

Our Built and Natural Environments:

A Technical Review of the Interactions Among Land Use, Transportation, and Environmental Quality

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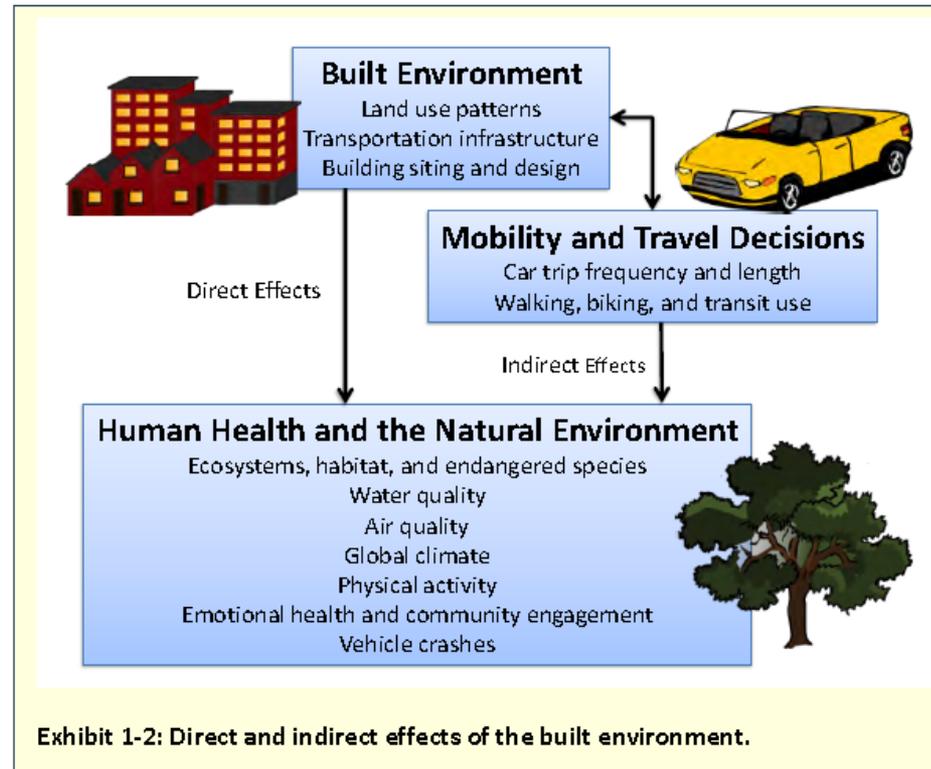
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Background

- Decisions about how and where we build communities impact the natural environment.
- 2nd edition updates 2001 edition with information available as of October 2012.
- Intended audience:
 - Federal, state, and local government agencies
 - Real estate developers and investors
 - Communities across America

The Built Environment Has Direct and Indirect Effects on the Natural Environment





Document Overview

- Trends in land use, buildings, and travel behavior
- Environmental consequences of these trends
- Effects of different types of development on the environment
 - Where we build
 - How we build

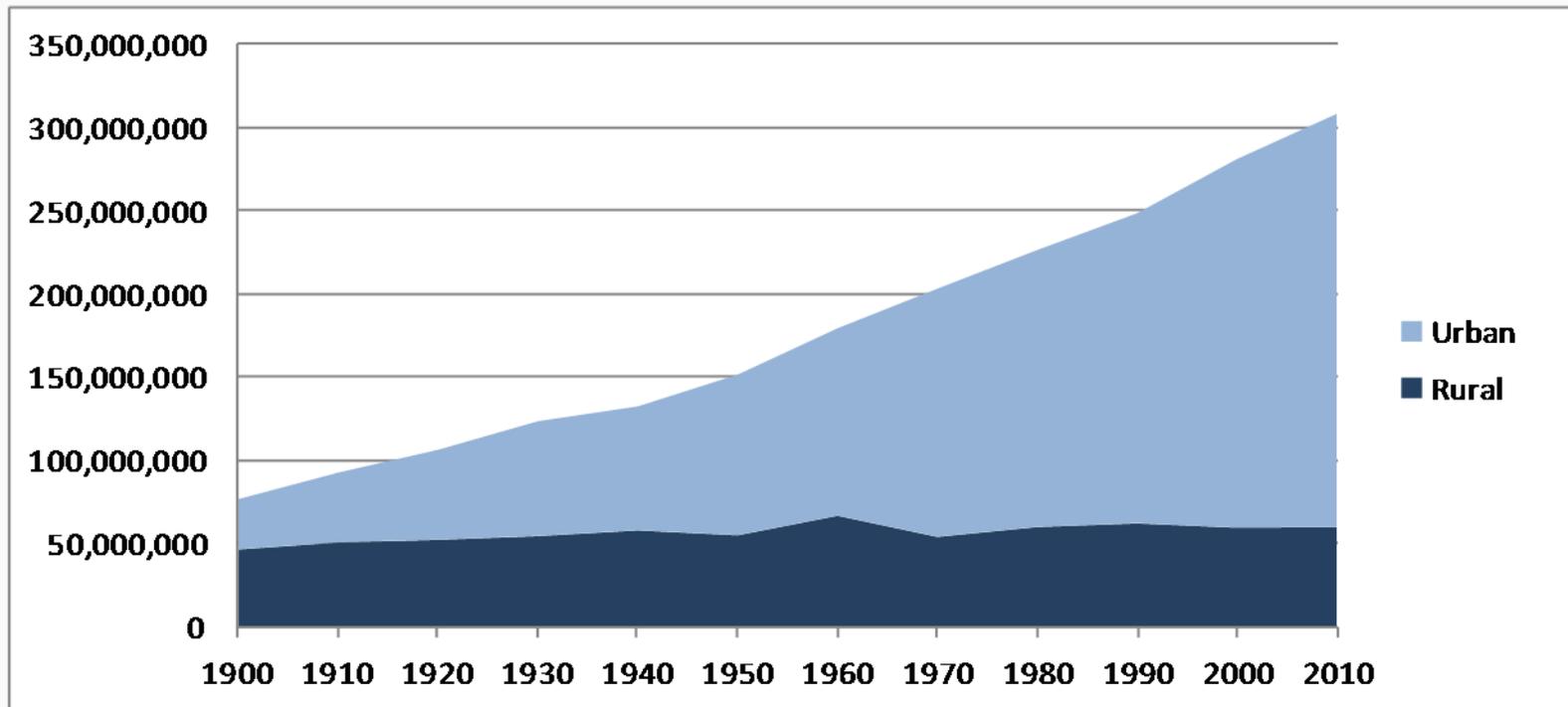


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Population



Data source: U.S. Census Bureau



Metropolitan Area Size

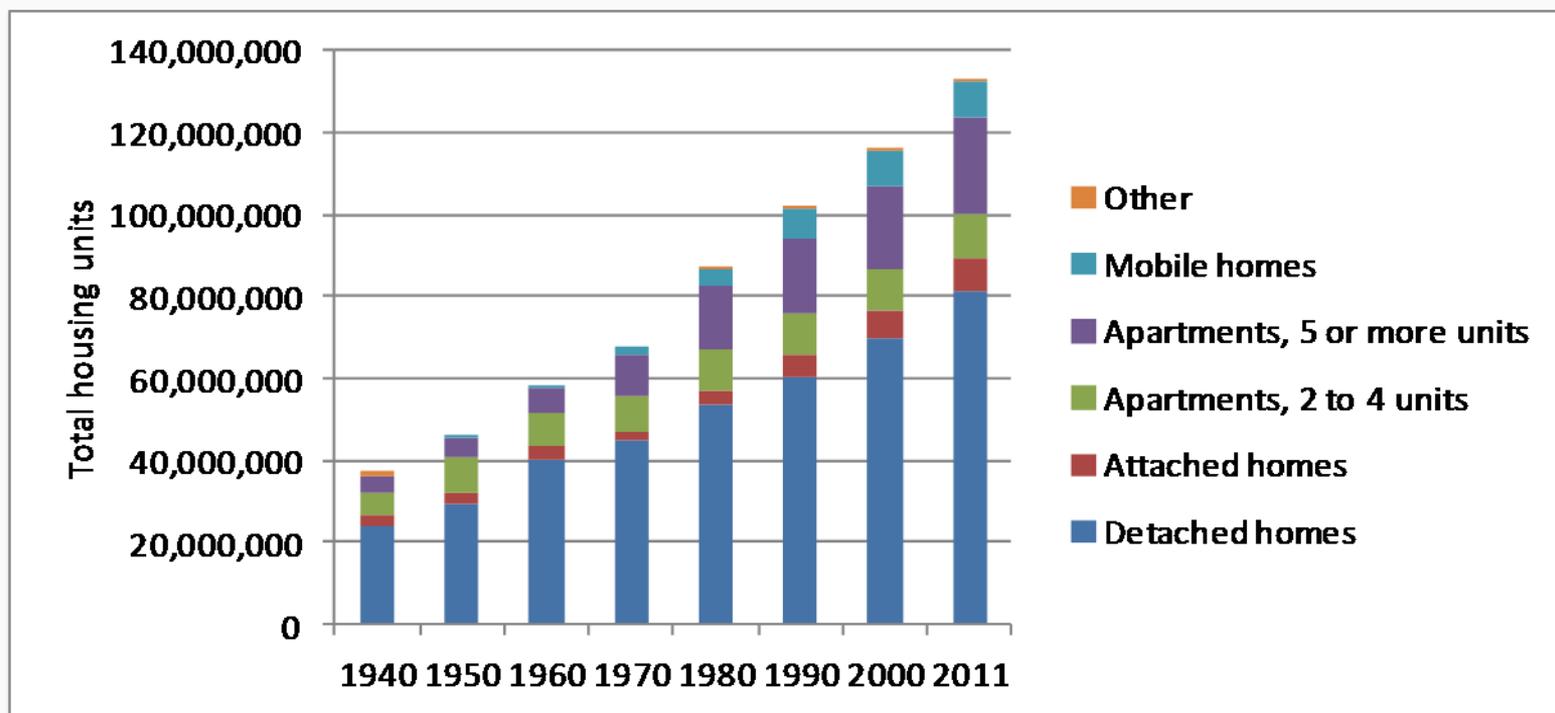
- Virtually every metropolitan region in the U.S. has expanded substantially in land area since 1950.
- Urbanized area increased 2.5 times faster than population growth between 1950 and 2010.
- Urbanized area continued to grow even in areas losing population.



Developed Land

- 1982: Nearly 71 million acres of land developed
- 2007: More than 111 million acres (57% increase)
- Over this 25-year period, the U.S. population increased about half as much (30%).
- Of the newly developed land:
 - Nearly half (17,083,500 acres) was forestland.
 - About one quarter (11,117,500 acres) was cropland.
 - The remainder was pastureland, rangeland, or other rural land.

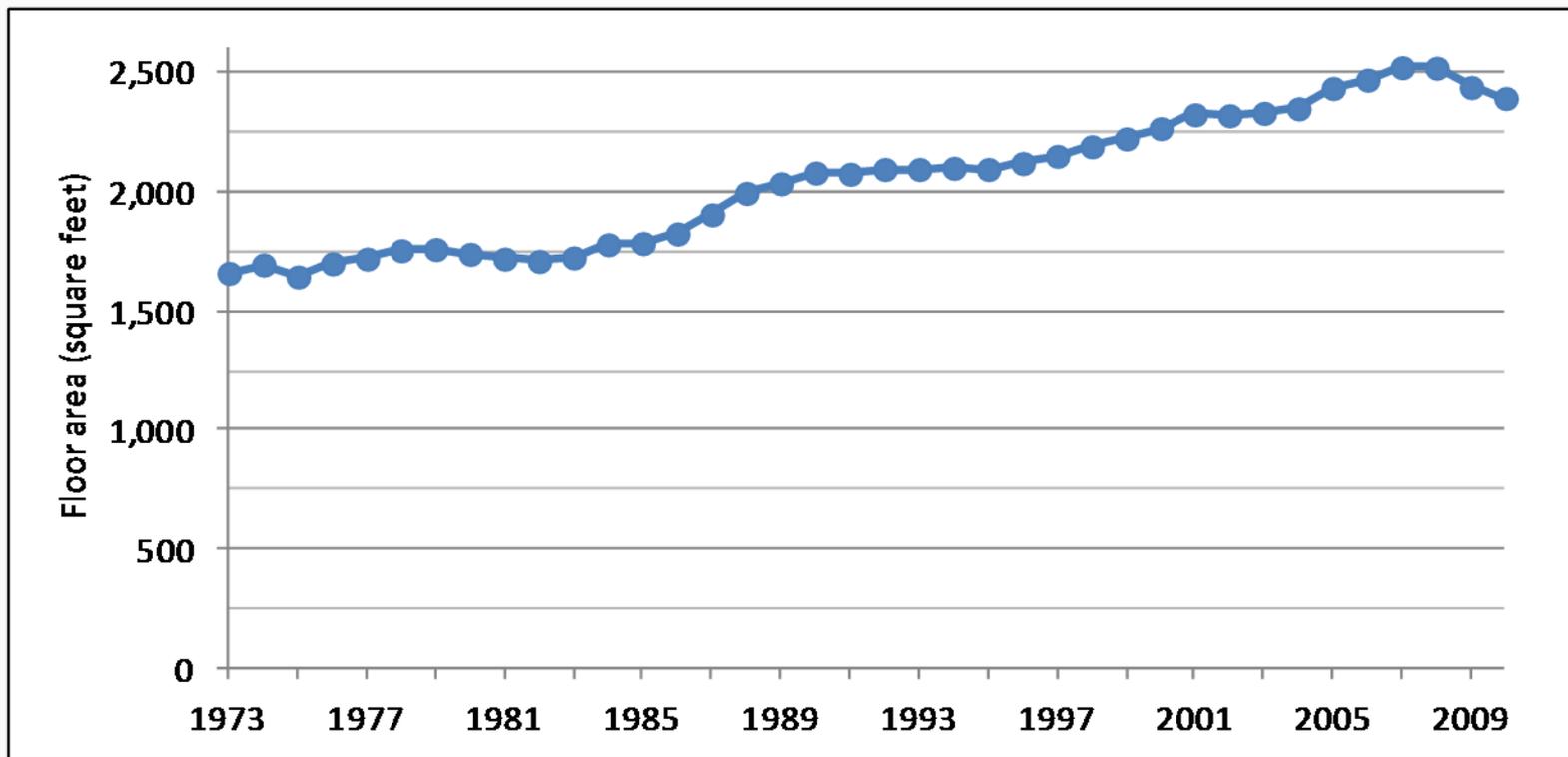
Housing Units



Data source: U.S. Census Bureau



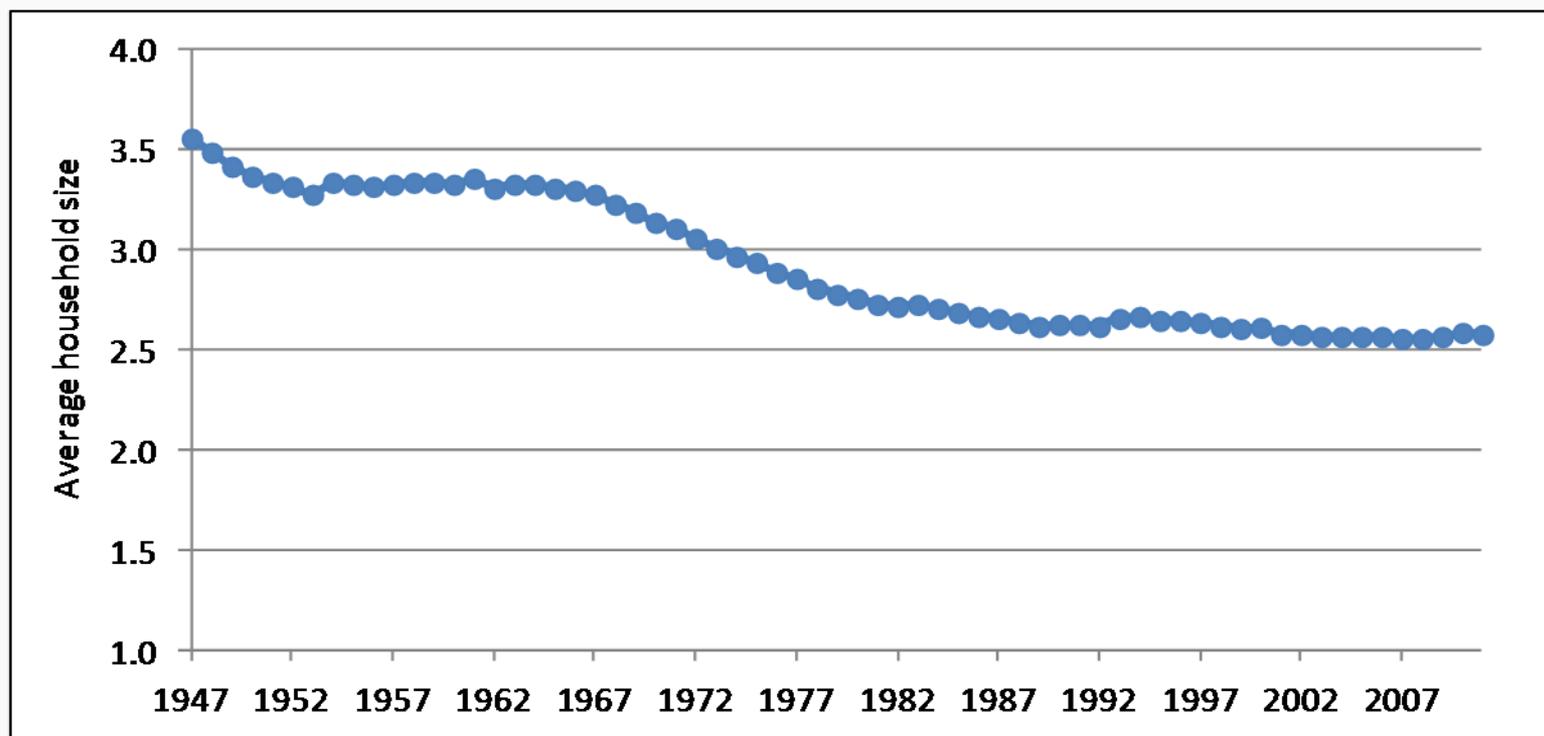
Average Size of Single-Family Homes



Data source: U.S. Census Bureau



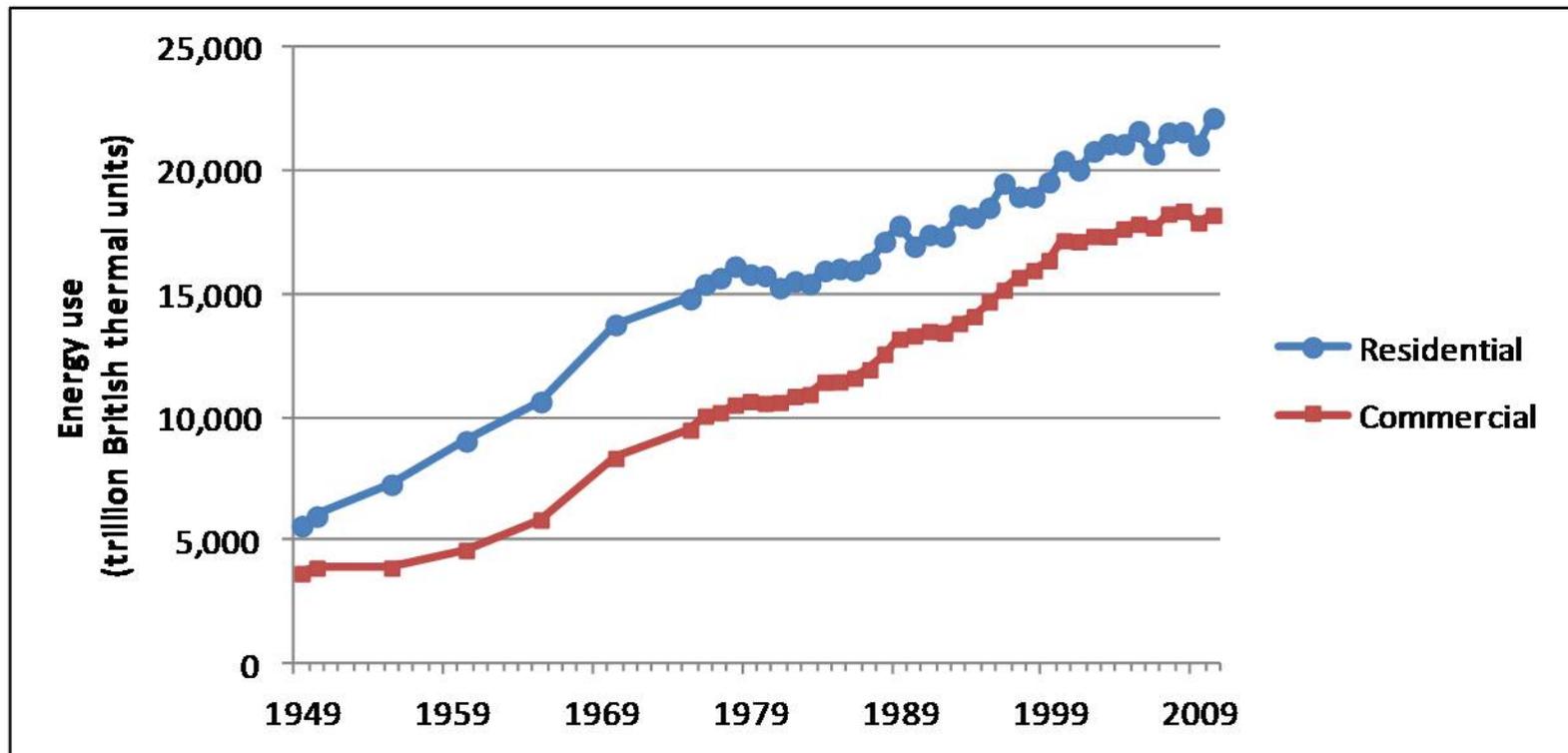
Average U.S. Household Size



Data source: U.S. Census Bureau



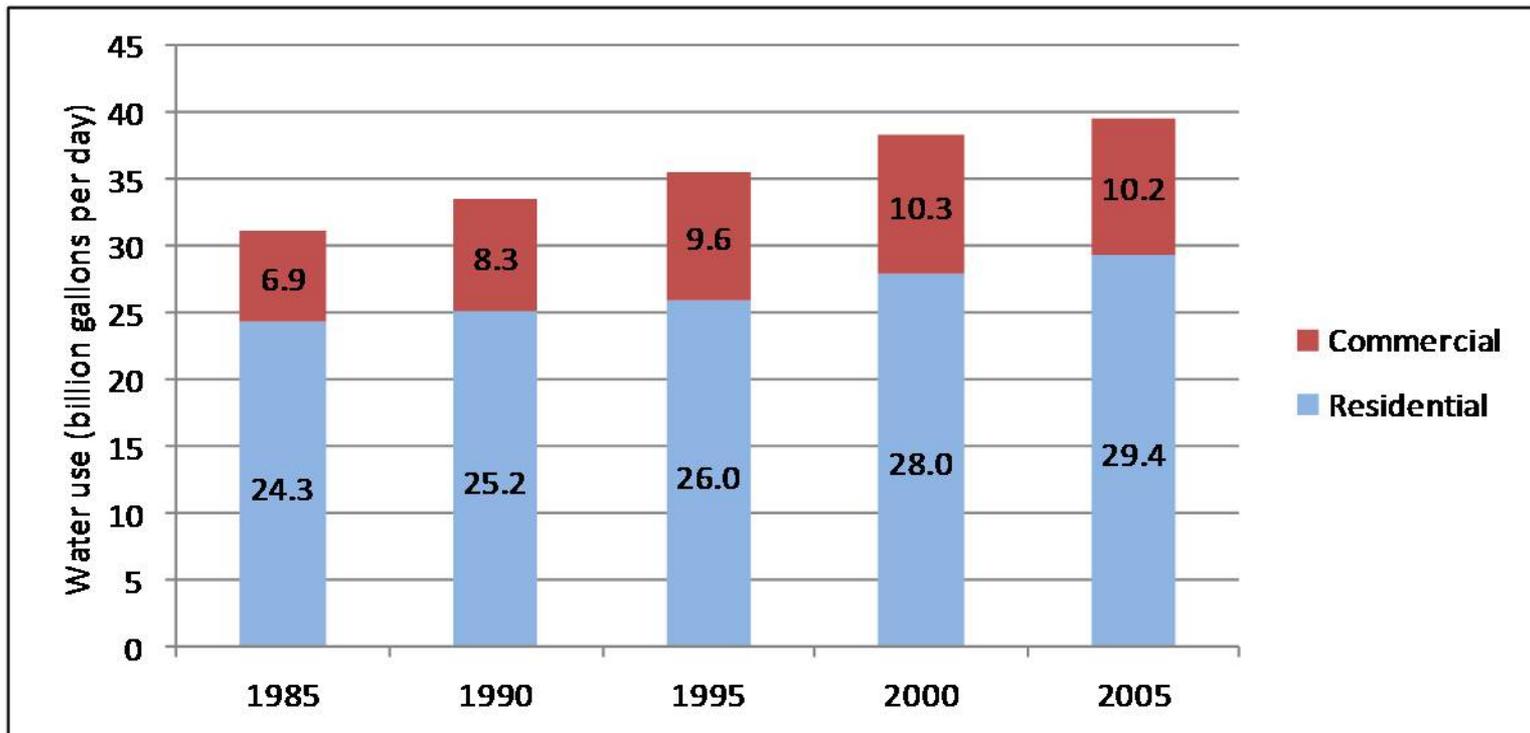
Building Energy Use



Data source: U.S. Energy Information Administration

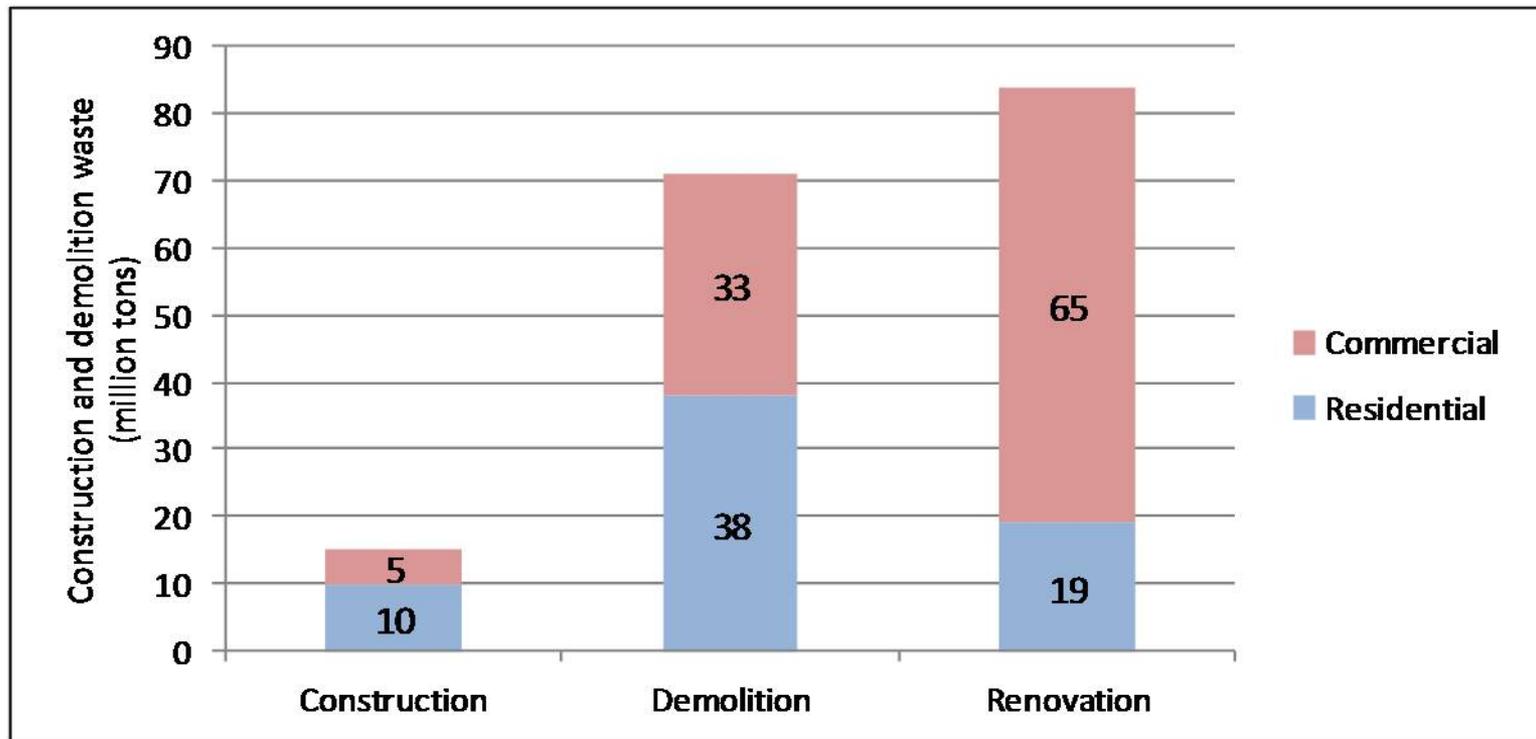


Building Water Use



Data source: U.S. Department of Energy

Building Construction Waste Production



Data source: U.S. EPA

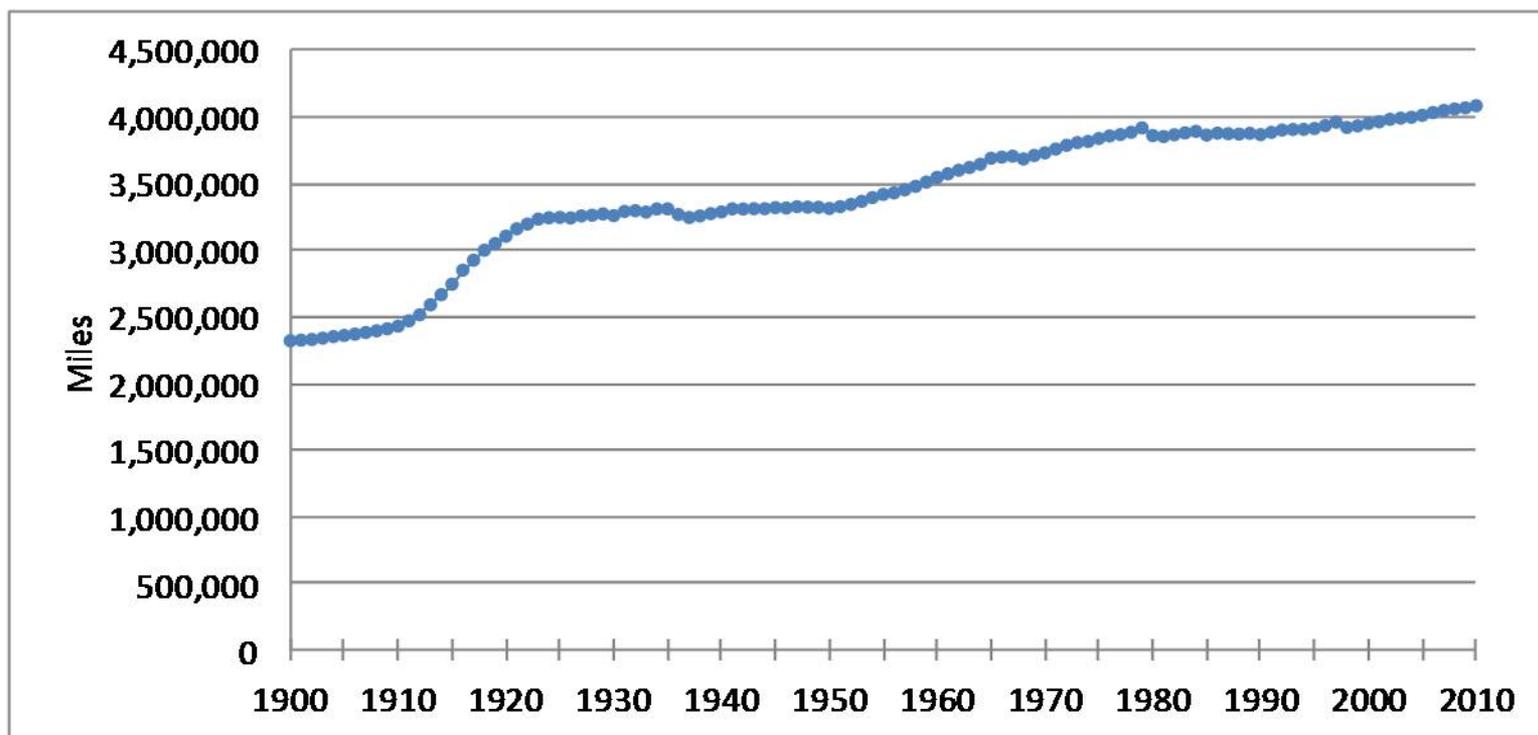


Impervious Cover

- One estimate: 40,006 square miles—an area slightly smaller than Kentucky
- 4% increase between 2001 and 2006
 - Arizona: 8.9% increase
 - Georgia: 8.4% increase
 - South Carolina: 7.9% increase
- Most cities have levels of impervious cover known to stress or seriously degrade watersheds.
 - One study of 18 cities in the 2000s showed a 0.31% increase per year while canopy cover declined.



Roads

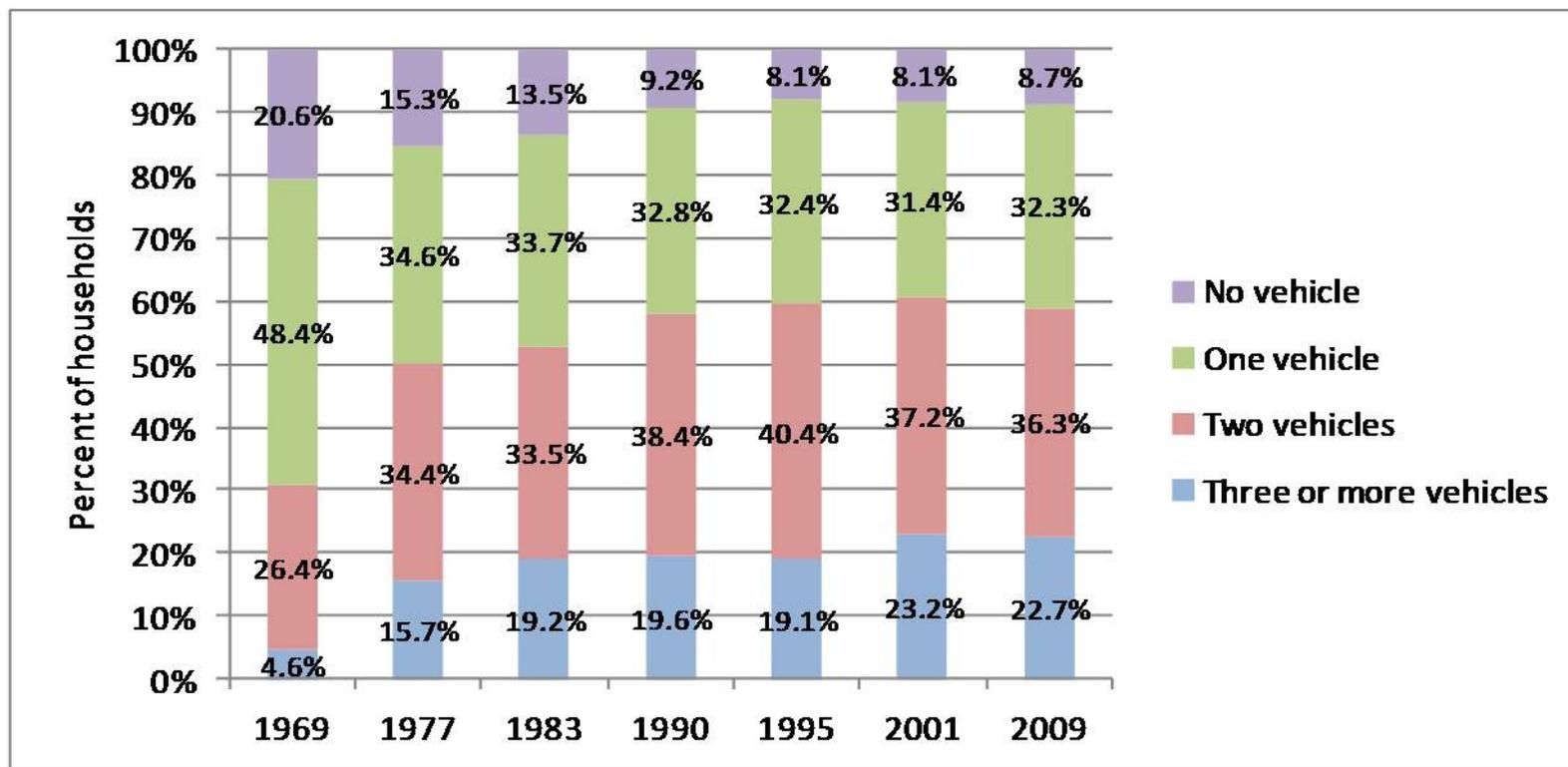


Data source: Federal Highway Administration

Parking

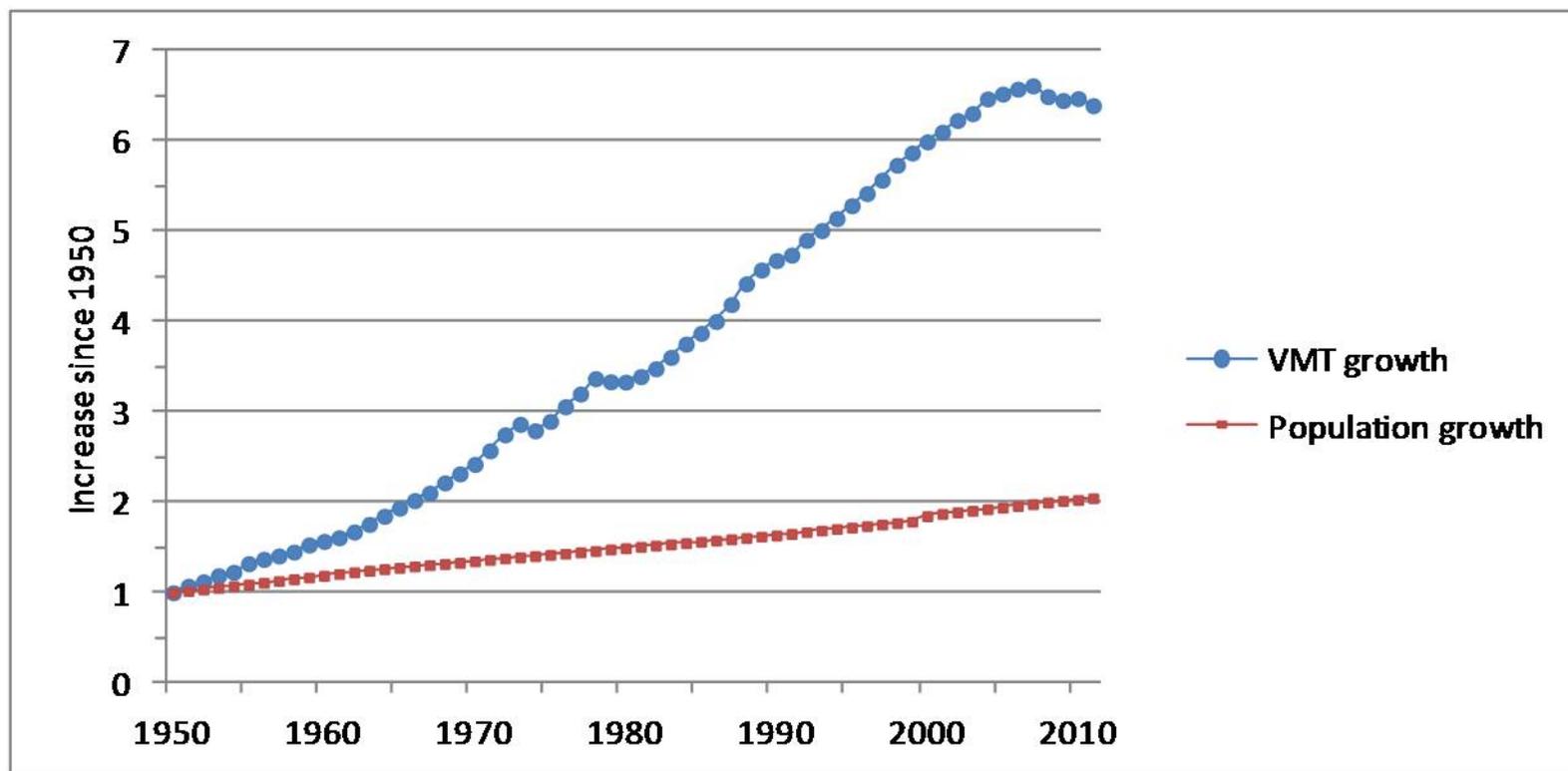
- 2010: More than 240 million cars, buses and trucks in the U.S.
- One estimate of total parking in the United States: 820 million spaces cover 8,500 square miles
- When combined with space devoted to roads: 23,900 square miles of land is paved for driving and parking—nearly the size of West Virginia.

Vehicles per Household



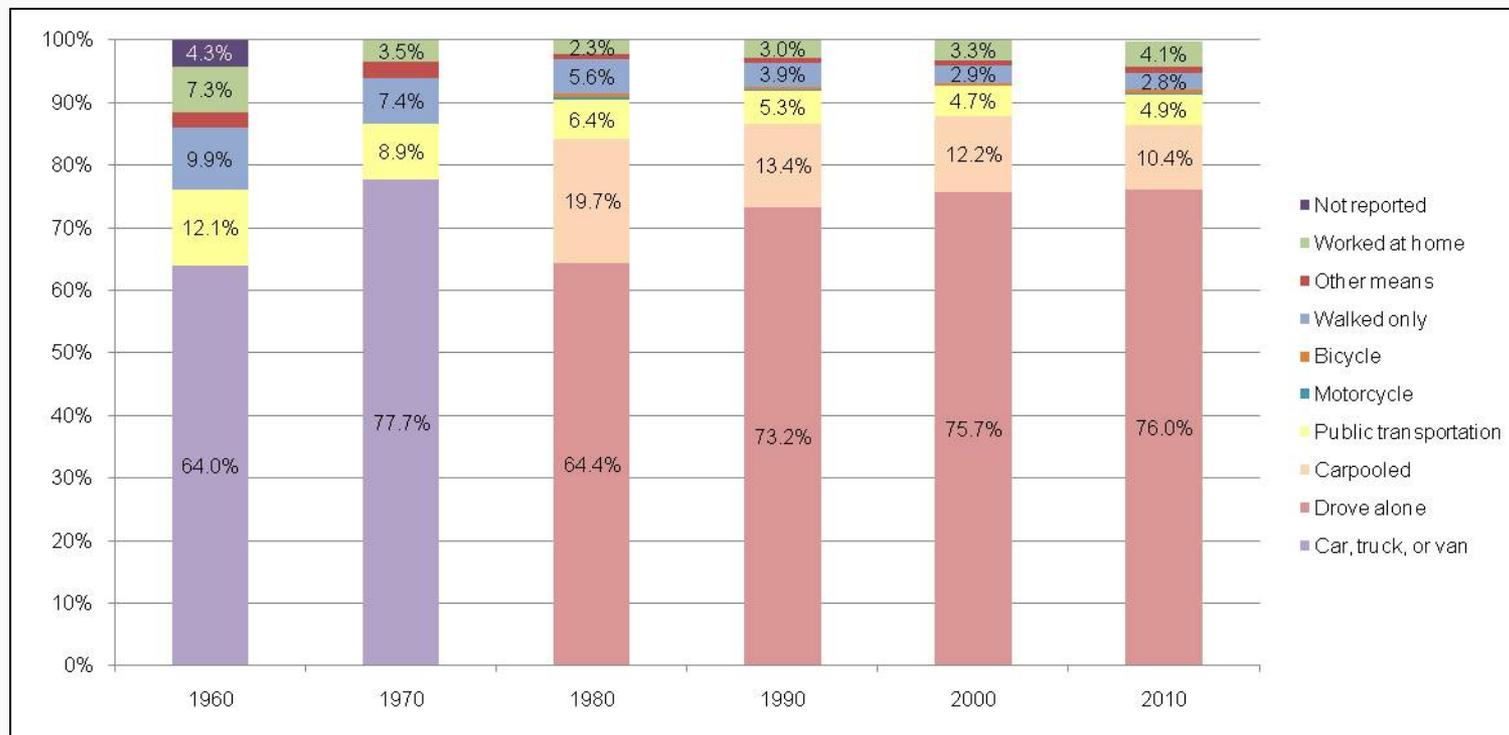
Data source: Federal Highway Administration

Growth in Vehicle Miles Traveled (VMT) and Population



Data sources: U.S. Census Bureau; Federal Highway Administration

Means of Transportation to Work



Data source: U.S. Census Bureau (reported by U.S. Department of Energy)



Future Trends

- 2010 to 2050
 - Population growth: 42%
 - New housing: 52 million units
 - Replacement housing: 37 million units
- One estimate of acres that will be lost between 1997 and 2060:
 - Rural land: 60-85 million acres
 - Forests: 24-38 million acres
 - Cropland: 19-28 million acres
 - Rangeland: 8-11 million acres



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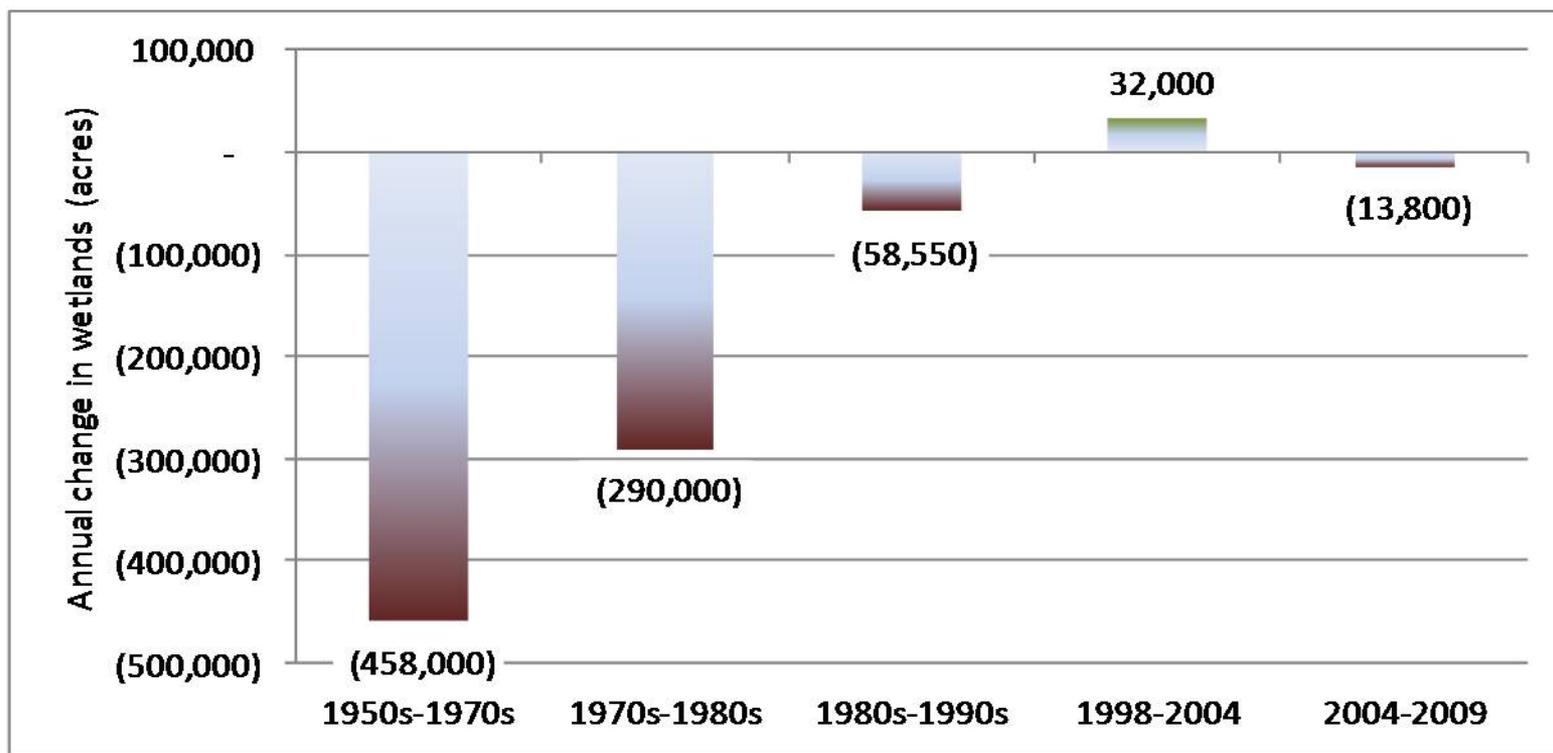


Environmental and Human Health Impacts

- Habitat loss, degradation, and fragmentation
- Degradation and loss of water resources
- Degradation of air quality
- Heat island effect
- Greenhouse gas emissions and global climate change
- Health and safety

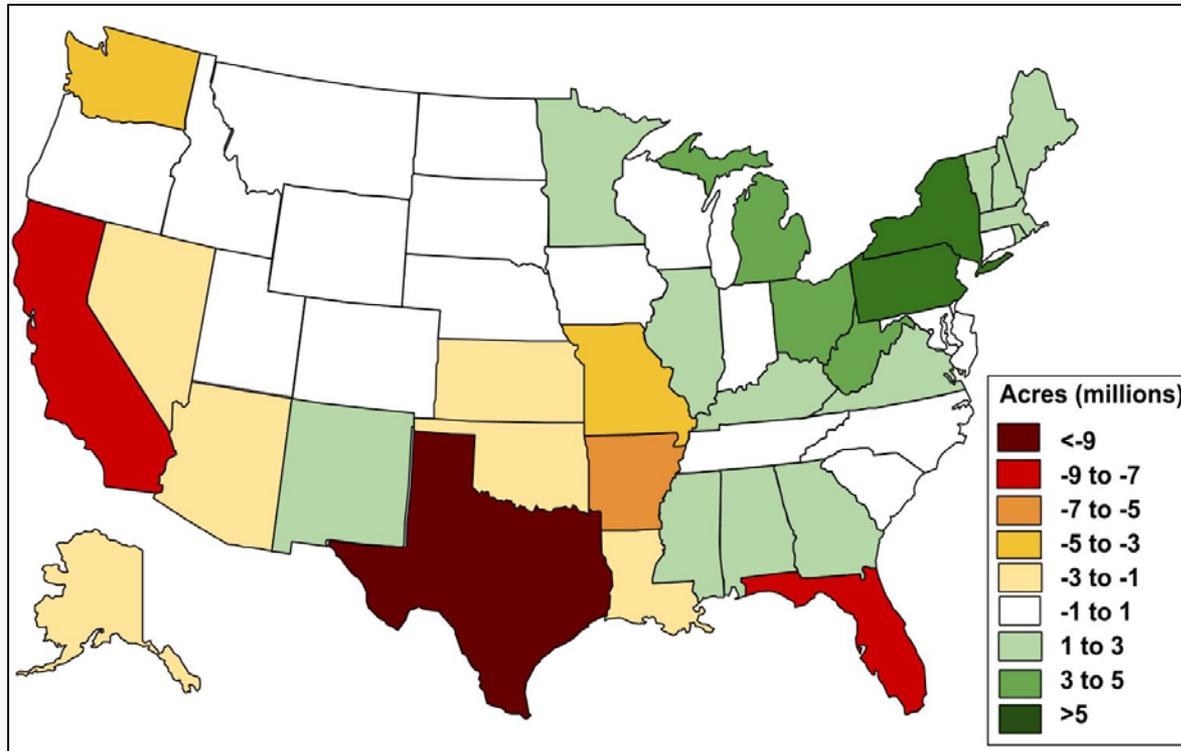


Loss of Wetlands



Data source: U.S. Fish and Wildlife Service (Dahl 2011)

Change in Forest Area, 1907-2002



Data source: Ramankutty, Heller, and Rhemtulla 2010

Habitat Degradation

- Lawns have relatively low infiltration rates; often require irrigation, fertilizer, and pesticides; and require energy for mowing.
- Non-native plants found in many managed landscapes can reduce the abundance and diversity of insect herbivores, reducing the energy available in food webs.
- Some of these non-native species have become invasive. Invasive species are at least partly responsible for the listing of about 42% of the species that are threatened or endangered.

Effects of Roads

- Habitat destruction and fragmentation
 - Many species cannot survive along road edges. Species density tends to increase with distance from roads.
- Estimates of land ecologically affected by roads: 20% to 50% of the United States
- Animal mortality
 - 1 to 2 million collisions between vehicles and large animals per year
 - Major cause of death for 21 animals on the federal threatened or endangered species list

Land Contamination

- Between 235,000 and 355,000 sites in the U.S. are contaminated with hazardous waste and petroleum products:
 - Atlanta: 4% of land area
 - Cleveland: >7% of land area
 - Milwaukee: 7.5% of land area
- Poor and minority neighborhoods often have a disproportionately high number of brownfields.





Degradation of Water Resources

- Urban-related stormwater runoff is thought to be responsible for the impairment of:
 - 51,548 miles of rivers and streams
 - 858,186 acres of lakes, reservoirs, and ponds
 - 1,877 square miles of bays and estuaries
 - 270 coastal shoreline miles
 - 452 square miles of ocean and near coastal area
 - 13,867 square miles of Great Lakes open water
- But the majority of U.S. waters have not been assessed.



Effects of Development on Stream Hydrology

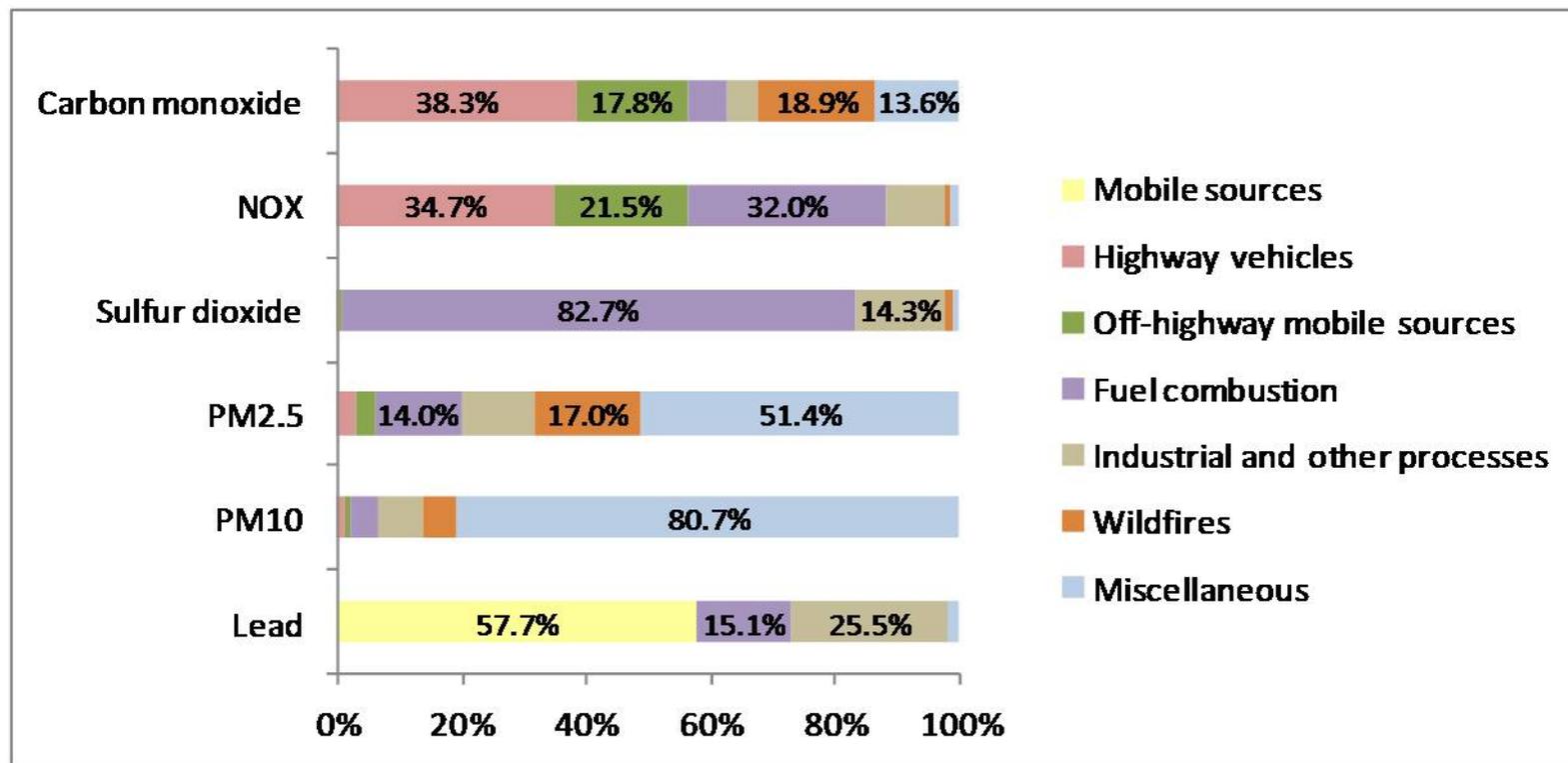
- Removing vegetation decreases evapotranspiration.
- Impervious surfaces increase runoff:
 - Water recharge is reduced.
 - Floods more frequent and severe.
 - Water temperature increases.
- Streamflow is altered at 86% of monitoring stations in developed areas.

Effects of Development on Stream Geomorphology

- Increased flow causes:
 - Erosion
 - Wider, deeper channels
 - Lower flow levels



National Air Pollution Emissions by Source Sector, 2010



Data source: U.S. EPA



Indoor Air Pollution

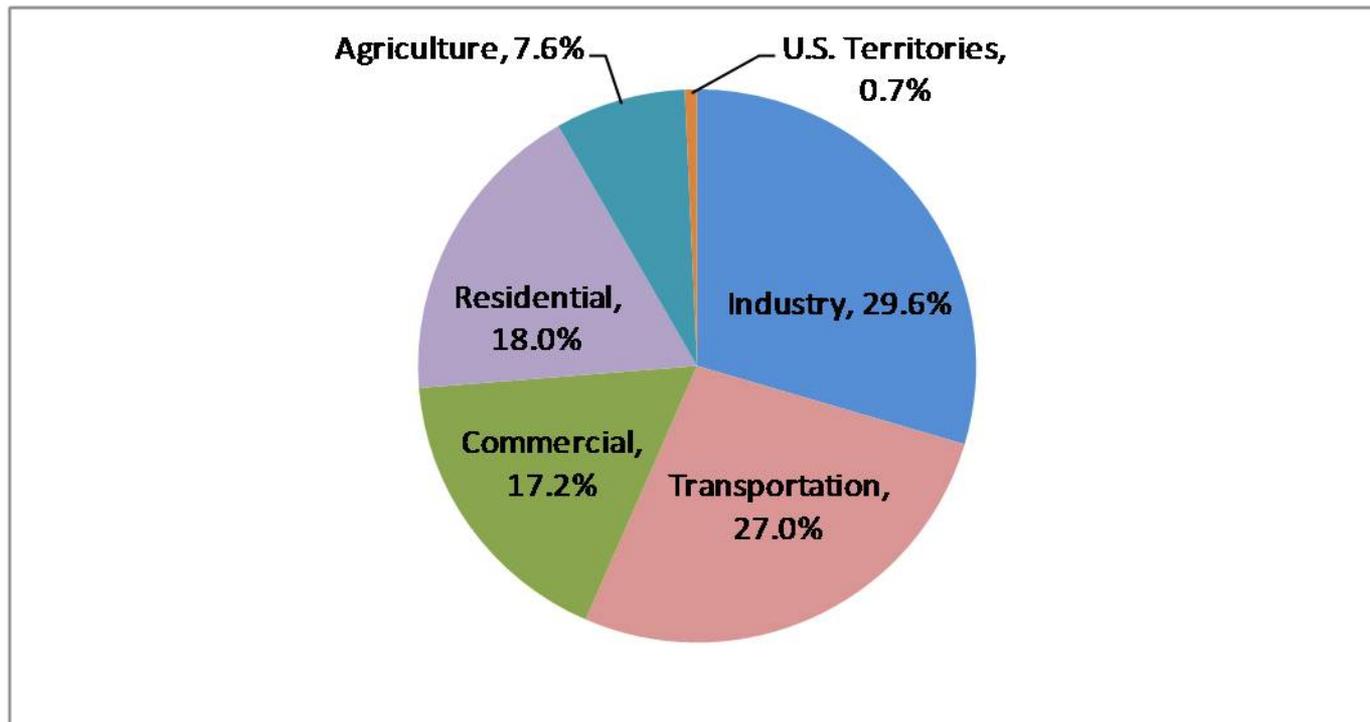
- Biological pollutants
- Volatile organic compounds (VOCs)
- Asbestos
- Incomplete combustion products of solid fuels
- Radon gas
- Polychlorinated biphenyls (PCBs)
- Polybrominated diphenyl ethers (PBDEs)



Heat Island Effect

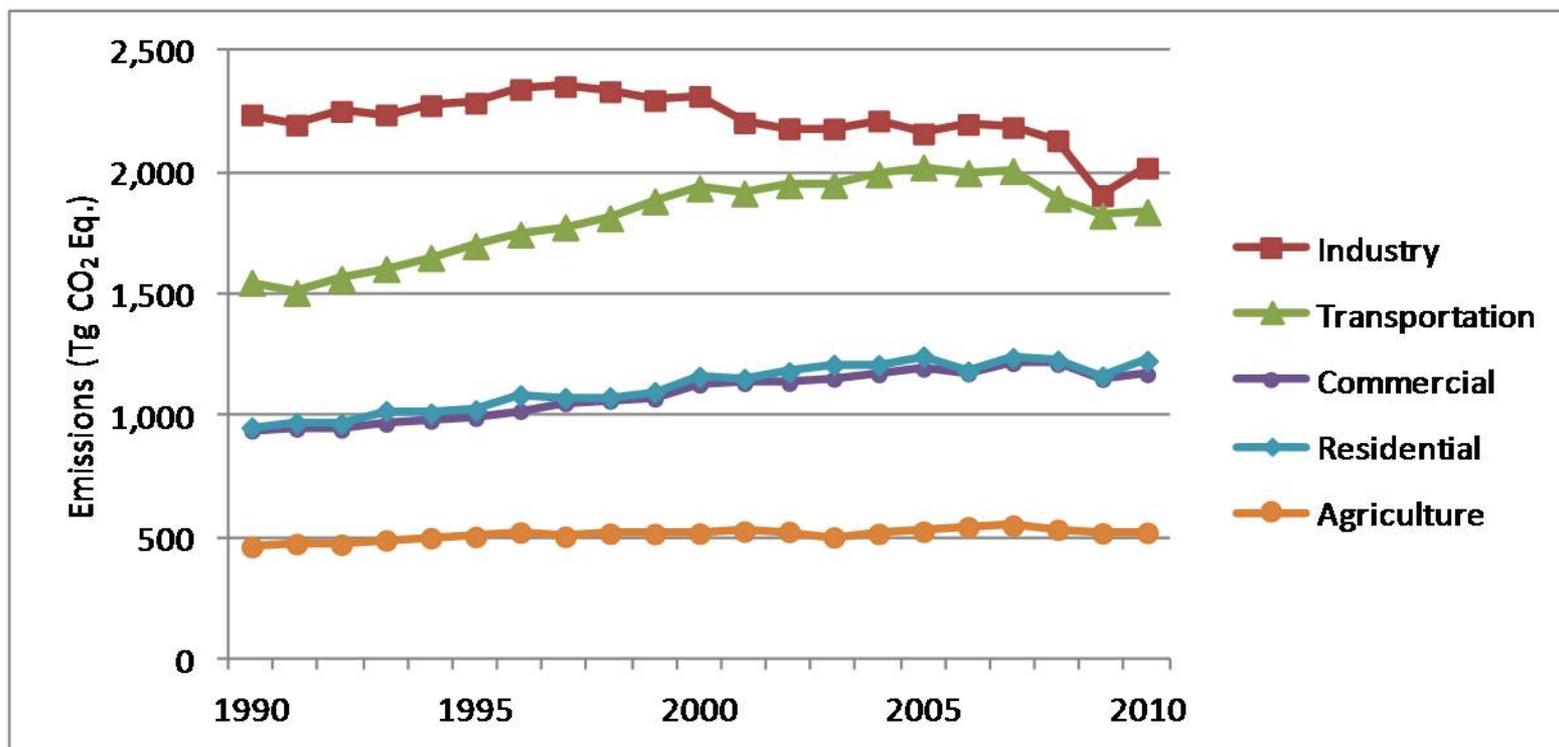
- Cities can be 6-8°F warmer than outlying areas due to:
 - Dark pavement and roofs that absorb and reflect more heat.
 - Fewer trees and less vegetation that reduce shade and evaporative cooling.
- Increased heat can be a health hazard:
 - Heat stroke
 - Increased air pollution

U.S. Greenhouse Gas Emissions by Economic Sector, 2010



Data source: U.S. EPA

U.S. Greenhouse Gas Emissions, 1990-2010



Data source: U.S. EPA

Effects of Global Climate Change

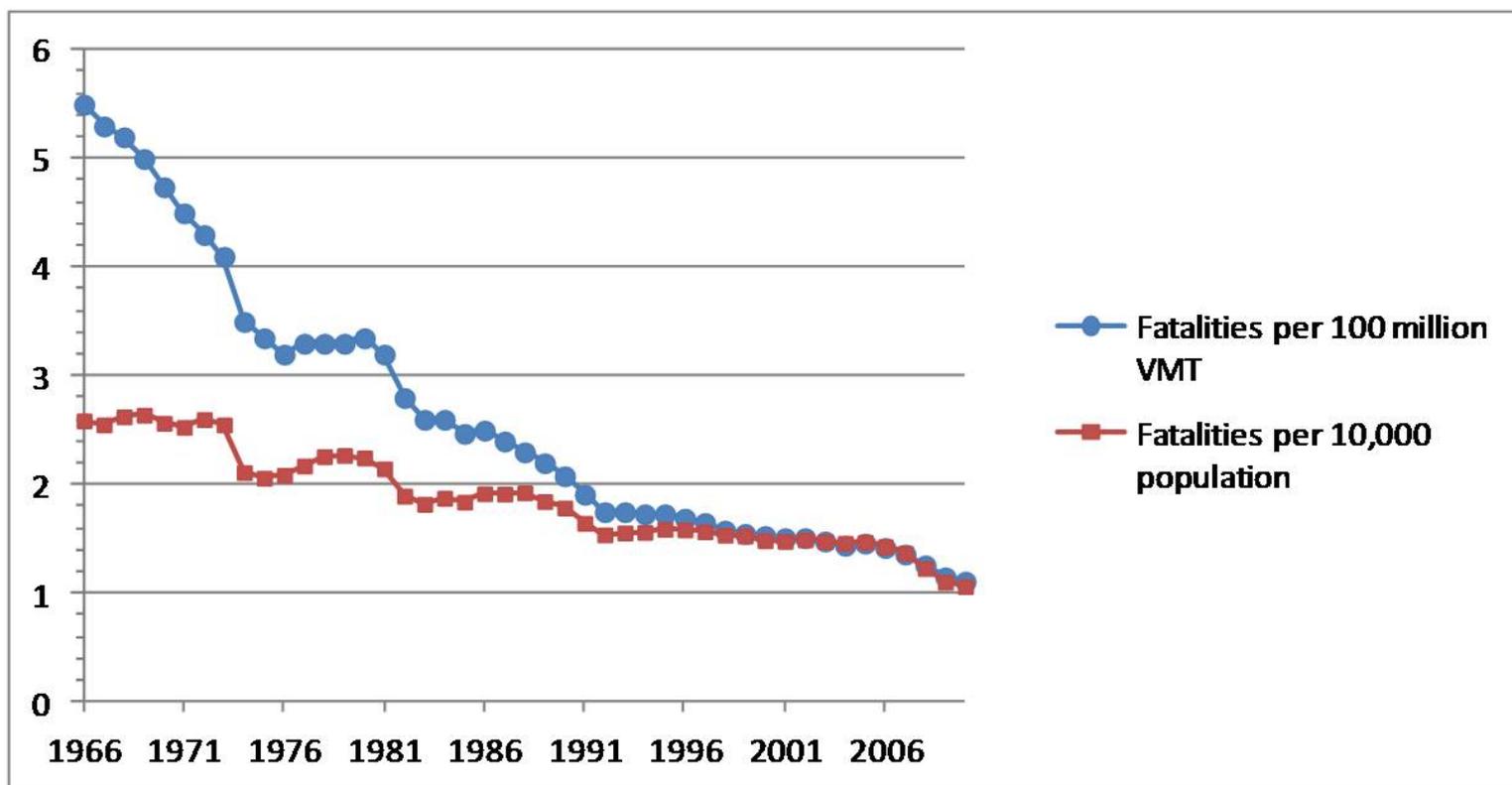
- Increased temperature
- Rainfall changes
- More frequent and intense extreme weather events
- Stronger winter storms
- Increased wildfires
- Rising sea level
- Shrinking sea ice



Activity Levels, Obesity, and Chronic Disease

- How we build our communities affects:
 - The amount of time we spend in cars.
 - The opportunity, practicality, and necessity of physical activity.
- The degree of land use mix and county-level measures of sprawl both likely affect the incidence of obesity.
- As the number of minorities and poor increases in an area, the number of facilities for physical activity and recreation often decreases.

Vehicle Crashes



Data sources: National Highway Traffic Safety Administration; U.S. Department of Transportation



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Effects of Different Types of Development on the Environment

- Where we build
 - Safeguarding sensitive areas
 - Locating development in built-up areas
 - Focusing development around existing transit
- How we build
 - Compact development
 - Mixed-use development
 - Street connectivity
 - Community design
 - Destination accessibility
 - Transit accessibility
 - Green building



Safeguarding Sensitive Areas

- Communities can encourage development:
 - Where transportation, utilities, and public services already exist.
 - Adjacent to built-out communities.
 - On brownfields and greyfields.
- Such development can remove pressure to develop farmland and sensitive natural areas that serve important ecological functions and provide scenic/recreational areas.



Importance of Infill Development

- Many cities have populations far from their peak, suggesting existing infrastructure could accommodate more people.
 - 2006 estimate: California has half a million infill parcels.
 - Among 20 metropolitan regions, 21% of new home construction in 2000-2009 occurred in previously developed areas; in some regions infill development exceeded 60%.
- Cleanup and redevelopment of brownfield and hazardous waste sites can bring substantial environmental and health benefits.

Benefits of Focusing Development Around Transit Stations

- A bus carrying 20 passengers consumes only about 1/3 of the energy that would be needed if each person drove alone.
 - Public transit also provides mobility to people who cannot or choose not to drive.
- Across 17 transit-oriented development projects, 47% fewer trips than projected occurred.
- People living in transit-oriented developments are 2-5 times more likely to use public transit.

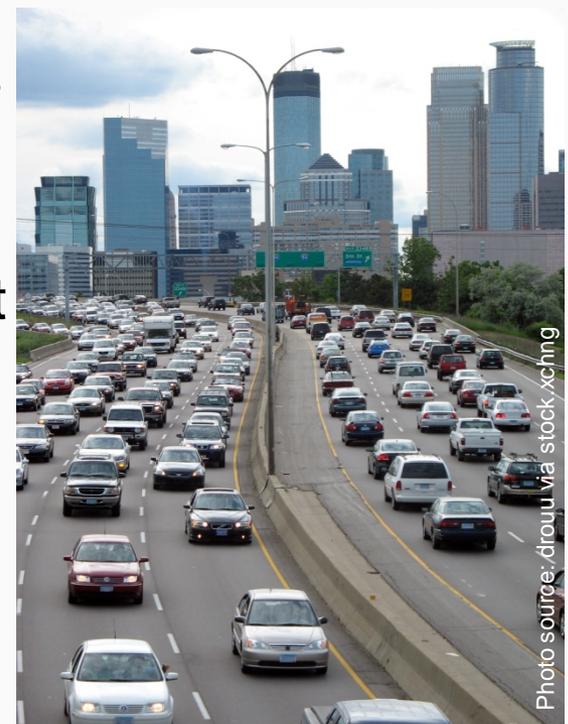
Compact Development

- The greater the population and employment density of an area, the less the area's residents tend to drive.
- Density is strongly correlated with:
 - Mixed residential, commercial, institutional areas.
 - Destinations close together.
 - Sidewalks.
 - Public transit service.



Compact Development and Air Pollution

- Study of 100 metro regions: highest emitting regions emit almost 2.5 times as much CO₂ per resident as the lowest-emitting regions.
- Study of 45 metro regions: least compact regions had 60% more high ozone days than most compact regions.
- Meta-analysis: Nationally, compact development plus other strategies could reduce VMT 10-14%, reducing U.S. transportation CO₂ emissions 7-10%.



Mixed-Use Development

- Mixed-use development can reduce VMT by:
 - Decreasing trip lengths.
 - Providing transportation options.
 - Reducing car ownership.
- A study of 239 mixed-use developments across six metro regions showed that 30% of trips were short, located entirely within the development.



Street Connectivity

- Street hierarchies discourage walking and biking, leading to driving for even short trips.
- Locating retail and commercial uses on arterial streets and funneling all traffic to these arterials can make streets more dangerous.
- Street connectivity can also reduce car use and emissions.



Community Design

- Many factors can improve the environment for walkers and bicyclists, e.g., sidewalks, crosswalks lighting, shade trees, bike paths and lanes, bike parking.
- Roads are safest with street design elements that slow down drivers, e.g., narrow lanes, traffic-calming measures, street trees.
- Green street design can also improve water quality.





Destination Accessibility

- Meta-analysis: Destination accessibility is the measure most strongly associated with VMT and the amount people walk.
- Studies show various measures of destination accessibility are important: neighborhood accessibility, urban contiguity, and population centrality.

Green Building

- Carefully choosing site location
- Limiting environmental impacts of construction and renovation practices
- Conserving water and energy in building operations
- Using building materials safe for occupants
- Designing sites to capture and reuse stormwater





Scenario Planning

- Scenario planning studies look at how the combined effects of land use strategies could improve the environmental outcomes of development.
- A meta-analysis of many regional studies showed that the United States could reduce VMT 17% below current trends between 2007 and 2050 by:
 - Increasing average regional density by 50%.
 - Directing development to infill locations.
 - Mixing land uses.
 - Coordinating transportation investments.



Find *Our Built and Natural Environments* at
<http://epa.gov/smartgrowth/built.htm>

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