder Green

While building more compactly benefits the environment at the regional level, adding more people, businesses, buildings and cars in a neighborhood can create local environmental impacts. Fortunately, Boulder has many policies in place to mitigate these impacts, enabling the city to gain the benefits of compact development while preserving the natural environment, public health and quality of life in all of its neighborhoods.[172]

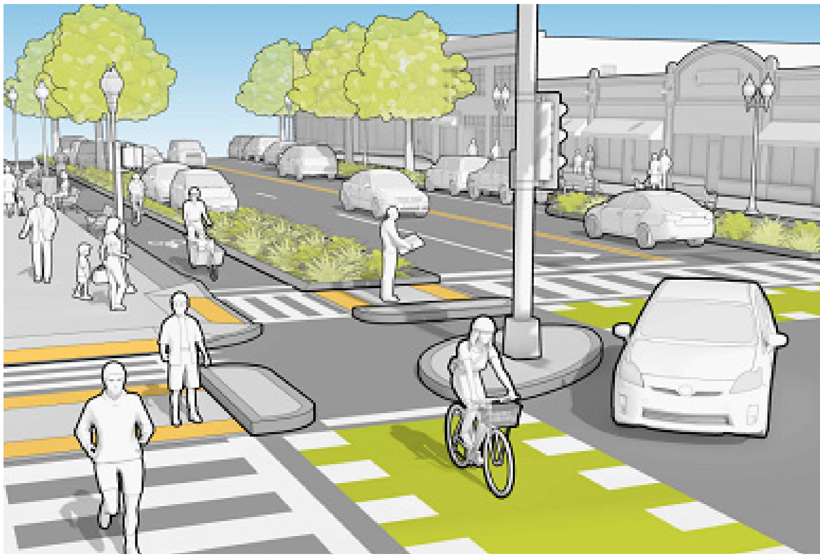
Reducing Transportation-Related Emissions

Compact development leads to lower air pollution emissions per capita, in large part due to lower transportation needs, and increased use of public transit and other alternatives to single-occupancy vehicles. For local areas experiencing increased development, however, there may be increased vehicle traffic, with localized effects on air quality – especially if alternatives to vehicle ownership and use such as transit, shared mobility, and safe biking and walking infrastructure are unavailable.

The city of Boulder has many initiatives to limit vehicle-related emissions by supporting walking, biking, transit, shared transportation mobility and electric vehicles. For example, Boulder uses revenue from its metered parking spots and garages to fund transit, bikeshare, and other programs.[173]

Boulder should strengthen its clean transportation requirements, programs and infrastructure to enable development without increasing vehicle traffic, including:

Bicycle and pedestrian infrastructure improvements can ensure that bicycling and walking are viable, safe and comfortable modes of travel. Zero-carbon mobility is important to substitute for short car trips to local destinations, reducing congestion and emissions. Boulder has invested heavily in cycling infrastructure over the last 20 years, and is consistently ranked among the most bike-friendly cities in the country – including being ranked the most bike friendly city in the U.S. by PeopleForBikes in 2019.[174] Boulder's current Transportation Master Plan places a strong emphasis on further enhancing the city's cycling infrastructure, with the addition of 92 miles of cycle lanes, routes and shoulders, as well as improved crossings, overpasses and underpasses.[175] Enticing more residents to travel by bike can reduce the congestion impact of new compact development.



Bicycle infrastructure improvements include separations between bike lanes, sidewalks and roads; corner refuge islands and pedestrian- and bicycle-specific lighting signals.[176] Credit: Massachusetts Department of Transportation, November 2015.

Consolidating growth around **public transit** hubs can support transit expansion, which can prevent growth from resulting in added vehicle travel.[177] According to decades of research, the minimum neighborhood density required to support "intermediate transit service" with one-quarter to half-mile route spacing – the distance most people will walk to bus stops – and 40 buses per day, is 7 dwelling units per residential acre.[178] Density should intensify closer to transit stops. Puget Sound Regional Council recommends densities of 10 to 20 dwelling units or 30 residents and/or jobs per gross acre.[179] This level of density generates enough transit ridership to justify frequent transit service, which can reduce driving in the existing community and prevent added residents and jobs from adding more vehicle traffic. (See page 8 for a map of the maximum residential densities allowed in Boulder by current zoning.)

In 2015, Boulder spent $32 million on RTD's base system bus service, which includes a Community Transit Network (CTN) of 13 local bus routes. Many of these bus routes, like the SKIP along Broadway, operate on 10- to 20-minute intervals with less than quarter-mile spacing between bus stops. These service levels are comparable with larger urban transit systems and have the capacity to accommodate much higher levels of ridership. The local bus service has plenty of capacity, but in many neighborhoods, ridership is constrained by lack of density.[180]

Smart transit technology optimizes public transit to meet the needs of commuters and minimize air quality impacts. For example, bus rapid transit lines that have dedicated lanes and/or can turn traffic lights green as they approach idle less, use less energy and generate fewer emissions.[181]

Supporting expansion of the RTD to serve more areas more frequently will also help cut down on regional emissions.

Vehicle electrification will also be necessary to cut exhaust and associated air pollution. Widespread adoption of plug-in electric vehicles running on clean power can improve local air quality and help regions meet national air quality standards.[182]

Statewide, Colorado aims to get 940,000 electric vehicles on the road by 2040, and in January 2019 Governor Jared Polis signed an executive order calling for a program to require auto manufacturers to hit certain zero-emission vehicle sales targets.[183] The state has adopted numerous policies designed to support the EV market, including deregulating the resale of electricity for EV charging (for example by operators of charging stations), creating a tax credit of $5,000 per EV, and creating an infrastructure fund to support the installation of EV charging in public locations, workplaces and multifamily housing.[184] Governor Polis also called for $70 million from the Volkswagen emissions settlement to go toward transportation electrification – including the replacement of old diesel buses with new electric ones.[185]

Boulder has one of the highest per capita percentages of hybrid and electric vehicle (EV) ownership in the country, but also one of the highest per capita percentages of SUV ownership.[186] The city's 2017 Climate Commitment includes a commitment to support the adoption of EVs, including expanding regional charging infrastructure, promoting electrification of the RTD transit fleet, and developing an employee EV commuting pilot project.[187] Boulder's updated building code requires new residential and commercial buildings to include EV charging infrastructure for residents and community members to charge their electric vehicles.[188] Future developments can maximize charging opportunities and explore other creative clean transportation solutions such as electric carshare subscriptions for tenants. Southwest Energy Efficiency Project

(SWEEP) laid out many steps Boulder can take to further encourage EV adoption in its 2015 report, *Boulder Electric Vehicle Infrastructure and Adoption Assessment*.[189]

Transportation demand management (TDM) measures focus on addressing the factors that make us drive in the first place to reduce travel demand from automobiles. These measures align incentives to discourage unnecessary driving and to change behavior over the long-term. Employers, for example, can set incentives to encourage sustainable commuting practices. Boulder has multiple TDM measures including EcoPass, and rebates and tax benefits for employees who commute via bike or transit.[190]

Boulder laid out potential additional TDM strategies in its Access Management & Parking Strategy report, including the following.[191]

- **EcoPass expansion**: As of 2017, about half of Boulder's residents had an EcoPass through a neighborhood, business, or university program and 34,000 additional Boulder residents are eligible to sign-up for an Ecopass. Boulder's TDM plan considers making EcoPass universally available or available to more groups.[192]

- **Parking cash outs:** Employers often subsidize the cost of parking for their employees. Parking cash outs give employees the option to receive cash directly instead, which creates a financial incentive to not drive to work. SolidFire, a tech equipment company in downtown Boulder implemented such a program and it resulted in fewer employees commuting alone in their cars and reduced parking demand. It also saved the company about $17,000 per month. Google and Rocky Mountain Institute have also instituted parking cash-out policies for their Boulder employees.[193]

- **Parking maximums:** The Boulder Junction project incorporated parking *maximums* of one spot per housing unit, which is different than Boulder's current, general policies, which set parking *minimums* of 1.5 parking spaces per unit. The Boulder Junction development unbundled the housing units from parking spaces, giving tenants the choice to "opt-in" and purchase a parking space for $100 per month. The early results from this arrangement suggest that Boulder Junction tenants average 0.9 parking spaces per unit, or about 40 percent less than the City's normal requirements for new residential units.[194]

- **Implementing the TDM Plan Ordinance:** This would require new developments to meet targets to limit the amount of peak-hour traffic they generate with assistance from city TDM programs.

- **Encouraging carsharing and bikesharing programs:** This can be achieved through subsidies, parking spots and docking stations, advertising and other means.[195] Installing EV charging stations near these carshare locations can encourage EV adoption.

A combined land use and transportation strategy can help Boulder reduce driving and associated air pollution emissions. Boulder has already incorporated a number of these tools, including walking, biking, transit and electric vehicle infrastructure and programs, which can all be expanded as Boulder grows.

Fighting the Urban Heat Island Effect

Increasing development can increase the urban heat island effect, but this can be offset with multiple tools, including planting trees and using light colored roofs and pavement.

Developed areas tend to have higher temperatures than their surroundings – this is known as the "urban heat island effect." Urban areas tend to be hotter because they have a greater density of buildings and sidewalks that absorb and radiate heat, as well as cars, industrial equipment, air conditioning and other sources that generate excess heat. Cities can use reflective surfaces and plant urban vegetation to cool down and help reduce air conditioning demand by up to one-fifth, achieving energy savings and improving urban air quality from reduced power plant emissions.[196]

Use of light-colored materials and reflective coatings on roofs and in pavements is a powerful tool to combat the urban heat island effect. For instance, a light-colored roof reduces cooling energy use, both directly

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

Credit: John Panella via Shutterstock.

within the building, since it absorbs less sunlight, as well as indirectly in neighboring buildings, since the roof also radiates less heat.[197] One study focused on development in Houston found that placing shade trees near buildings and using light-colored roofing and paving materials that reflect sunlight could save $82 million on energy, decrease peak power demand by 730 megawatts and cut carbon emissions by 170,000 tons, an amount equivalent to taking more than 36,000 cars off the road.[198] This simple shift, which can be incorporated into routine re-roofing and resurfacing schedules, can lead to significant reductions in energy use and emissions.

Integrating nature into cities is key to cooling them down, with tangible health benefits for residents. Shade trees cool the air, block sunlight before it reaches buildings or pavements, shield streets from wind, and filter the air. A 2019 study published in the journal *Ecosystems* estimates that urban trees provide heat-reduction services, in the form of reduced health impacts and energy consumption, worth between $5.3 billion and $12.1 billion annually across the U.S.[199] The Texas Trees Foundation found in its 2017 *Dallas Urban Heat Island Effect* report that planting trees in the hottest areas with high-density residential buildings reduced heat-related deaths by more than 20 percent by lowering the temperature.[200] City trees are also a form of green stormwater infrastructure (see page 31), intercepting rain in their leaves and branches, and contributing to flood mitigation and runoff control.[201]

Every year, Boulder's 650,000 urban trees sequester 18,709 tons of carbon; absorb 139 tons of air pollutants, including carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide and particulate matter; and reduce stormwater runoff volume by approximately 422 million gallons.[202] Tree shade reduces annual average cooling costs by

22 percent per household. Citywide, this equates to an annual savings of 27 million kWh, or $1.65 million.[203] By focusing on infill development, Boulder can grow without cutting into this valuable resource. The City of Boulder's work to support its urban forest will be crucial to fighting the urban heat island effect, and could be strengthened with other tools like reflective or light-colored roofing and pavements.

Reducing Local Flood Risks

Boulder has historically been a leader in addressing stormwater management issues. Among the action items identified in the City's Comprehensive Flood and Stormwater Utility Master Plan is the need to address the problem of impervious cover, preserve natural areas and minimize stormwater pollution from development.[204] Focusing on compact urban forms and deterring regional sprawl can help limit the total amount of impervious cover and fragmentation in watersheds, and minimize the vulnerability of the watershed to surface runoff and flash floods.[205]

Although higher-density development generates less stormwater runoff per housing unit than low-density development, higher densities result in more runoff per acre in the areas that are the focus of development.[206] In other words, while new, low-density, suburban development has a far greater impact at the regional level, compact development can increase runoff within city centers.[207]

Retrofitting stormwater drainage systems in existing urban areas and using low-impact design principles in new development can help maximize local infiltration and minimize stormwater runoff to waterways.[208] Green and gray stormwater infrastructure and impervious cover limits can help counter urban flooding.

Green stormwater infrastructure (GSI) uses plants, soil, and natural drainage to capture and cleanse rain where it falls.[209] Rain gardens, green roofs and permeable pavement can remove pollutants from rain water and let the water soak into the soil, evaporate into the air, or be held temporarily for flood detention.[210] Rain harvesting systems can collect and store water so that it can be used later for landscape irrigation and other onsite uses.[211]

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

- **Pollution reduction**: These features can be especially successful in improving water quality, because they can capture and cleanse the first inch of stormwater runoff, which contains the highest concentration of pollutants that have accumulated on surfaces between rains.[212]
- **Erosion mitigation**: These features can reduce both the volume and speed of runoff, which reduces the scouring effect of stormwater on stream banks.[213]
- **Beautification**: Since most features use plants, they double as landscape amenities. For example, green roofs and parking lot bioswales can introduce greenery where there otherwise would be none.[214]
- **Economic benefit**: Developers can often save money with GSI, since using these features may allow them to reduce the size (and cost) of other stormwater infrastructure such as drainage pipes and detention ponds. This in turn may sometimes allow more of the property to be developed.[215]
- **Flood mitigation**: While these features generally cannot trap enough runoff to prevent the worst flooding, such as

100-year floods, they can usually retain enough water to reduce more frequent and smaller floods.[216]

By collecting rainwater and helping it percolate through the soil, GSI systems help replenish groundwater, trap between 45 and 99 percent of solid pollutants, capture carbon dioxide, and beautify the urban landscape. When combined with open space preservation in flood-prone areas, GSI practices can help protect floodplains, minimize flood hazard, and reduce property damage.[217] Finally, GSI features can mitigate any negative health effects, like mosquito breeding in ponds, through thoughtful design, maintenance, and public health promotion and awareness.[218]

Gray stormwater infrastructure refers to conventional piped drainage, pumps, detention ponds and water treatment systems. Combining green and gray infrastructure can also help lower the risk of urban floods. The Blake Transit Oriented Development (TOD) site at 38th Street and Walnut Street in Denver, for example, incorporates green infrastructure in the form of planter boxes, tree boxes, permeable pavement and green roofs to reduce runoff volume, combined with underground detention storage to meet peak flow requirements.[219]

GSI features are being used in urban areas across Colorado, including in Boulder and Denver. Rain gardens can be found at the Colorado Supreme Court Building in Denver, as well as the city's River North Taxi redevelopment and Highland Bridge Lofts on Central St. between 15th and 16th streets.[220] Permeable pavement is used at various locations on the University of Colorado Boulder campus. The Denver Botanic Gardens and the cardiology building of the Boulder Community Hospital both have green roofs. And the Denver Green School, in partnership with the Urban Drainage and Flood Control District and the Water Environment Research Foundation, has experimented with rainwater harvesting systems.[221]

Impervious cover limits establish caps on the percentage of an area devoted to impervious cover, which limits flood risk. Cities have used various policy mechanisms to limit impervious surface cover. To prevent these limits from halting beneficial compact development, cities can include allowances for more compact development if it integrates GSI features.

- Grand Rapids, Michigan, waives stormwater detention requirements for compact developments that reduce impervious surface cover by 80 percent relative to less-compact developments with the same number of housing units.[222]

- Some places, including Boulder County, use **transferable development rights (TDR)** programs to divert development pressures away from areas that communities wish to preserve. Through these programs, developers buy development rights from the owners of rural land in areas designated by county authorities for preservation. A perpetual conservation easement is placed on the property, and the developers can then use their development rights to build in areas where development is desired.[223]

The city of Boulder and state of Colorado already have programs and infrastructure in place to mitigate the localized flood risks of increased development, which could be expanded.

Policy Recommendations

BOULDER HAS TAKEN MEASURES to limit sprawl within city limits, but it also has many policies that limit compact development. Many of these policies are intended to maintain the look and character of historic neighborhoods, but have unintended consequences. These include encouraging developers to create the largest and most expensive single-family homes possible, reducing housing availability and increasing costs significantly, and isolating residential areas from commercial areas, which encourages driving.

Most importantly, a lack of housing has contributed to 60 percent of Boulder jobs being held by people who live in surrounding communities and make long commutes into Boulder each day in their personal cars. This contributes to traffic in Boulder, regional air pollution and global warming emissions. Additionally, the development of surrounding undeveloped land consumes more land, water and energy, and generates more air, water and global warming pollution than allowing more people to live in Boulder would.

The High Mar apartment community for residents 55 years and older is an example of compact development in Boulder. Credit: Dennis Schroeder, National Renewable Energy Laboratory via Flickr, CC BY-NC-ND 2.0.

Compact, connected cities with mixed-use neighborhoods that incorporate homes, jobs and recreation opportunities are more environmentally friendly than sprawling, auto-dependent communities. Compact commercial and residential development – such as duplexes and low-rise apartment buildings – can reduce energy use, limit greenhouse gas emissions from buildings and transportation, reduce land consumption, improve regional air and water quality, reduce flood risk and lower water consumption relative to lower-density development.

Strategies are available to mitigate many of the potential local impacts of compact development, many of which are already in use in Boulder. These include green stormwater infrastructure, shade trees and measures to promote walking, biking, transit, shared transportation modes and electric vehicles.

Through thoughtful policies – many of which Boulder already has in place – compact development can increase quality of life in the city. Compact development can enable more people to live close to transit, jobs and recreational opportunities, enabling them to walk and bike more and drive less. Compact development can be pursued in ways that help increase affordable housing availability, preserve open space, decrease vehicle traffic and connect the community.

In 2015, Boulder drafted *A Toolkit of Housing Options* that could increase housing in the city, but has not implemented most of those recommendations.[224] Boulder should use the following suggestions, which include many tools from that report, to create a more compact and connected community with a smaller environmental impact.

Update zoning to enable more compact, mixed-use development and establish density minimums – particularly along transit corridors and near commercial centers.

Every parcel of land in Boulder is zoned for the type of development that can occur there and how compact that development can be. Over 56 percent of Boulder's residential area is reserved reserved for detached single-family homes at low densities.[225] Some estimate that about 80 percent of Boulder's residential area is effectively limited to single-family homes due to additional policies and practices.[236] Boulder should update its zoning districts to encourage infill development, particularly along transit corridors, as studies show that most people will walk five to ten minutes or a quarter of a mile to bus stops.[226] Boulder should also allow for more housing and commercial development in commercial and industrial-zoned areas to create mixed-use neighborhoods where residents can walk and bike to their destinations. Boulder should increase the allowed housing density in residential areas – for example by allowing duplexes, triplexes and four-plexes by right as the state of Oregon recently adopted.[227] The city should also establish density minimums for new developments. All of these changes will help focus new growth where residents can live within walking distance of local destinations and transit stops.

Boulder can change the zoning of the entire city during the next Boulder Valley Comprehensive Plan (BVCP) Major Update, which occurs every five years with the next scheduled for 2020. Alternatively, specific areas can be re-zoned through an area planning process, which can occur at any time.[228]

Encourage accessory dwelling units (ADUs).

ADUs are additional housing units within existing homes or on the same property, such as basement, attic, above-garage or detached guest house apartments. ADUs are a great option to increase housing density in existing residential areas without the need for much, if any, new construction. Rented ADUs can also provide a source of income for households – as well as assistance for aging households, which is an important opportunity in Boulder, which has a large aging population. Boulder limits the creation of ADUs in several ways (see page 11). Boulder should eliminate all of these barriers to creating ADUs. In 2019, Seattle passed the most progressive ADU policy in the U.S., which will allow the construction of ADUs on three-quarters of Seattle's single-family zoned area. The new policy includes an allowance for up to two ADUs on each property and a resolution to remove parking requirements for new ADUs. It also includes a size limit on new single-family homes.[229]

Increase or eliminate occupancy limits.

Boulder limits the number of unrelated people who can live together in one household to three people in low-density residential areas and four people in medium-to-high density areas.[230] Boulder should increase or eliminate these limits to add new housing in currently unoccupied bedrooms without building any new structures.

Lower or eliminate parking requirements or institute parking maximums instead of parking minimums, and implement reforms to better manage parking in Boulder.

Boulder requires housing units to have a certain number of off-street parking spaces, which varies by zoning district and the number of bedrooms or occupants in multi-unit homes. The city of Boulder also requires businesses and other institutions to provide a certain amount of parking.[231] These parking requirements can drive up the cost of new construction, especially in redevelopment areas where land costs are high, and can make it more difficult to build multi-unit buildings.[232] Boulder should reduce or eliminate parking requirements, consider instituting parking maximums and use the freed-up parking lots for infill development where feasible. Boulder should also implement the parking principles from its Access Management and Parking Strategy (AMPS) (see page 14).[233]

Exempt compact housing developments from the residential growth cap.

Boulder's Residential Growth Management System (RGMS) limits residential growth to 1 percent per year, but exempts certain types of housing, including permanently affordable housing and mixed-use developments that include both housing, stores and other uses. Boulder should also exempt compact housing development from the growth cap, raise the cap or eliminate it entirely.

Raise building height limits.

In 1971, Boulder adopted a 55-foot height limit for all buildings and structures in the city. In the last few years the city council has imposed a moratorium on buildings over 35 to 40 feet in most of the city, effectively lowering the height limit. Boulder should lift this moratorium and consider raising the 55-foot height limit for residential development in strategic locations, such as nearby transit corridors and commercial centers, particularly in the areas east of Folsom Street. The city should also revise the zoning code to automatically approve residential buildings above 35 feet but below 55 feet in height.

Streamline the building permitting process.

Boulder should reduce or waive fees and revise the review process for building projects that increase beneficial housing density – for example, housing projects that are affordable and near transit or commercial centers.

Remove incentives to build large, expensive homes.

Boulder requires each housing unit to be built on a lot of a certain size with a certain amount of open space. Because these requirements apply to each housing *unit*, rather than the floor area of the building, multi-unit buildings require larger lot sizes and more open space than single-family homes. This encourages developers to build large, expensive single-family homes rather than multi-unit buildings.[234] Boulder should reduce or eliminate the minimum lot size and open space requirements and/or have them apply to the floor area of residential buildings rather than the number of units to solve this issue.

To ensure that new development does not increase local vehicle traffic, Boulder should also:

Increase Boulder's TDM programs and implement a TDM ordinance for new developments to reduce vehicle travel.

Boulder should expand its TDM programs like the EcoPass, carshare, and bikeshare programs, which encourage residents and employees to get around by means other than driving. The city should also establish a TDM ordinance for new developments that includes a target for how many vehicle trips a new development can add during peak-hour travel periods. The city should also encourage developers to partner with the city's Transportation Division to implement a full suite of TDM programs designed to reduce car travel and promote more sustainable modes of transportation.

Integrate land-use and transportation planning.

The city's ability to reduce greenhouse gas emissions from the transportation sector is highly dependent on where and how it decides to grow, so compact development should be formally adopted as one of Boulder's key climate strategies. Land-use and transportation are inextricably linked and therefore all major planning processes and decisions should be developed collaboratively.

Support regional transit expansion.

To reduce inbound commuter vehicle travel while Boulder increases housing availability, and to accommodate those who choose to continue to live outside of the city and work in Boulder, the city should support expansion of RTD to serve a larger area more frequently. This will require collaboration between RTD, Colorado Department of Transportation (CDOT), Denver Regional Council of Governments (DRCOG) and others.

By taking the steps outlined above, Boulder can encourage the creation of compact neighborhoods where homes, jobs and recreational opportunities coexist, connected by a transportation system that enables and encourages walking, biking, transit, shared modes of transportation and electric vehicles. By prioritizing infill development and maximizing the housing potential of existing buildings, Boulder can increase density while preserving open spaces. These changes can create a more vibrant and connected community, with more affordable housing options – allowing more of Boulder's workforce to live within the city. These changes would reduce overall land consumption, air and water pollution, flood risk, water consumption, energy use and greenhouse gas emissions – both from transportation and building construction and use in the region.

Compact development is the right choice for Boulder, the region and the environment.

Notes

1 City of Boulder, *Boulder's Climate Commitment*, May 2017, archived at http://web.archive.org/web/20190626230810/https://www-static.bouldercolorado.gov/docs/City_of_Boulder_Climate_Commitment_5.9.2017-1-201705091634.pdf?_ga=2.2208432.1231615852.1561343994-481371527.1557793878.

2 Land areas of zoning districts: City of Boulder, *Zoning*, CSV file, downloaded 24 June 2019, archived at http://web.archive.org/web/20170514105335/https://bouldercolorado.gov/open-data/boulder-zoning/; Residential - Rural 1, Residential - Rural 2, Residential - Estate, and Residential - Low 1 zoning districts are reserved for "Single-family detached residential dwelling units at low to very low residential densities": City of Boulder, *Municipal Code, Title 9 – Land Use Code, Chapter 5 – Modular Zone System, Section 2 – Zoning Districts*, accessed 8 July 2019, archived at http://web.archive.org/web/20190708142710/https://library.municode.com/co/boulder/codes/municipal_code?nodeId=TIT9LAUSCO_CH5MOZOSY.

3 City of Boulder, *Community Profile*, 2019.

4 Nonresident employees commute 28.68 miles roundtrip to Boulder each day on average: Data provided by Chris Hagelin, Senior Transportation Planner, City of Boulder, personal communication, June 2019; 77 percent: City of Boulder, *2017 Boulder Valley Employee Transportation Survey Report of Results*, May 2018, archived at http://web.archive.org/web/20190708162745/https://www-static.bouldercolorado.gov/docs/BVES_Report_2018-05-02_rkr_no_links-1-201901071058.pdf.

5 Up to 49,214 nonresidents commute into Boulder in single-occupant vehicles **-** Boulder has 106,524 jobs and 60 percent are held by nonresidents: See note 3; 77 percent of Boulder in-commuters are in single-occupant vehicles: City of Boulder, *2017 Boulder Valley Employee Transportation Survey Report of Results*, May 2018, archived at http://web.archive.org/web/20190708162745/https://www-static.bouldercolorado.gov/docs/BVES_Report_2018-05-02_rkr_no_links-1-201901071058.pdf; Approximately 49,000 vehicles enter Boulder between 6 and 10 AM: City of Boulder, Public Works Department Division of Transportation, *The 2018 Transportation Report on Progress*, 2018, archived at http://web.archive.org/web/20190529201154/https://www-static.bouldercolorado.gov/docs/2018_Report_on_Progress_Draft_16-1-201802011349.pdf?_ga=2.200716909.2116566227.1558638967-481371527.1557793878.

6 **Figures and Sources –** Boulder has 106,524 jobs: U.S. Department of Labor, Bureau of Labor Statistics, Quarterly Census Employment and Wages, 2017; 60 percent of jobs in Boulder are held by people who live outside of the city: See note 3; 47 percent of Boulder residents commute in single occupant vehicles (SOV) driving 8.8 miles roundtrip on average, and 5 percent commute in multiple occupant vehicles (MOV) driving 3.5 miles roundtrip per person on average. 77 percent of nonresidents commute to Boulder in SOVs, 35.8 miles roundtrip on average, and 6 percent commute in MOVs, 12.52 miles roundtrip per person on average. All data: Chris Hagelin, Senior Transportation Planner, City of Boulder, personal communication, 4 June 2019. We estimate that Boulder workers work 160 days per year on average. This is based on the number of weeks worked per year and hours worked per week by Boulder residents, which may differ from nonresidents commuting to Boulder: U.S. Census Bureau, American Community Survey, Table S2303: Work Status in the Past 12 Months, Five-year Estimates, 2013-2017. **Calculations –** 106,524 jobs * 60 percent held by nonresidents = 63,914 jobs held by nonresidents. Because some people hold multiple jobs, the number of inbound commuters may be smaller than the number of jobs held by nonresidents. Calculations therefore represent the maximum possibilities. Total nonresident vehicle miles travelled (VMT) per year: (63,914 inbound commuters * 35.8 SOV miles * 77% SOV * 160 work days/year) + (63,914 inbound commuters * 12.52 MOV miles * 6% MOV * 160 work days/year) = 289,578,431 miles. Total VMT per year if all nonresident workers lived in Boulder: (63,914 commuters * 8.8 SOV miles * 47% SOV * 160 work days/year) + (63,914 commuters * 3.5 MOV miles * 5% MOV * 160 work days/year) = 44,085,321 miles. Difference: 289,578,431 miles – 44,085,321 miles = 245,493,110 miles.

7 **Figures and Sources –** Average passenger vehicles emit 404 grams of carbon dioxide per mile: U.S. Environmental Protection Agency, Green Vehicle Guide, Greenhouse Gas Emissions from a Typical Passenger Vehicle, accessed 1 June 2019, archived at http://web.archive.org/web/20190522000719/https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle; 21,000 cars: U.S. Environmental Protection Agency, Greenhouse Gas Equivalencies Calculator, available at https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator. **Calculation –** 245,493,110 miles * 404 g CO2/mile = 99,179,216,440 g CO2 / 1,000,000 g CO2/metric ton = 99,179 metric tons CO2.

8 Boulder County emissions: Gabriele Pfister et al., National Center for Atmospheric Research (NCAR) and Atmospheric Chemistry Observations and Modeling Laboratory (ACOM), *Process-Based and Regional Source Impact Analysis for FRAPPÉ and DISCOVER-AQ 2014,* 31 July 2017, available at https://www.colorado.gov/airquality/tech_doc_repository.aspx?action=open&file=FRAPPE-NCAR_Final_Report_July2017.pdf; Ozone formation: U.S. Environmental Protection Agency, *Ground-Level Ozone Basics*, accessed 5 June 2019, archived at http://web.archive.org/web/20190604153024/https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics.

9 **Figures and Sources** – 63,914 Boulder jobs are held by nonresidents. Because some people hold multiple jobs, the number of inbound commuters may be smaller than the number of jobs held by nonresidents. Calculations therefore represent the maximum possibilities: See note 6; 77 percent of Boulder inbound commuters and 47 percent of resident commuters are in single occupant vehicles (SOV): City of Boulder, 2017 Boulder Valley Employee Transportation Survey Report of Results, May 2018, archived at http://web.archive.org/web/20190708162745/https://www-static.bouldercolorado.gov/docs/BVES_Report_2018-05-02_rkr_no_links-1-201901071058.pdf. **Calculations** – One-third of nonresident workers: 63,914 nonresident workers / 3 = 21,305 nonresident workers. One-third of nonresident commuters in SOV: 21,305 workers * 77% SOV = 16,405 workers in SOV. Number of SOVs if those workers lived in Boulder: 21,305 workers * 47% SOV = 10,013 workers in SOV. Difference: 16,405 SOV - 10,013 SOV = 6,392 fewer SOV.

10 **Figures and Sources –** Nonresident commuters collectively drive 245,493,110 miles more per year than if they were Boulder residents: See note 6; This results in 99,179 metric tons of additional CO2 emissions, equivalent to the annual emissions of over 21,000 cars: See note 7. **Calculations –** If one-third of nonresident workers moved to Boulder: 245,493,110 miles / 3 = 81,831,037 miles. 99,179 metric tons CO2 / 3 = 33,060 metric tons CO2. 21,000 cars / 3 = 7,000 cars.

11 **Figure and Source –** Boulder aims to reduce greenhouse gas emissions from transportation by 305,000 metric tons of carbon dioxide equivalent by 2050: See note 1. **Calculation –** 33,060 metric tons CO2 / 305,000 metric tons CO2 = 10.8%.

12 National Research Center Inc. for the City of Boulder Transportation Division, *Modal Shift in the Boulder Valley 1990 to 2018*, Figure 62, January 2019, archived at http://web.archive.org/web/20190705220438/https://www-static.bouldercolorado.gov/docs/Boulder_Modal_Shift_1990-2018_Report-1-201907010932.pdf?_ga=2.264382287.1385049506.1562186009-481371527.1557793878.

13 Dwelling units per acre in Boulder neighborhoods: City of Boulder, *Boulder Valley Comprehensive Plan, Existing Land Use Maps,* accessed 7 July 2019, archived at http://web.archive.org/web/20190707164550/https://www-static.bouldercolorado.gov/docs/draft-existing-land-use-maps-bvcp-1-201506051603.pdf?_ga=2.96977375.1160472323.1559584217-481371527.1557793878; 7 dwelling units per acre support intermediate transit service: Victoria Transport Policy Institute, *Transit Oriented Development, Using Public Transit to Create More Accessible and Livable Neighborhoods,* updated 21 March 2019, archived at http://web.archive.org/web/20190507213918/http://www.vtpi.org/tdm/tdm45.htm.

14 City of Boulder, Public Works Department Division of Transportation, *The 2018 Transportation Report on Progress,* 2018, archived at http://web.archive.org/web/20190529201154/https://www-static.bouldercolorado.gov/docs/2018_Report_on_Progress_Draft_16-1-201802011349.pdf?_ga=2.200716909.2116566227.1558638967-481371527.1557793878.

15 Puget Sound Regional Council, *Transit-Supportive Densities and Land Uses,* February 2015, archived at http://web.archive.org/web/20190520113917/https://www.psrc.org/sites/default/files/tsdluguidancepaper.pdf.

16 U.S. Environmental Protection Agency, *Location Efficiency and Housing Type Boiling it Down to BTUs*, 2011, archived at http://web.archive.org/web/20171123110944/https://www.epa.gov/sites/production/files/2014-03/documents/location_efficiency_btu.pdf.

17 Brian Stone Jr., "Urban Sprawl and Air Quality in Large U.S. Cities," *Journal of Environmental Management*, 86: 688-698, DOI: 10.1016/j.jenvman.2006.12.034, 2008.

18 Tamara Chuang, "The Front Range Fails to Meet Federal Standards for Healthy Air Quality. Again.*," The Colorado Sun*, 30 October 2018.

19 Scott J. Landes, Supervisor and Air Quality Meteorologist, Meteorology and Prescribed Fire Unit, Technical Services Program, State of Colorado, personal communication, 29 July 2019.

20 John S. Jacob and Ricardo Lopez, "Is Denser Greener? An Evaluation of Higher Density Development as an Urban Stormwater-Quality Best Management Practice," *Journal of the American Water Resources Association*, 45(3): 687-701, DOI: 10.1111/j.1752-1688.2009.00316.x, 2009, archived 9 October 2017 at web.archive.org/web/20171009210048/https://pdfs.semanticscholar.org/2e2d/e65bde5f920a59b02af67dada705b5e56e59.pdf.

21 Kelly Clifton et al., "Quantitative Analysis of Urban Form: A Multidisciplinary View," *Journal of Urbanism*, 1(1): 17-45, DOI: 10.1080/17549170801903496, 2008.

22 City of Boulder, *2016 Water Efficiency Plan*, October 2016, archived at http://web.archive.org/web/20170208015851/https://www-static.bouldercolorado.gov/docs/WEP_October_Final-1-201610180831.pdf.

23 City of Boulder, *Housing Boulder: A Toolkit of Housing Options*, July 2015, archived at http://web.archive.org/web/20170507200624/https://www-static.bouldercolorado.gov/docs/Toolkit_Draft_7_23_15-1-201507231627.pdf.

24 Ibid.

25 Downtown Boulder, *A Perfect Day Downtown*, accessed 15 July 2019, archived at http://web.archive.org/web/20190222052351/https://www.boulderdowntown.com/visit/day-in-downtown.

26 City of Boulder, *Large Homes and Lots Code Amendment Project, City Council Study Session,* 28 May 2019, archived at http://web.archive.org/web/20190706233710/https://www-static.bouldercolorado.gov/docs/CC_Large_Homes_5.28-1-201905281438.pdf?_ga=2.19840056.1232411293.1559014263-1983469655.1546995235.

27 City of Boulder, *Boulder Valley Comprehensive Plan,* accessed 10 June 2019, archived at http://web.archive.org/web/20190602074016/https://bouldercolorado.gov/bvcp.

28 RRC Associates, *Boulder Valley Comprehensive Plan Community Survey 2016*, 24 January 2017, archived at http://web.archive.org/web/20190610185110/https://www-static.bouldercolorado.gov/docs/RRC-Boulder_Comp_Plan_2017_presentation.V3-1-201702031241.pdf?_ga=2.230448092.1536048442.1559168964-481371527.1557793878.

29 Mercer, *2019 Quality of Living Ranking*, accessed 6 July 2019, archived at http://web.archive.org/web/20190702080253/https://mobilityexchange.mercer.com/Insights/quality-of-living-rankings.

30 Map made by Rachel Meier, GIS Specialist. Map layers – Boulder city limits: City of Boulder, *Boulder City Limits*, available at https://bouldercolorado.gov/open-data/boulder-city-limits/; Ownership parcels: City of Boulder, *Ownership Parcels*, available at https://bouldercolorado.gov/open-data/boulder-ownership-parcels/; Zoning: City of Boulder, *Zoning,* available at https://bouldercolorado.gov/open-data/boulder-zoning/; Land-use and housing density estimates: City of Boulder, *Municipal Code, Title 9 – Land Use Code, Chapter 6 – Use Standards*, available at https://library.municode.com/co/boulder/codes/municipal_code?nodeId=TIT9LAUSCO_CH6USST; Streets: City of Boulder, *Street Centerlines*, available at https://bouldercolorado.gov/open-data/boulder-street-centerlines/; Bus routes: Regional Transportation District (RTD), *Open GIS Data Download, Bus Routes*, available at http://gis-rtd-denver.opendata.arcgis.com/datasets/17749050721d427399ab4e038028929d_1; Bus stops: Regional Transportation District (RTD), *Open GIS Data Download, Bus Stops Active,* available at http://gis-rtd-denver.opendata.arcgis.com/datasets/17749050721d427399ab4e038028929d_2; Neighborhood and regional centers: City of Boulder, *Boulder Valley Comprehensive Plan*, available at https://www-static.bouldercolorado.gov/docs/draft-existing-land-use-maps-bvcp-1-201506051603.pdf?_ga=2.96977375.1160472323.1559584217-481371527.1557793878.

31 Boulder: City of Boulder, *2018 Boulder Community Profile*, accessed 29 May 2019, archived at http://web.archive.org/web/20190529201037/https://www-static.bouldercolorado.gov/docs/community_profile_infographic2018-1-201810221008.pdf?_ga=2.237952448.1170792551.1559155297-837547178.1559155297; U.S. and Colorado: U.S. Census Bureau, *Rental Vacancy Rates by State*, 2017, downloaded at https://www.census.gov/housing/hvs/data/ann17ind.html.

32 Ibid.

33 Zillow, *Home Prices & Values*, accessed 19 May 2019, available at https://www.zillow.com/boulder-co/home-values/.

34 City of Boulder, *2018 Boulder Community Profile*, accessed 29 May 2019, archived at http://web.archive.org/web/20190529201037/https://www-static.bouldercolorado.gov/docs/community_profile_infographic2018-1-201810221008.pdf?_ga=2.237952448.1170792551.1559155297-837547178.1559155297.

35 U.S. Census Bureau, Center for Economic Studies, Longitudinal Employer-Household Dynamics (LEHD), *OnTheMap*, available at https://onthemap.ces.census.gov/.

36 Lucas High, "Timnath Leads Region in Population Growth," *Bizwest.com*, 23 May 2019.

37 See note 34.

38 City of Boulder, *Boulder Valley Comprehensive Plan, 2015-2040 Projections,* http://web.archive.org/web/20190712210307/https://drive.google.com/file/d/1LUfRtDhCl4uKkf9BJiL0bsSqshubruZo/view.

39 60 percent of Boulder jobs are held by non-residents: See note 3; Boulder has 106,524 jobs: U.S. Department of Labor, Bureau of Labor Statistics, *Quarterly Census Employment and Wages*, 2017.

40 See note 5.

41 U.S. Environmental Protection Agency, *Carbon Pollution from Transportation*, accessed 17 June 2019, archived at http://web.archive.org/web/20190721132026/https://www.epa.gov/transportation-air-pollution-and-climate-change/carbon-pollution-transportation.

42 See note 14.

43 Data provided by Chris Hagelin, Senior Transportation Planner, City of Boulder, personal communication, June 2019.

44 See note 6.

45 See note 7.

46 See note 18.

47 U.S. Environmental Protection Agency, *Health Effects of Ozone Pollution*, accessed 5 June 2019, archived at http://web.archive.org/web/20190506135209/https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution.

48 See note 8.

49 See note 14.

50 See note 12.

51 Nelson Nygaard for Boulder County, Boulder County Intercounty Commute Analysis, June 2016, archived at http://web.archive.org/web/20190730202759/https://assets.bouldercounty.org/wp-content/uploads/2017/12/Intercounty-LEHD-Analysis-Memo.pdf.

52 Center for American Progress, The Disappearing West, accessed 17 June 2019, archived at http://web.archive.org/web/20190502212149/https://disappearingwest.org/map/.

53 Ibid.

54 City of Boulder, *2017 Boulder Valley Employee Transportation Survey Report of Results*, May 2018, archived at http://web.archive.org/web/20190708162745/https://www-static.bouldercolorado.gov/docs/BVES_Report_2018-05-02_rkr_no_links-1-201901071058.pdf; City of Boulder, *Transportation Master Plan, 2014*, available at https://www-static.bouldercolorado.gov/docs/transportation-master-plan-tmp-2014-1-201408271459.pdf?_ga=2.134733425.1834806199.1559169935-474120732.1558655787.

55 See note 43.

56 See note 23.

57 See note 2.

58 City of Boulder, *Municipal Code, Title 9 – Land Use Code, Chapter 6 – Use Standards*, accessed 31 May 2019, archived at http://web.archive.org/web/20190531202703/https://library.municode.com/co/boulder/codes/municipal_code?nodeId=TIT9LAUSCO_CH6USST_9-6-3SPUSSTESUS.

59 American Planning Association, *Accessory Dwelling Units*, accessed 26 June 2019, archived at http://web.archive.org/web/20190608020801/https://www.planning.org/knowledgebase/accessorydwellings/.

60 See note 23.

61 Northwestern University, *Research Report: City of Evanston "Three-Unrelated" Ordinance (Ordinance 6-4-1-14)*, 5 September 2011, archived at http://web.archive.org/web/20190711193137/https://www.academia.edu/12877743/Rental_Unit_Occupancy_Restrictions_Common_Practices_and_Analysis_of_City_of_Evanston_Ordinance_6-4-1-14.

62 City of Boulder, *Municipal Code, Title 9 – Land Use Code, Chapter 9 – Development Standards, Parking Standards*, accessed 8 June 2019, archived at http://web.archive.org/web/20190609015827/https://library.municode.com/co/boulder/codes/municipal_code?nodeId=TIT9LAUSCO_CH9DEST_9-9-6PAST.

63 Strong Towns, *The Many Costs of Too Much Parking*, 20 November 2018, archived at http://web.archive.org/web/20190608002925/https://www.strongtowns.org/journal/2018/11/20/the-many-costs-of-too-much-parking.

64 City of Boulder, *Transportation Master Plan, 2014*, available at https://www-static.bouldercolorado.gov/docs/transportation-master-plan-tmp-2014-1-201408271459.pdf?_ga=2.134733425.1834806199.1559169935-474120732.1558655787.

65 See note 23.

66 *The Charter of the City of Boulder, Colorado, Article V. – Administrative Service, Sec. 84. – Height Limit*, accessed 31 May 2019, archived at http://web.archive.org/web/20190531164709/https://library.municode.com/co/boulder/codes/municipal_code?nodeId=THCHBOCO_ARTVADSE_DEPL_S84HELI.

67 City of Boulder, *Municipal Code, Title 9 – Land Use Code, Chapter 7 – Form and Bulk Standards,* accessed 31 May 2019, archived at http://web.archive.org/web/20190531170001/https://library.municode.com/co/boulder/codes/municipal_code?nodeId=TIT9LAUSCO_CH7FOBUST_9-7-1SCFOBUST.

68 See note 23.

69 The City of Boulder, *Building Permit Review Process*, accessed 27 June 2019, archived at http://web.archive.org/web/20170513194000/https://bouldercolorado.gov/plan-develop/building-permit-review-process.

70 National Association of Home Builders, *Development Process Efficiency: Cutting Through the Red Tape*, 30 November 2015, available at https://www.nahb.org/en/research/~/media/9DF7168BA27A4FADB1566FAF6EF375A2.

71 See note 23.

72 Rocky Mountain Real Estate Law, *Boulder Approves New, Contentious Co-Op Housing Ordinance*, 9 January 2017, archived at http://web.archive.org/web/20190712215156/https://www.lexology.com/library/detail.aspx?g=dd3259a6-d400-4a83-9e9d-575c12a285f5.

73 City of Minneapolis, *Minneapolis 2040*, accessed 23 July 2019, archived at http://web.archive.org/web/20190630041156/https://minneapolis2040.com/.

74 Angie Schmitt, StreetsBlog USA, *How Two Cities Actually Reduced Driving*, 8 February 2019, https://usa.streetsblog.org/2019/02/08/minneapolis-and-seattle-have-achieved-the-holy-grail-for-sustainable-transportation/.

75 See note 73.

76 City of Minneapolis, *Minneapolis Greenhouse Gas Emissions Tracking*, accessed 27 June 2019, archived at http://web.archive.org/web/20170801033502/http://www.minneapolismn.gov/sustainability/climate-action-goals/ghg-emissions.

77 Minneapolis 2040, *Land Use and Build Form*, accessed 27 June 2019, archived at http://web.archive.org/web/20180909082046/http://minneapolis2040.com:80/topics/land-use-built-form/.

78 City of Boulder, *Boulder Junction*, accessed 12 July 2019, archived at http://web.archive.org/web/20190622194446/https://bouldercolorado.gov/public-works/boulder-junction.

79 Deeproot, *A Place for Trees, People, and Transit*, accessed 12 July 2019, archived at http://web.archive.org/web/20190712222431/https://www.deeproot.com/products/silva-cell/case-studies/pearl-parkway.html

80 See note 14.

81 City of Boulder, *Boulder Junction Transportation Demand Management District*, accessed 12 July 2019, archived at http://web.archive.org/web/20190712222834/https://bouldercolorado.gov/pages/boulder-junction-3.

82 Terrain.org, *Holiday Neighborhood, Boulder, Colorado*, accessed 5 June 2019, archived at http://web.archive.org/web/20140723032924/http://terrain.org/unsprawl/29/.

83 Boulder Housing Partners, *Red Oak Park*, accessed 5 June 2019, archived at http://web.archive.org/web/20190605152331/https://www.boulderhousing.org/property/red-oak-park.

84 See note 9.

85 See note 10.

86 See note 1.

87 City of Boulder, *2017 Boulder Valley Employee Transportation Survey Report of Results*, May 2018, archived at http://web.archive.org/web/20190708162745/https://www-static.bouldercolorado.gov/docs/BVES_Report_2018-05-02_rkr_no_links-1-201901071058.pdf.

88 The Center for Neighborhood Technology (CNT), *Housing and Transportation (H+T) Affordability Index*, available at https://htaindex.cnt.org/.

89 See note 14.

90 Ibid.

91 Mark R. Stevens, "Does Compact Development Make People Drive Less?" *Journal of the American Planning Association*, 83(1): 7-18, 2017.

92 Ibid.

93 Ibid.

94 Jinwon Kim and David Brownstone, "The Impact of Residential Density on Vehicle Usage and Fuel Consumption: Evidence from National Samples," *Energy Economics*, 10: 196-206, doi.org/10.1016/j.eneco.2013.06.012, 2013, archived 22 September 2017 at web.archive.org/web/20170922213023/http://www.economics.uci.edu/%7Edbrownst/KimBrownstoneUCE3WP.pdf.

95 Sherman Lewis and Emilio Grande del Valle, "San Francisco's Neighborhoods and Auto Dependency," *Science Direct*, 86: 11-24, https://doi.org/10.1016/j.cities.2018.12.017, March 2019.

96 Shlomo Angel et al., "The Persistent Decline in Urban Densities: Global and Historical Evidence of 'Sprawl'," *Lincoln Institute of Land Policy*, 2010, archived at web.archive.org/web/20161103145021/http://www.lincolninst.edu:80/publications/working-papers/persistent-decline-urban-densities, pp. 53, 114.

97 Reid Ewing et al., Urban Land Institute, *Growing Cooler: The Evidence on Urban Development and Climate Change*, September 2007.

98 Ibid.

99 National Research Center Inc. for the City of Boulder Transportation Division, *Modal Shift in the Boulder Valley 1990 to 2018*, Figure 39, January 2019, archived at http://web.archive.org/web/20190705220438/https://www-static.bouldercolorado.gov/docs/Boulder_Modal_Shift_1990-2018_Report-1-201907010932.pdf?_ga=2.264382287.1385049506.1562186009-481371527.1557793878.

100 Density and bicycling: E.K. Nehme et al., "Sociodemographic Factors, Population Density, and Bicycling for Transportation in the United States," *Journal of Physical Activity and Health*, in press, DOI: 10.1123/jpah.2014-0469; mixed-use and bicycling: Yan Xing, Susan L. Handy and Patricia L. Mokhtarian, "Factors Associated with Proportions and Miles of Bicycling for Transportation and Recreation in Six Small U.S. Cities," *Transportation Research Part D*, 15:73-81, 2010, DOI: 10.1016/j.trd.2009.09.004.

101 Capitol Region Council of Governments et al., *Growing with the Flow: How Connecticut Communities Can Take Advantage of Transit-Oriented Development (TOD),* Conference on Transit-Oriented Development, 29 January 2007, available at https://www.ccsu.edu/imrp/about/archive/files/TODWhitePaperGoingWithTheFlow.doc; see also: Lawrence D. Frank and Gary Pivo, "Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, and Walking," *Transportation Research Record,* 1466: 44-52, 1994.

102 Chanam Lee and Anne Vernez Moudon, "Correlate of Walking for Transportation or Recreation Purposes," *Journal of Physical Activity and Health*, 3 (Supp. 1): S77-S98, 2006.

103 Brian D. Taylor and Camille N.Y. Fink, "The Factors Influencing Transit Ridership: A Review and Analysis of the Ridership Literature," *University of California Transportation Center, Working Papers,* 2003, archived 2 October 2015 at web.archive.org/web/20151002084903/http://reconnectingamerica.org/assets/Uploads/ridersipfactors.pdf; Robert Cervero and Erick Guerra, *Urban Densities and Transit: A Multi-Dimensional Perspective*, September 2011.

104 Adam Miller-Ball et al., "Car-Sharing: Where and How It Succeeds," *Transportation Research Board,* Transit Cooperative Research Project Report 108, 2005.

105 Ibid.

106 See note 14.

107 See note 16.

108 Urban Land Institute, *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*, July 2009.

109 Pounds of CO_2: Table 5 from Edward L. Glaeser and Matthew E. Kahn, "The Greenness of Cities: Carbon Dioxide Emissions and Urban Development," *Journal of Urban Economics*, 6(3): 404-418, doi.org/10.1016/j.jue.2009.11.006, 2010, archived at web.archive.org/web/20171009210136/https://www.hks.harvard.edu/sites/default/files/centers/taubman/files/glaeser_08_greencities.pdf; Gasoline equivalent: U.S. Environmental Protection Agency, *Greenhouse Gas Equivalencies Calculator*, archived 8 October 2017 at web.archive.org/web/20171008021918/https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

110 California Air Resources Board (CARB), *Research on Land Use and Transportation Planning*, accessed 22 July 2019, archived at http://web.archive.org/web/20190425183424/https://ww2.arb.ca.gov/research/research-land-use-and-transportation-planning.

111 The San Diego Association of Governments (SANDAG), *San Diego Forward, The Regional Plan,* October 2015, archived at http://web.archive.org/web/20190425115524/http://sdforward.com/pdfs/Final_PDFs/The_Plan_combined.pdf.

112 John W. Holzclaw, Natural Resources Defense Council and Sierra Club, *Smart Growth - As Seen From the Air, Convenient Neighborhood, Skip the Car*, 2000, archived at http://web.archive.org/web/20160625115358/http://vault.sierraclub.org:80/sprawl/transportation/holtzclaw-awma.pdf.

113 Dwelling units per acre in Boulder neighborhoods: City of Boulder, *Boulder Valley Comprehensive Plan, Existing Land Use Maps,* accessed 7 July 2019, archived at http://web.archive.org/web/20190707164550/https://www-static.bouldercolorado.gov/docs/draft-existing-land-use-maps-bvcp-1-201506051603.pdf?_ga=2.96977375.1160472323.1559584217-481371527.1557793878.

114 Ibid.

115 See note 15.

116 Brice G. Nichols and Kara M. Kockelman, "Life-Cycle Energy Implications of Different Residential Settings: Recognizing Buildings, Travel, and Public Infrastructure," *Energy Policy*, 68: 232-242, archived 9 October 2017 at web.archive.org/web/20150906061647/http://www.caee.utexas.edu/prof/kockelman/public_html/TRB14neighborhoodsLCA.pdf.

117 Ibid.

118 Ibid.

119 Ibid.

120 PlaNYC, Mayor's Office of Operations, New York City, *Inventory of New York City Greenhouse Gas Emissions*, 2007, archived 9 August 2017 at web.archive.org/web/20170809213359/http://www.nyc.gov/html/om/pdf/ccp_report041007.pdf.

121 Statistics Canada, *Households and the Environment: Energy Use*, 27 November 2015, archived at http://web.archive.org/web/20190516031814/https://www150.statcan.gc.ca/n1/pub/11-526-s/2013002/part-partie1-eng.htm.

122 Peter Rickwood, "Residential Operational Energy Use," *Journal of Urban Policy and Research*, 27(2): 137-155, dx.doi.org/10.1080/08111140902950495, 2009, archived 9 October 2017 at web.archive.org/web/20171009210045/https://opus.lib.uts.edu.au/bitstream/10453/11852/1/2009005323.pdf.

123 Jonathan Norman, Heather L. MacLean, and Christopher A. Kennedy, "Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and Greenhouse Gas Emissions," *Journal of Urban Planning in Development,* 132(1): 10-21, DOI: 10.1061/(ASCE)0733-9488(2006)132:1(10), 2006.

124 International Council for Local Environmental Initiatives, *District Energy in Cities Initiative*, archived 6 June 2017 at web.archive.org/web/20170606130316/http://www.iclei.org/activities/agendas/low-carbon-city/districtenergy.html.

125 Carol Stewart and Todd Schmitt, EEA Consulting Engineers, *Austin Energy District Cooling System Expansion* (presentation), accessed 10 June 2019, archived at http://web.archive.org/web/20190610204623/https://www.districtenergy.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=91729c11-bc17-181e-f658-082644aac9e4.

126 Lisa Benton-Short, John Rennie Short and Chris Mayda, *A Regional Geography of the United States and Canada: Toward a Sustainable Future*, 2nd Edition, (Rowman & Littlefield, 2018.)

127 Peter Pollock, *Controlling Sprawl in Boulder: Benefits and Pitfalls*, Lincoln Institute of Land Policy, January 1998, archived at http://web.archive.org/web/20180125221048/http://www.lincolninst.edu:80/publications/articles/controlling-sprawl-boulder.

128 See note 52.

129 Kevin R. Cromar et al., "Estimated Excess Morbidity and Mortality Associated with Air Pollution above American Thoracic Society-recommended Standards, 2013-2015," *Annals of the American Thoracic Society,* 15(5), 1 May 2018.

130 Centers for Disease Control and Prevention, *Most Recent Asthma State or Territory Data,* archived 20 May 2019 at https://web.archive.org/web/*/https://www.cdc.gov/asthma/most_recent_data_states.htm.

131 U.S. Environmental Protection Agency, *Health and Environmental Effects of Particulate Matter (PM),* archived 25 August 2017 at web.archive.org/web/20170825202235/https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm.

132 U.S. Environmental Protection Agency, *Health Effects of Ozone,* archived 25 August 2017, archived at web.archive.org/web/20170825202228/https://www.epa.gov/ozone-pollution/health-effects-ozone-pollution.

133 Boulder County, *Ozone*, accessed 10 June 2019, archived at http://web.archive.org/web/20181001165707/https://www.bouldercounty.org/environment/air/ozone/.

134 See note 19.

135 American Lung Association, *State of the Air 2019*, accessed 17 June 2019, archived at http://web.archive.org/web/20160827111343/http://www.lung.org:80/our-initiatives/healthy-air/sota/city-rankings/states/colorado/boulder.html.

136 See note 14.

137 See note 17.

138 Elena McDonald-Buller, Jihee Song, Alba Webb and David Allen, "Regional Visions of Urbanization in Austin, Texas, and the Impacts on Air Quality and Population Exposure Metrics," *Proceedings of the Air & Waste Management Association Annual Meeting*, Portland, OR, June 2008.

139 Juli I. Rubin et al., "Temperature Dependence of Volatile Organic Compound Evaporative Emissions from Motor Vehicles," *Journal of Geophysical Research,* 111: D03305, DOI:10.1029/2005JD006458, 2006, available at onlinelibrary.wiley.com/doi/10.1029/2005JD006458/pdf.

140 Hao He et al., "High Ozone Concentrations on Hot Days: The Role of Electric Power Demand and NO_x Emissions," *Geophysical Research Letters,* 40: 5291-5294, DOI:10.1002/grl.50967, 2013, available at onlinelibrary.wiley.com/doi/10.1002/grl.50967/pdf.

141 Intergovernmental Panel on Climate Change, *The Regional Impacts of Climate Change*, archived 13 October 2017 at web.archive.org/web/20171013145450/https://www.ipcc.ch/ipccreports/sres/regional/index.php?idp=231.

142 "Denver Passes Ordinance Aimed at Curbing Heat Island Effect," *WeatherNation*, 8 November 2-17, archived at http://web.archive.org/web/20171109005648/http://www.weathernationtv.com/news/denver-passes-ordinance-aimed-curbing-heat-island-effect/.

143 Peter Ferrante, "The Urban Heat Island Effect Warms Colorado's Biggest City," *Boulder Weekly*, 10 March 2016; Brian Stone, Jeremy Hess and Howard Frumkin, "Urban Form and Extreme Heat Events: Are Sprawling Cities More Vulnerable to Climate Change Than Compact Cities?" *Environmental Health Perspectives,* 118(10): 1425-1428, DOI:10.1289/ehp.0901879, 2010, accessed 31 August 2017 at citeseerx.ist.psu.edu/viewdoc/download;jsessionid=BD2CB8D4F2381588061933E30C63E02D?doi=10.1.1.351.8597&rep=rep1&type=pdf.

144 City of Boulder, *Boulder Valley Comprehensive Plan, 2015-2040 Projections,* http://web.archive.org/web/20190712210307/https://drive.google.com/file/d/1LUfRtDhCl4uKkf9BJiL0bsSqshubruZo/view; Brian Stone, Jeremy Hess, and Howard Frumkin, "Urban Form and Extreme Heat Events: Are Sprawling Cities More Vulnerable to Climate Change Than Compact Cities?" *Environmental Health Perspectives,* 118(10): 1425-1428, DOI:10.1289/ehp.0901879, 2010, accessed 31 August 2017 at citeseerx.ist.psu.edu/viewdoc/download;jsessionid=BD2CB8D4F2381588061933E30C63E02D?doi=10.1.1.351.8597&rep=rep1&type=pdf.

145 See note 17.

146 Brian Stone Jr. et al., "Is Compact Growth Good for Air Quality?" *Journal of the American Planning Association,* 73(4): 404-420, DOI:10.1080/01944360701653235, 2007.

147 Elena McDonald-Buller, Alba Webb, Kara M. Kockelman and Bin Zhou, "Air Quality Impacts of Transportation and Land Use Policies: A Case Study in Austin, Texas," *Transportation Research Record,* 2158: 28-35, 2010, archived 22 February 2016 at web.archive.org/web/20160222022754/http://www.caee.utexas.edu:80/prof/kockelman/public_html/TRB10Emissions.pdf.

148 C.A. Pope et al, "Cardiovascular Mortality and Long-Term Exposure to Particulate Air Pollution: Epidemiological Evidence of General Pathophysiological Pathways of Disease," *Circulation*, 109(1): 71-77, DOI: 10.1161/01.CIR.0000108927.80044.7F, 2004, available at web.archive.org/web/20170116054339/https://www.ncbi.nlm.nih.gov/pubmed/14676145; F Laden, J Schwartz, FE Speizer and DW Dockery, "Reduction in Fine Particulate Air Pollution and Mortality: Extended Follow-up of the Harvard Six Cities Study," *American Journal of Respiratory and Critical Care Medicine*, 173(6): 667-672, DOI: 10.1164/rccm.200503-443OC, 2006, archived at web.archive.org/web/20170106172720/https://www.ncbi.nlm.nih.gov/pubmed/16424447.

149 John S. Jacob and Ricardo Lopez, "Is Denser Greener? An Evaluation of Higher Density Development as an Urban Stormwater-Quality Best Management Practice," *Journal of the American Water Resources Association*, 45(3): 687-701, DOI: 10.1111/j.1752-1688.2009.00316.x, 2009, archived at web.archive.org/web/20171009210048/https://pdfs.semanticscholar.org/2e2d/e65bde5f920a59b02af67dada705b5e56e59.pdf.; Daniel A. Bosch, "Hydrological and Fiscal Impacts of Residential Development: Virginia Case Study," *Journal of Water Resources Planning and Management,* 129(2): 107-114, 2003.

150 See note 20.

151 Robert McDonald et al., "Estimating Watershed Degradation over the Last Century and Its Impact on Water-Treatment Costs for the World's Large Cities," *Proceedings of the National Academy of Sciences*, 113(32): 9117-9122, DOI: 10.1073/pnas.1605354113, 2016.

152 See note 20.

153 Mike Nelson, *Colorado Weather Almanac*, (Johnson Books, 2007), p.145.

154 United States Geological Survey, *Effects of Urban Development on Floods* (fact sheet 076-03), November 2003, archived at web.archive.org/web/20170223115855/https://pubs.usgs.gov/fs/fs07603/pdf/fs07603.pdf.

155 Ashantha Goonetilleke et al., "Understanding the Role of Land Use in Urban Stormwater Quality Management," *Journal of Environmental Management*, 74(1): 31-42, 2005; Nora Sillanpaa and Harri Koivusalo, "Impacts of Urban Development on Runoff Event Characteristics and Unit Hydrographs across Warm and Cold Seasons in High Latitudes," *Journal of Hydrology*, 521, 328-340, February 2015.

156 See note 21.

157 Daniel A. Bosch, "Hydrological and Fiscal Impacts of Residential Development: Virginia Case Study," *Journal of Water Resources Planning and Management*, 129(2): 107-114, 2003.

158 Ibid.

159 U.S. National Integrated Drought Information System, *Drought in Colorado from 2000-2019*, downloaded 7 June 2019, available at https://www.drought.gov/drought/states/colorado.

160 Stephen Saunders and Tom Easley, Rocky Mountain Climate Organization, *Climate Change in the Headwaters: Water and Snow Impacts*, 2018, archived at http://web.archive.org/web/20181008182902/http://nwccog.org:80/wp-content/uploads/2018/02/Climate-Change-in-the-Headwaters.pdf.

161 See note 22.

162 Boulder Valley Comprehensive Plan, *Our Legacy, Our Future: Trends Report*, 8 December 2015.

163 See note 22.

164 Lily A. House-Peters, Bethany Pratt and Heejun Chang, "Effects of Urban Spatial Structure, Sociodemographics, and Climate on Residential Water Consumption in Hillsboro, Oregon," *Journal of the American Water Resources Association*, 46(3): 461-472, DOI: 10.1111/j.1752-1688.2009.00415.x, 2010.

165 Marjo Curgus, Del Corazon Consulting for Babbitt Center for Land and Water Policy and Sonoran Institute, *Growing Water Smart: The Water-Land Use Nexus,* September 2018, archived at http://web.archive.org/web/20190610221205/https://resilientwest.org/wp-content/uploads/SI-Workbook-interactive.pdf.

166 See note 164.

167 Ibid.

168 Subhrajit Guhathakurta and Patricia Gober, "The Impact of the Phoenix Urban Heat Island on Residential Water Use," *Journal of the American Planning Association*, 73(3): 317-329, dx.doi.org/10.1080/01944360708977980, 2007, archived at web.archive.org/web/20170811165201/http://dog-years.com/edm/2007_guhathakurta_gober.pdf.

169 Ibid.

170 See note 168 and note 164.

171 U.S. Environmental Protection Agency, *Growing Toward More Efficient Water Use: Linking Development, Infrastructure, and Drinking Water Policies*, available at https://www.epa.gov/sites/production/files/2014-01/documents/growing_water_use_efficiency.pdf, 2014.

172 Jeff Larson, "Fiscal Impacts of Residential Growth," *Strong Towns,* 10 July 2014, archived at web.archive.org/web/20170716180000/https://www.strongtowns.org/journal/2014/7/10/fiscal-impacts-of-residential-growth.html; insight2050, *Fiscal Impacts,* archived at web.archive.org/web/20161021020017/http://getinsight2050.org/the-report/scenario-metrics/fiscal-impacts/.

173 Chrissy Mancini Nichols, "Parking as Economic Development Tool in Boulder," *Smart Cities Dive*, archived at http://web.archive.org/web/20170905094231/http://www.smartcitiesdive.com:80/ex/sustainablecitiescollective/solving-parking-predicament-using-parking-economic-development-tool-boulder-col/156511/.

174 Henao, Alejandro, "Sustainable Transportation Infrastructure Investments and Mode Share Changes: A 20-Year Background of Boulder, Colorado," *Transport Policy*, 37 (2015) 64-71; People for Bikes, *The Best Cities for Bikes*, accessed 11 July 2019, archived at http://web.archive.org/web/20190530182111/https://cityratings.peopleforbikes.org/.

175 City of Boulder, *Transportation Master Plan, 2014*, available at https://www-static.bouldercolorado.gov/docs/transportation-master-plan-tmp-2014-1-201408271459.pdf?_ga=2.134733425.1834806199.1559169935-474120732.1558655787; City of Boulder, *Bicycle Planning,* available at https://bouldercolorado.gov/transportation/bicycle-planning.

176 Massachusetts Department of Transportation, *Separated Bike Lane Planning and Design Guide*, November 2015, accessed 6 September 2017 at www.massdot.state.ma.us/highway/DoingBusinessWithUs/ManualsPublicationsForms/SeparatedBikeLanePlanningDesignGuide.aspx.

177 Richard M. Haughey, *Higher-Density Development: Myth and Fact*, (Washington, D.C.: Urban Land Institute, 2005), accessed 19 September 2017 at uli.org/wp-content/uploads/ULI-Documents/HigherDensity_MythFact.ashx_.pdf.

178 Victoria Transport Policy Institute, *Transit Oriented Development, Using Public Transit to Create More Accessible and Livable Neighborhoods,* updated 21 March 2019, archived at http://web.archive.org/web/20190507213918/http://www.vtpi.org/tdm/tdm45.htm.

179 See note 15.

180 City of Boulder, *Transportation Master Plan Update: Renewed Vision for Transit, State of the System Report*, September 2013, archived at http://web.archive.org/web/20170127040654/https://www-static.bouldercolorado.gov/docs/BOULDER_TMP-SOS_Final_Rept_COMP-1-201311011558.pdf.

181 Moazzem Hossain and Scott Kennedy, "Estimating Energy Savings from Bus Improvement Options in Urban Corridors," *Journal of Public Transportation,* 11(3): 19-40, 2008, archived 11 October 2017 at web.archive.org/web/20171011142904/https://www.nctr.usf.edu/jpt/pdf/JPT11-3Hossain.pdf.

182 Brice G. Nichols and Kara M. Kockelman, "Life-Cycle Energy Implications of Different Residential Settings: Recognizing Buildings, Travel, and Public Infrastructure," *Energy Policy*, 68: 232-242, accessed 9 October 2017, archived at web.archive.org/web/20150906061647/http://www.caee.utexas.edu/prof/kockelman/public_html/TRB14neighborhoodsLCA.pdf.

183 Andrew Krok, "Colorado to Implement Zero Emission Vehicle Mandate," *Road Show by CNET*, 18 January 2019, archived at http://web.archive.org/web/20190220161004/https://www.cnet.com/roadshow/news/colorado-mandates-zero-emission-vehicle-program/.

184 Will Toor and Mike Salisbury, Southwest Energy Efficiency Project, *Boulder Electric Vehicle Infrastructure and Adoption Assessment*, April 2015, archived at http://web.archive.org/web/20150915050544/http://www.swenergy.org/data/sites/1/media/documents/publications/documents/Boulder_Electric_Vehicle_Infrastructure_and_Adoption_Assessment_April-2015.pdf.

185 Catherine Morehouse, "Colorado Gov Polis' First Executive Order Advances Transportation Electrification," *UtilityDive*, 18 January 2019.

186 City of Boulder, *Boulder's Climate Commitment: Rising to the Climate Challenge, Powering a Vibrant Future*, accessed 10 June 2019, archived at http://web.archive.org/web/20190610223600/https://www-static.bouldercolorado.gov/docs/City_of_Boulder_Climate_Commitment_5.9.2017-1-201705091634.pdf?_ga=2.210566549.1070974012.1558550328-1113255941.1558550328.

187 Ibid.

188 City of Boulder, *Municipal Code, Title 10 – Structures, Chapter 6 – Electrical Code*, accessed 8 July 2019, archived at http://web.archive.org/web/20190708142442/https://library.municode.com/co/boulder/codes/municipal_code?nodeId=TIT10ST_CH6ELCO_10-6-3ELVECHRENEMUDW.

189 See note 184.

190 City of Boulder, *Transportation Demand Management (TDM) Program*, accessed 18 June 2019, archived at http://web.archive.org/web/20170516171313/https://bouldercolorado.gov/pages/go-boulder-transportation-demand-management-program.

191 City of Boulder, *Access Management & Parking Strategy*, accessed 8 June 2019, archived at http://web.archive.org/web/20190608232121/https://www-static.bouldercolorado.gov/docs/Boulder_AMPS_Deliverable_-_EMAIL-1-201707092131.pdf?_ga=2.182531686.1315186445.1559954912-837547178.1559155297.

192 See note 14.

193 Rocky Mountain Institute: Allison Crow, *Rocky Mountain Institute, Choosing to Ditch the Car Commute: What Helps Office Workers Decide*, 9 October 2017, archived at http://web.archive.org/web/20190708144530/https://rmi.org/choosing-ditch-car-commute-helps-office-workers-decide/; Google: "Take a Look Inside Google's New Boulder Home," *CPR News,* 22 February 2018, archived at http://web.archive.org/web/20190708144845/https://www.cpr.org/show-segment/take-a-look-inside-googles-new-boulder-home/.

194 City of Boulder, *Alpine-Balsam Access and Mobility Strategy*, accessed 12 July 2019, archived at http://web.archive.org/web/20190712224729/https://www-static.bouldercolorado.gov/docs/ATT_E_Access_and_Mobility_Strategy_w_Traffic_Impact_Study_Results.docx-1-201905311711.pdf.

195 See note 191.

196 Hashem Akbari, Lawrence Berkeley National Laboratory, "Energy Saving Potentials and Air Quality Benefits of Urban Heat Island Mitigation," 2005, archived at web.archive.org/web/20171011143609/https://escholarship.org/uc/item/4qs5f42s.

197 Ibid.

198 S. Konopacki and H. Akbari, Lawrence Berkeley National Laboratory, *Energy Savings for Heat-Island Reduction Strategies in Chicago and Houston (Including Updates for Baton Rouge, Sacramento, and Salt Lake City),* February 2002, archived at web.archive.org/web/20171009210105/https://buildings.lbl.gov/sites/default/files/erin_beardsley_-_lbnl-_49638_-_energy_savings_for_heat-island_reduction_strategies_in_chicago_and_houston_including_updates_for_baton_rouge_sacramento_and_salt_lake_city.pdf.

199 Robert I. McDonald et al., "The Value of U.S. Urban Tree Cover for Reducing Heat-Related Health Impacts and Electricity Consumption," *Ecosystems*, May 2019, pp.1-14, DOI: https://doi.org/10.1007/s10021-019-00395-5.

200 Texas Trees Foundation, *Texas Trees Foundation Announces New Dallas Urban Heat Island Effect Report and Findings* (press release), 17 August 2017, accessed 15 September 2017 at https://texastrees.blob.core.windows.net/uploads/2017/08/TexasTreesFdn-Aug-17th-Press-Release.pdf.

201 See note 196.

202 City of Boulder, *Urban Forest Strategic Plan,* 2018, archived at http://web.archive.org/web/20190610223922/https://www-static.bouldercolorado.gov/docs/Boulder_UFSP_v2018_06_06-1-201806111602.pdf; City of Boulder, *Benefits of Trees*, accessed 10 June 2019, archived at http://web.archive.org/web/20170514004433/https://bouldercolorado.gov/forestry/the-benefits-of-trees.

203 Boulder Area Sustainability Information Network (BASIN), *Calculating the Value of Boulder's Urban Forests, Chapter Two*, 2002, archived at http://web.archive.org/web/20061130230958/http://bcn.boulder.co.us/basin/boulder/urbanforest/chapter_two.pdf.

204 City of Boulder, *Comprehensive Flood and Stormwater Utility Master Plan,* October 2004, archived at http://web.archive.org/web/20170128062925/https://www-static.bouldercolorado.gov/docs/comprehensive-flood-stormwater-utility-master-plan-1-201406101202.pdf.

205 See note 21.

206 Lynn Richards, U.S. Environmental Protection Agency, *Protecting Water Resources with Higher-Density Development*, January 2006, archived 30 June 2017 at web.archive.org/web/20170630061300/https://www.epa.gov/sites/production/files/2014-03/documents/protect_water_higher_density1.pdf. p. 13-14.

207 U.S. Environmental Protection Agency, *Smart Growth and Water*, available at https://www.epa.gov/smartgrowth/smart-growth-and-water; Jamie Tratalos et al., "Urban Form, Biodiversity Potential and Ecosystem Services," *Landscape and Urban Planning,* 83: 308-317, DOI:10.1016/j.landurbplan.2007.05.003, 2007.

208 Belinda E. Hatt et al., "The Influence of Urban Density and Drainage Infrastructure on the Concentrations and Loads of Pollutants in Small Streams," *Journal of Environmental Management,* 34(1): 112-124, DOI: 10.1007/s00267-004-0221-8, 2004.

209 For resources on GSI and compact development, see: U.S. Environmental Protection Agency, *Smart Growth and Water*, available at https://www.epa.gov/smartgrowth/smart-growth-and-water.

210 Brian Zabcik, Environment Texas Research & Policy Center, *Texas Stormwater Scorecard: Evaluating Municipal Policies for Green Stormwater Infrastructure & Low Impact Development*, Fall 2017, available at environmenttexascenter.org/sites/environment/files/reports/Texas%20Stormwater%20Scorecard.pdf.

211 Elizabeth Berg, Frontier Group and Luke Metzger and Brian Zabcik, Environment Texas Research & Policy Center, *Catching the Rain: How Green Infrastructure Can Reduce Flooding and Improve Water Quality in Texas*, February 2017, available at frontiergroup.org/sites/default/files/reports/Frontier%20Group%20-%20Catching%20the%20Rain%20-%20Feb%202017.pdf.

212 U.S. Climate Resilience Toolkit, *Improving Water Quality by Dealing with the First Inch of Rain*, 17 January 2017, archived at http://web.archive.org/web/20190525154352/https://toolkit.climate.gov/case-studies/improving-water-quality-dealing-first-inch-rain.

213 Soil Science Society of America, Green Infrastructure, accessed 24 June 2019, archived at http://web.archive.org/web/20190404033056/https://www.soils.org/discover-soils/soils-in-the-city/green-infrastructure.

214 See note 211.

215 Ibid.

216 U.S. Environmental Protection Agency, *Flood Loss Avoidance Benefits of Green Infrastructure for Stormwater Management*, December 2015, archived at http://web.archive.org/web/20170624200121/https://www.epa.gov/sites/production/files/2016-05/documents/flood-avoidance-green-infrastructure-12-14-2015.pdf.

217 Ibid.

218 Mare Löhmus and John Balbus, "Making Green Infrastructure Healthier Infrastructure," *Infection Ecology & Epidemiology*, 5, dx.doi.org/10.3402%2Fiee.v5.30082, 2015.

219 U.S. Environmental Protection Agency, *Conceptual Green Infrastructure Design for the Blake Street Transit-Oriented Development Site, City of Denver*, August 2013, archived at http://web.archive.org/web/20170713225640/https://www.epa.gov/sites/production/files/2015-10/documents/denver_blakestreet_concept_design.pdf.

220 "Bioretention in the Desert, You're Joking, Right?" *American Society of Landscape Architects*, accessed 10 June 2019, archived at http://web.archive.org/web/20150911084559/http://asla.org/uploadedFiles/CMS/Meetings_and_Events/2014_Annual_Meeting_Handouts/FRI-B03%20_Bioretention%20in%20the%20Desert,%20You're%20Joking%20Right.pdf.

221 Urban Drainage and Flood Control District, *Rainwater Harvesting*, accessed 10 June 2019, archived at http://web.archive.org/web/20190610224636/https://udfcd.org/services/research-test/rain-water-harvesting/.

222 John Jacob, "Watersheds, Walkability and Stormwater," *Stormwater,* 1 January 2011, archived at web.archive.org/web/20171011134227/http://foresternetwork.com/daily/water/watersheds-walkability-and-stormwater/.

223 Boulder County, *Transferable Development Rights (TDR) Program*, accessed 10 June 2019, archived at http://web.archive.org/web/20181005194921/https://www.bouldercounty.org/property-and-land/land-use/planning/transferable-development-rights-tdr/; Center for Land Use Education, *Planning Implementation Tools: Transfer of Development Rights (TDR)*, November 2005, archived at http://web.archive.org/web/20190602074102/https://www.uwsp.edu/cnr-ap/clue/Documents/PlanImplementation/Transfer_of_Development_Rights.pdf; Maryland Department of Planning, Resource Conservation, *Transfer of Development Rights Programs*, accessed 10 June 2019, archived at http://web.archive.org/web/20190110184403/https://planning.maryland.gov/Pages/OurWork/envr-planning/transfer-dev-rights.aspx.

224 See note 23.

225 See note 2.

226 See note 178.

227 Michael Andersen, Sightline Institute, *Oregon Just Voted to Legalize Duplexes on Almost Every City Lot*, 30 June 2019, archived at http://web.archive.org/web/20190704034342/https://www.sightline.org/2019/06/30/oregon-just-voted-to-legalize-duplexes-on-almost-every-city-lot/.

228 See note 23.

229 Dan Bertolet and Margaret Morales, Sightline Institute, *Seattle Says Yes to the Best Rules in America for Backyard Cottages*, 1 July 2019, archived at http://web.archive.org/web/20190708145143/https://www.sightline.org/2019/07/01/seattle-approves-best-backyard-cottages-rules-united-states/.

230 See note 23.

231 See note 62.

232 See note 63.

233 See note 191.

234 See note 23.

235 Boulder County Assessor data analyzed by David Adamson, Executive Director, Goose Creek Community Land Trust, personal communication, 10 June 2019.

236 Ibid.