UNC's Center for
Urban & Regional Studies

Policy Brief

Can Compact Growth Decrease Automobile Emissions?

Scientists and policy makers have examined the usefulness of vehicle technologies, alternative energy sources, and regulatory mechanisms to control automobile emissions. However, changing the patterns of future land development may be a promising complementary strategy often overlooked outside of planning circles. Existing evidence suggests that building more compactly, with harmonious land uses and with infrastructure to support transit, pedestrian, and bicycle modes of travel, may assist in decreasing harmful tailpipe emissions and mitigating global warming.

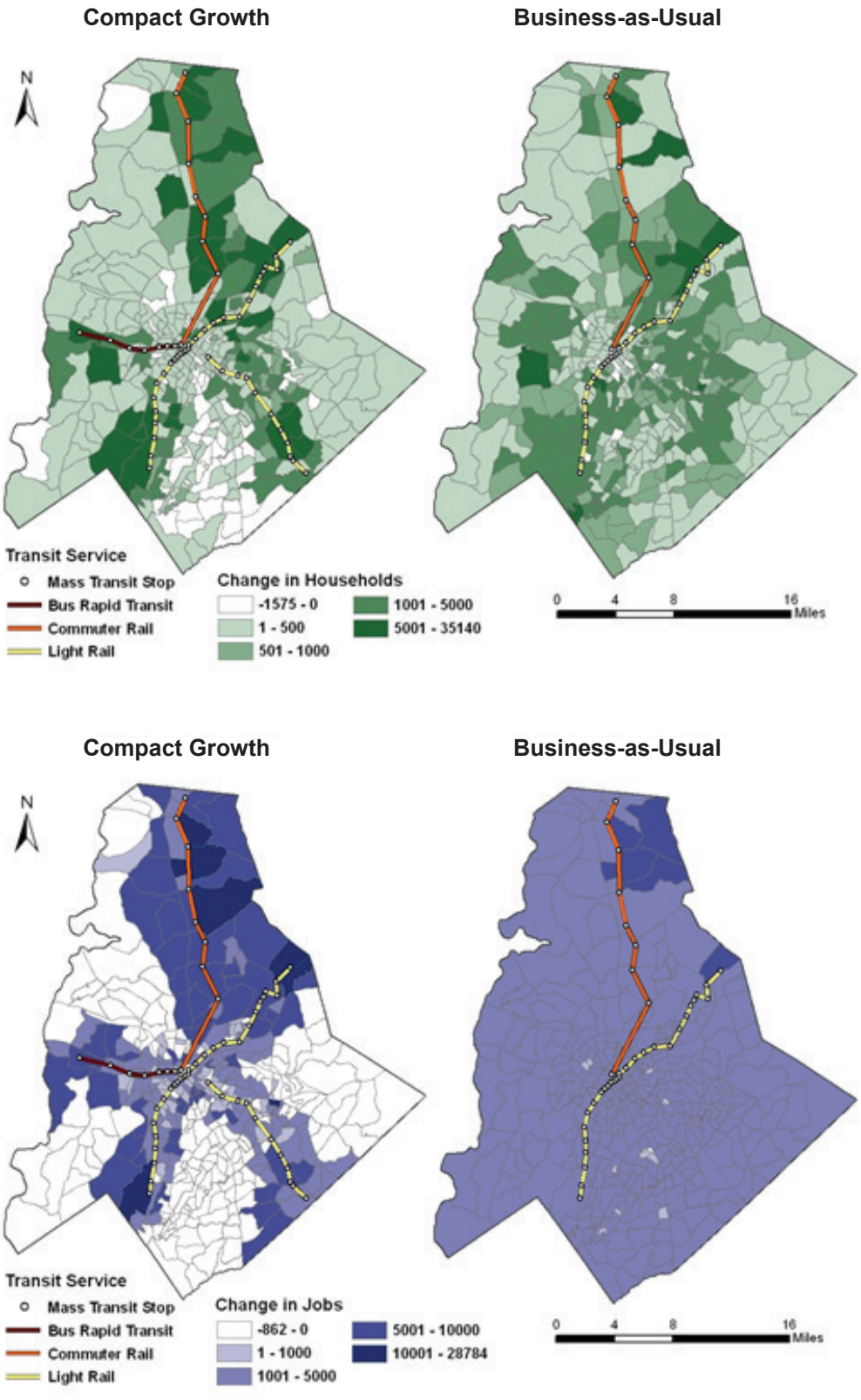
Importantly, compact growth is one of the few emissions reduction strategies implemented at the local level. Changes in technology and federally controlled emissions standards are out of reach of local communities. In this study, the research team examined whether compact development can reduce automobile emissions and how these compare to reductions from technology changes applied to vehicles.

This study focused on Mecklenburg County, North Carolina, a growing metropolitan area facing air quality challenges and sprawling development patterns. Mecklenburg County is dominated by the city of Charlotte, one of the fastest growing cities in the United States. The region is currently involved in a number of major transportation investments and coordinated land development that will change the spatial structure of the city. Transportation investments include the completion of a beltway, the construction of toll lanes on that beltway, and an investment in a new light rail service. With a relatively new beltway, decentralizing patterns have emerged resulting in a radial-corridor regional structure with employment concentrated in the central business district, the location of important offices for Bank of America, Wells Fargo, and other major employers.

Policy question:
Does compact development reduce harmful automobile emissions, and how do any reductions compare to reductions from vehicle technology solutions?

Critical findings:
Regardless of the scenario and compared to the baseline in 2000, by 2050 emissions for most pollutants will decrease between 59 percent and 89 percent due in part to projected stricter emissions standards and fleet turnover. The exception is carbon dioxide emissions, which will increase between 76 percent and 96 percent from 2000 to 2050 due to population growth and increases in vehicle miles traveled. Models predicted compact growth will decrease emissions 7.8 percent for hydrocarbons, 6.3 percent for carbon monoxide, 5.5 percent for nitrogen oxides, and 7.1 percent for carbon dioxide by 2050 without any improvements in vehicle technology. The joint contribution of compact growth patterns and a conservative change in alternative vehicle technologies lead to emission reductions of between 9.9 percent and 17.4 percent. For carbon monoxide emissions, the alternative technologies appear almost twice as effective as strategies encouraging compact growth. However, for hydrocarbons, nitrogen oxides, and carbon dioxides, compact growth yields emissions savings slightly higher than the contribution of alternative technologies.

Implications:
Strategies to reduce emissions will have a greater impact if they consider both changing urban form and address technological innovation and adoption simultaneously. The emissions benefits of compact growth combined with the health, water quality, fiscal, and mobility benefits shown elsewhere should motivate municipalities, regions, and states to find ways to encourage compact growth.



Change in households (top) and jobs (bottom) 2050-2000 in Mecklenburg County, NC, for Compact Growth and Business-as-Usual scenarios, with major transit lines shown.

Percent differences in 2050 peak-hour emissions relative to baseline and to 2050 Business-as-Usual scenarios, Mecklenburg County, NC

	2050 Business-as-Usual		2050 Compact Growth	
Market penetration of alternative vehicle technologies	No Market Penetration	27% Market Penetration	No Market Penetration	27% Market Penetration
2050 emissions relative to baseline (year 2000) with no penetration of alternative vehicle technologies				
Hydrocarbons (HC)	-78.5%	-79.8%	-80.1%	-81.0%
Carbon monoxide (CO)	-58.9%	-63.7%	-61.5%	-66.0%
Nitrogen Oxides (NO_x)	-85.6%	-86.3%	-86.3%	-87.0%
Carbon dioxide (CO_2)	96.0%	89.1%	82.1%	76.0%
2050 emissions relative to Business-as-Usual (year 2050) with no penetration of alternative vehicle technologies				
Hydrocarbons (HC)	0	-6.0%	-7.8%	-11.6%
Carbon monoxide (CO)	0	-11.6%	-6.3%	-17.4%
Nitrogen Oxides (NO_x)	0	-4.9%	-5.5%	-9.9%
Carbon dioxide (CO_2)	0	-3.5%	-7.1%	-10.2%

In the coming decades, the area is expected to face significant challenges related to managing development, including water scarcity, traffic congestion, and attainment of the National Ambient Air Quality Standards for ozone. These challenges will be driven by two fundamentals – where land development occurs and the ensuing travel behavior of residents.

Method

The team used TRANUS, an integrated land development/transportation model that simulates land markets and transportation networks on urban and regional scales, to simulate two development scenarios in 10-year increments until 2050. The business-as-usual scenario preserved a predominantly dispersed growth pattern. The compact growth scenario changed zoning to encourage higher density and walkable development along transit lines. Additional bus rapid transit and rail lines were included in the compact growth scenario, but highway capacity was added to both scenarios as dictated by projected congestion. Population and employment totals were held equal for both scenarios. To estimate the emissions reductions from alternative vehicle technologies, both 2050 scenarios were simulated with and without a total 27 percent market penetration rate of technologies that included biodiesel for trucks, compressed natural gas for buses, and for light duty vehicles a mix of propulsion systems such as hybrid, electric, and fuel cell vehicles, and fuels such as diesel, compressed natural gas, and ethanol85.

Results

Compared to the baseline in 2000, by 2050 emissions are estimated to decrease between 59 percent and 89 percent, regardless of the scenario. This is, in part, a result of projected stricter emissions standards. The exception is carbon dioxide, which will increase between 76 percent and 96 percent from 2000 to 2050 due to population growth and increases in vehicle miles traveled.

Comparing the 2050 scenarios with no market penetration of alternative technologies, compact growth decreases emissions of hydrocarbons by 7.8 percent, carbon monoxide by 6.3 percent, nitrogen oxides by 5.5 percent, and carbon dioxide by 7.1 percent relative to business-as-usual. The joint contribution of compact growth patterns and alternative vehicle technologies lead to emissions reductions of between 9.9 percent and 17.4 percent.

Implications

Emissions decreased significantly in nearly all the pollutants in the 50-year timeframe of the study, mostly due to fleet turnover and improvements in fuel efficiency. Complementary strategies to retire older vehicles and replace them with new conventional and preferably hybrid vehicles would improve vehicle fuel economy and supplement the compact growth benefits identified. The impacts of new propulsion systems or alternative fuels on regional emissions were largely a function of their market penetration in the vehicle fleet. The default assumption, based on projections of a 27 percent market penetration of such vehicles in the 2030 fleet, yielded modest reductions in emissions.

A near-doubling of carbon dioxide emissions was estimated for 2050 in both scenarios, showing that even with fleet turnover and more advanced technologies, carbon dioxide emissions increased significantly. Although the emissions in the compact growth scenario were lower than they would have been in a business-as-usual scenario, the increases in carbon dioxide emissions raise questions about the ability to manage the contribution of transportation to carbon dioxide gas emissions through current technology and the built environment. This should not deter planners from seeking change in the metropolitan landscape to allow for more compact patterns that support the walking, transit, and short trip behaviors accounted for in this research. However, it does require either breakthrough technologies or a dramatically altered travel landscape to significantly decrease the urban transportation footprint on the planet. Future research may determine whether additional policies not examined here, like parking reductions and pricing, may be able to curtail carbon dioxide emissions.

The Center for Urban & Regional Studies in the College of Arts & Sciences at the University of North Carolina at Chapel Hill conducts and supports research on urban and regional affairs—research that helps to build healthy, sustainable communities across the country and around the world.

This research was conducted Daniel Rodriguez and Brian Morton at UNC's Center for Urban & Regional Studies, and is part of the work of the Carolina Transportation Program (CTP), an interdisciplinary research and education program. The CTP focuses on the study of transportation planning, transit, non-motorized transportation, and land use programs, and their impacts on health, environment, energy, and economic development at the local, regional, national, and global scales. Find out more at http://ctp.unc.edu.

In addition, several other researchers contributed to this study, including Yan Song, Elizabeth Shay, and Tracy Hadden-Loh of the University of North Carolina - Chapel Hill, Christopher H. Frey and Nagui M. Rouphail of North Carolina State University, Asad J. Khattak of Old Dominion University, and Haibo Zhai of Carnegie Mellon University.

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