# Environmental and Health Impacts of Urbanization

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Mailman School of Public Health
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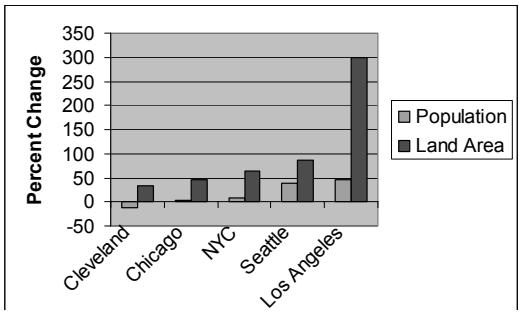
## *Today's Talk*

- Overview of some major environmental impacts of contemporary urbanization in the U.S.:
  - Water quality
  - Air quality
  - Urban heat island effect
  - Biodiversity loss

## *Major Points*

- In the US (and increasingly other nations), recent urbanization has become a process of "spreading out" – the vast expansion of metropolitan regions.
- The adverse ecological impacts that stem from low-density urbanization are associated with adverse public health impacts
- The public health and planning professions are challenged to work together to understand the impact of the built environment on health, and build communities that promote physical and mental health.

***Change in Metropolitan Population and Developed Land Area, 1970-1990***




Source: H. Diamond, P. Noonan, *Land Use in America*, Island Press, 1996

*Urban Density (persons per hectare)*

| Comparison of Land Use Data, 1990 | |
|---|---|
| | *Urban Density* |
| | *persons per ha* |
| SELECTED EUROPEAN CITIES | |
| Amsterdam | 48.8 |
| Europe | 47.1 |
| Stockholm | 42.1 |
| Vienna | 68.3 |
| Copenhagen | 93.8 |
| London | 42.3 |
| | |
| SELECTED AMERICAN CITIES | |
| Phoenix | 10.6 |
| Boston | 12 |
| Houston | 9.5 |
| Washington | 13.7 |
| New York | 19.2 |

*Source:* Adapted from Kenworthy, Laube, Newman and Barter 1996

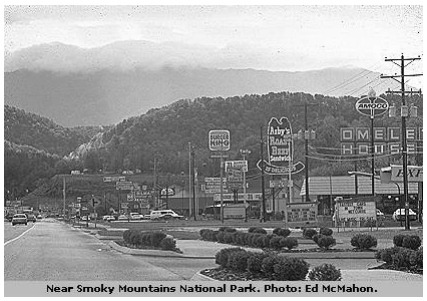
***Sprawl, defined:***

Includes “leapfrog” or scattered development, commercial strips along roadsides, and large expanses of low-density or single-use development that isolates living, working, and shopping places from each other.

Sprawl is best defined by it’s impacts or indicators: including poor accessibility between residences and other destinations and a lack of functional open space; and auto-oriented commercial land use at the edge or beyond existing urbanization.

Prof. Reid Ewing of Florida Int’l University; and Lee Epstein, Chesapeake Bay Foundation

*Changes in residential development styles: large-lot housing*

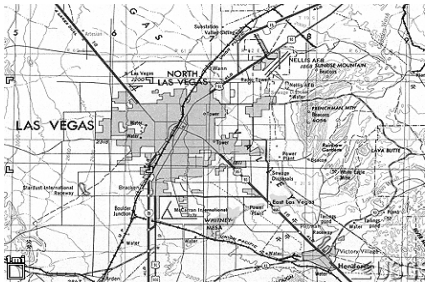


Near Smoky Mountains National Park. Photo: Ed McMahon.

## *Roots of Sprawl*

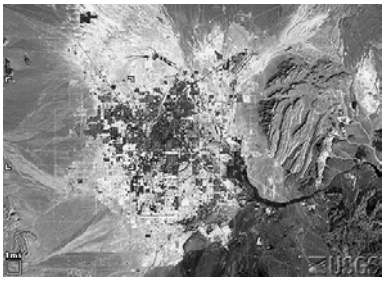
- Housing policies
- Highway building vs. transit investment
- Zoning policies
- Lack of regional planning
- Competition for tax revenue
- Lifestyle choices

***Las Vegas map and total population***

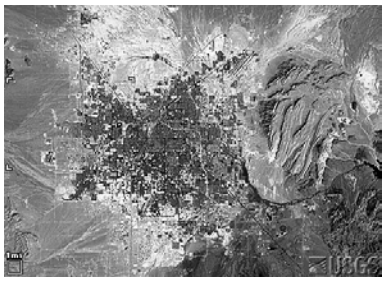



1964: 127,000
1972: 273,000
1986: 608,000
1992: 863,000
1997: 1,124,00

*Las Vegas, 1972*




*Las Vegas, 1986*



*Las Vegas, 1992*

## *Problems with Sprawl*

- Environmental impacts
- Health impacts
- Automobile dependency
- Land consumption & loss of farmland
- Loss of a ”sense of place"
- Costs to local government (infrastructure)
- Social impacts and disinvestment in city centers

*Environmental impacts of low-density land development -- aka Sprawl:*

•Water pollution: reduction in water quality through creation of impervious surfaces

* Air pollution: On-road vehicles impact on urban health and add greenhouse gases

* Soil erosion

* Habitat loss and fragmentation: loss of local biodiversity

* Loss of farmland

* Inefficient resource use: and depletion of non-renewable resources (e.g. petroleum); increased energy consumption

Urbanization impacts on aquatic resources in four categories:

* Hydrology
* Geomorphology
* Water quality
* Habitat

What is a Watershed?

A watershed is a geographic area of land that drains waters to a shared destination. Watershed is a drainage basin that divides the landscape into hydrologically defined areas.

* USEPA

INTENSITY OF LAND USE

POTENTIAL WATER QUALITY PROBLEMS

AMOUNT OF IMPERVIOUS SURFACE

## Impervious Surfaces

*Croton Watershed within the NYC Water Supply System*


**Land Cover**

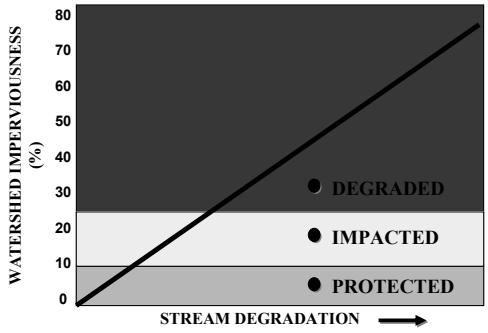
**Derived at the University of Connecticut from 1995 Landsat TM Imagery**

- Comm./Ind.
- High Dense Res./Comm
- Turf/Lawn
- Mixed Res./ Tree cover
- Open/Agr.
- Open/Fields
- Conif. Forest
- Dec. Forest
- Forested Wetland
- Wetland/Marsh

## Impervious surfaces

- Indicate intensive land uses that cause pollution
- Inhibit recharge of groundwater
- Prevent natural processing of pollutants in soil, plants
- Provide a surface for accumulation of pollutants
- Provide an express route for pollutants to waterways

**Relationship Between % Imperviousness and Water Quality**




ADAPTED FROM SCHUELER, ET. AL., 1992

## Air Quality

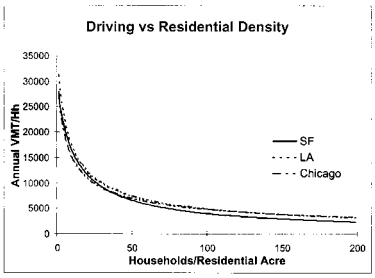
| Rank | Metro Area | Total Number of Days of Unhealthy Air Quality (2000 to 2002) |
|---|---|---|
| 1 | Riverside-San Bernandino, CA | 445 |
| 2 | Fresno, CA | 421 |
| 3 | Bakersfield, CA | 409 |
| 4 | Los Angeles- Long Beach, CA | 255 |
| 5 | Sacramento, CA | 163 |
| 6 | Pittsburgh, PA | 134 |
| 7 | Knoxville, TN | 109 |
| 8 | Birmingham, AL | 100 |
| 9 | Houston, TX | 94 |
| 10 | Baltimore, MD | 93 |

Source: Surface Transportation Policy Project, 2003

- Although improvements since the 1970 Clean Air Act, number of "unhealthy" days increasing for many metropolitan areas, especially in regards to ozone.

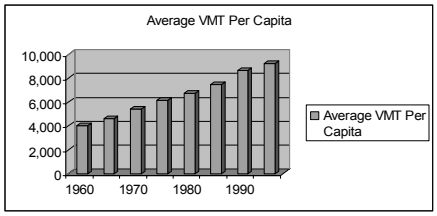
## Relationship between HH density and VMT:

Figure 1. The reduction in vehicle miles traveled per household as residential density increases.

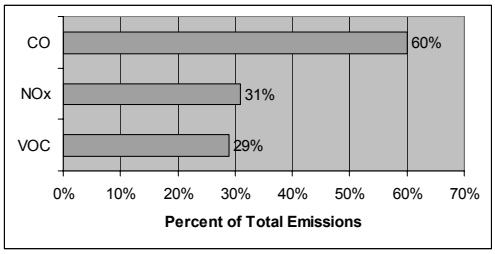



J. Holtzclaw et al., Transportation Plann Technol 2002;25 (1):1-27.

## Vehicle Miles Traveled (VMT) Per Capita, 1960-1995




## Contribution of Highway Vehicles to Total U.S. Emissions of CO, NOx, and VOC, 1996




Source: Bureau of Transportation Statistics, U.S. DOT, 1998.

## Air Quality Impacts

| Rank | Metro Area | Percent of all Criteria Pollutants from Transportation (1999) |
|---|---|---|
| 1 | Fort Worth-Arlington, TX PMSA | 60.2% |
| 2 | San Antonio, TX MSA | 57.1% |
| 3 | Los Angeles-Long Beach, CA PMSA | 56.9% |
| 4 | Austin-San Marcos, TX MSA | 56.7% |
| 5 | Dallas, TX PMSA | 56.4% |
| 6 | Hartford, CT MSA | 55.6% |
| 7 | New York, NY PMSA | 53.9% |
| 8 | Seattle-Bellevue-Everett, WA PMSA | 53.6% |
| 9 | Columbus, OH MSA | 53.4% |
| 10 | Denver, CO PMSA | 52.7% |

Source: Surface Transportation Policy Project, 2003

Vehicle emissions also include CO2, fine particulate matter, and other toxic air pollutants, and are associated with increased risk of premature mortality, asthma, cancer and heart disease.

## *Pedestrian Safety*

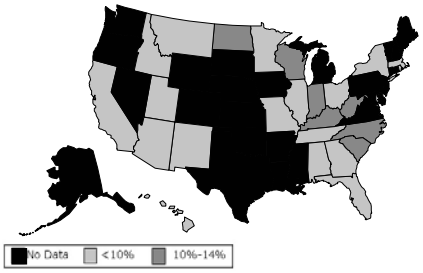
In the US, it's estimated that each year, automobiles cause about 5,000 – 6,000 fatalities and 80,000 – 120,000 injuries among pedestrians nationwide.

## Urban form and physical activity

- Urban form affects the relative convenience and viability of walking or biking for recreational, shopping, or work purposes – and thus influences the levels of physical activity patterns.
- Only 30-40% of the American population engages in regular sustained exercise – another 30% are completely inactive!
- Car dependency is associated with reduced walking or bicycling.

## Obesity Trends* Among U.S. Adults
## BRFSS, 1986

(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)

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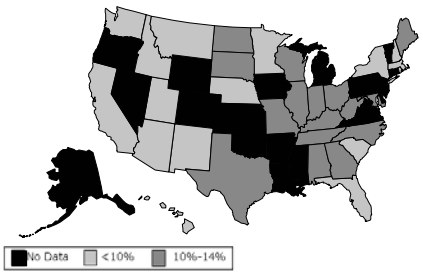


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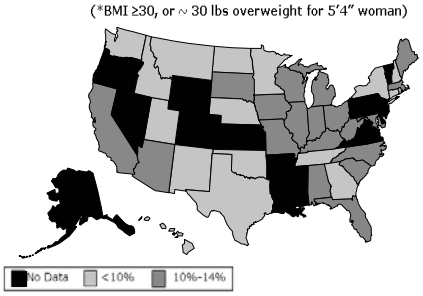


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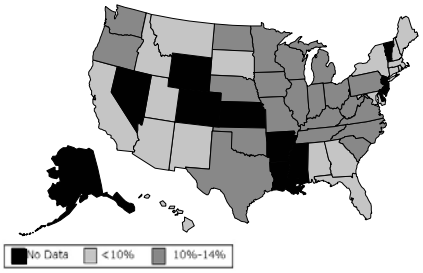


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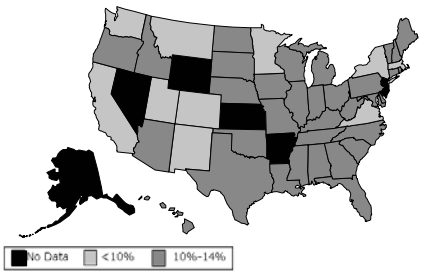


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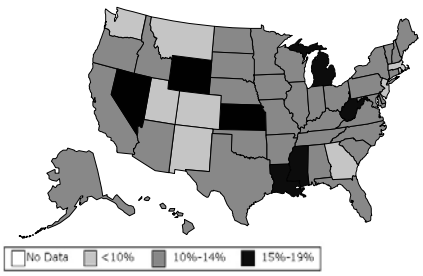


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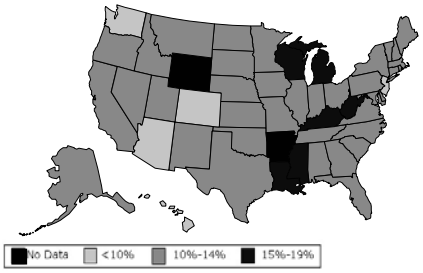


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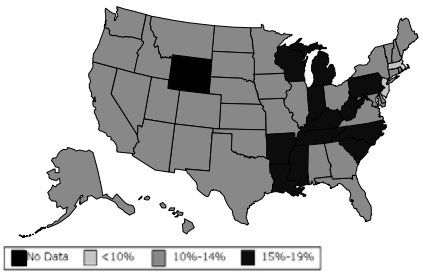


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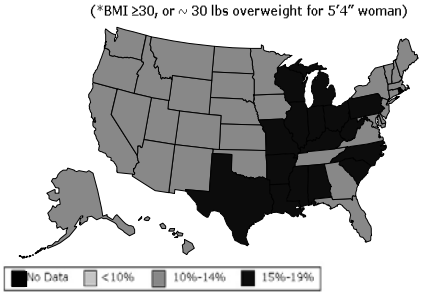


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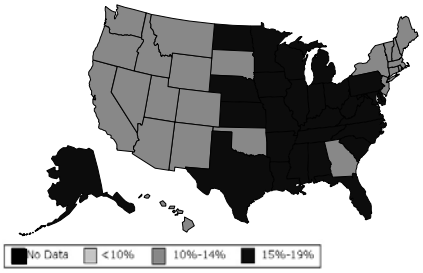


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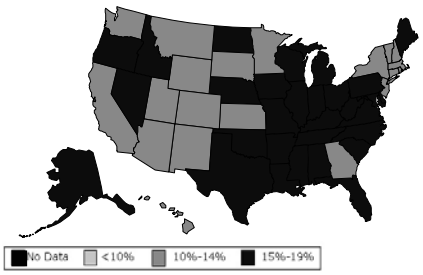


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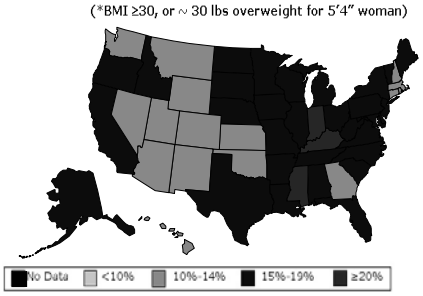


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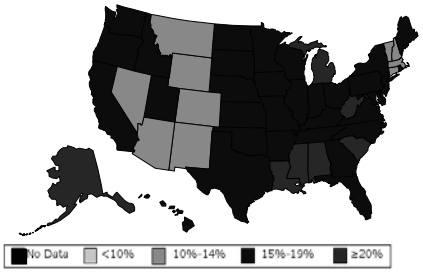


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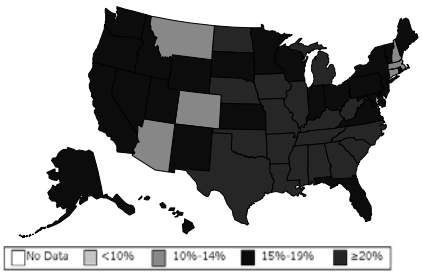


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## Obesity Trends* Among U.S. Adults
## BRFSS, 2000

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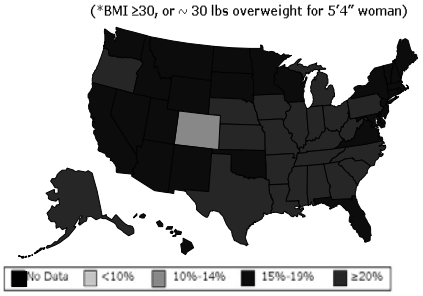


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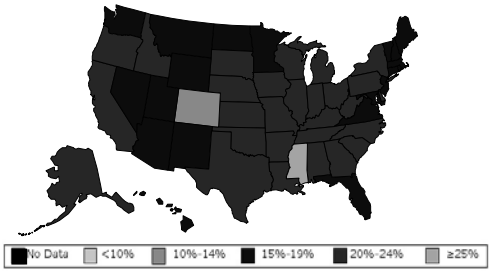
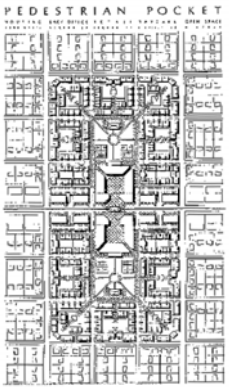
## Obesity Trends* Among U.S. Adults BRFSS, 2001

(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



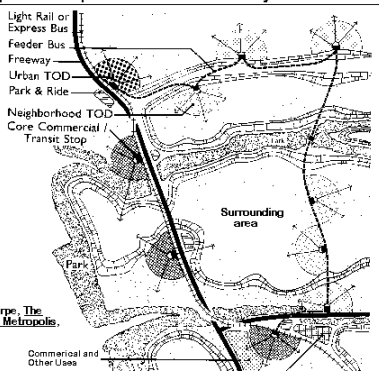




The "pedestrian pocket – a balanced, mixed-use area within a 5 minute walking radius of a transit station.

Functions within this zone include housing, offices, retail, day care, recreation and parks."

These pockets support light rail systems that are pedestrian-friendly.

**Calthorpe's Concept of Ideal TOD/Transit System Relationships**



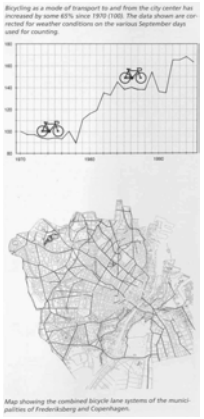

Source: Calthorpe, The Next American Metropolis, p. 67

Copenhagen, 2000

## *Car Free City Center, 1996*


*Plan of Copenhagen city center, showing the network of car-free streets and squares in 1996, after the most recent additions. When the first pedestrian street, Strøget, was inaugurated in 1962, a total of 15,800 m² were set aside for pedestrians. By 1996, Copenhagen had increased the total area of car-free streets and squares to 95,750 m², or six times more space for people activities.*

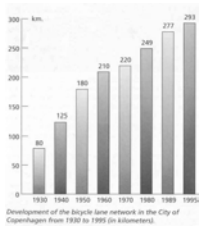
## *Bicycles in Copenhagen*



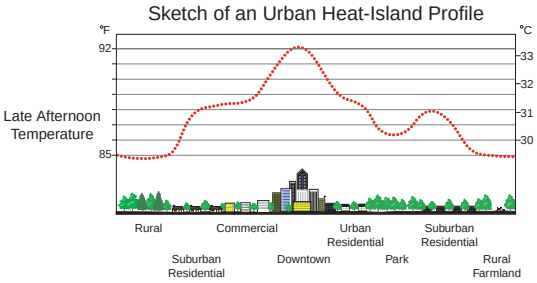
*Bicycling as a mode of transport to and from the city center has increased by some 45% since 1970 (100). The data shown are corrected for weather conditions on the various September days used for counting.*

*Map showing the combined bicycle lane systems of the municipalities of Frederiksberg and Copenhagen.*

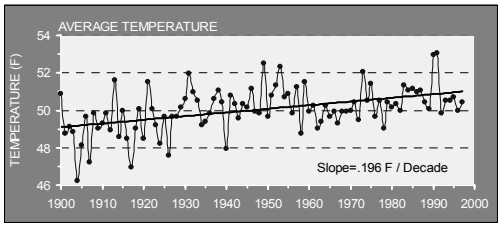
## *Bicycles in Copenhagen*



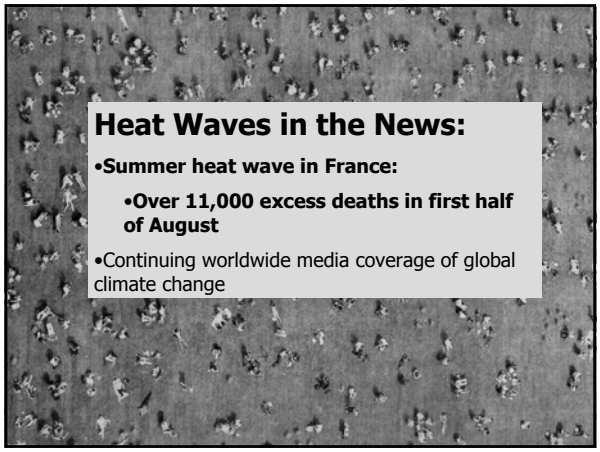

## *What Is an Urban Heat Island?*




## NY Regional Temperature Trends



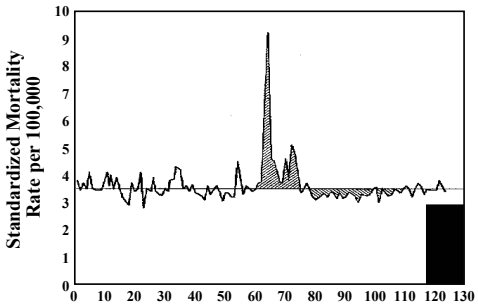

**Note: 23-station average for 31-county region,corrected for urban heat island effect.**
***Graph from NASA-GISS, MEC/NYCHP Team***




## Heat-Related Mortality: as Public Health Issue

* Direct heat casualties (*NOAA)*
  - 1936 1975: 20,000 US deaths
  - #1 US weather killer in 1995, 1998, 1999, 2000
  - current US average ~220/yr
* Heat related casualties *(health researchers)*
  - NYC: 307/aver summer now, 460 1000 by 2050 with climate change
  (Kalkstein & Greene, 1997)

## Deaths Associated with the July 1966 Heat Wave, New York City




Source: WHO, 1996

## Relevant Risk Factors for Heat-Related Mortality

- Elderly most susceptible to heat stress
- Built environment and social factors: A/C access, isolation
- Early season heat waves worst

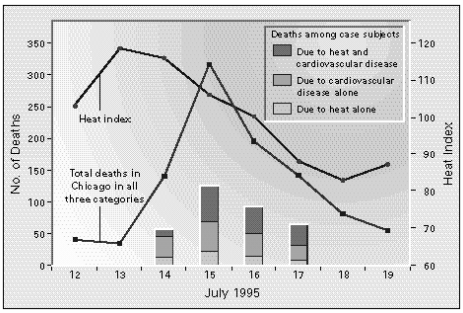



**Figure 1.** *Heat Index, Total Deaths, and Deaths of Case Subjects due to Heat, Cardiovascular Disease, and Heat and Cardiovascular Disease Combined in Chicago, July 12 through July 19, 1995.* Semenza et al., 1996

## *Cool City Project:* NYC Urban Heat Island Mitigation & Research

A Columbia University interdisciplinary initiative:
SPH, GSAPP, CIESIN

## *Mitigation Measures: Light-Colored Surfaces and Trees*

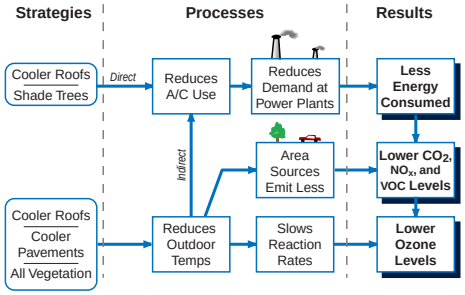
### Direct Effect

- **Light-colored or vegetated roofs** reflect solar radiation, reduce air-conditioning use
- **Trees** that shade buildings reduce air-conditioning use

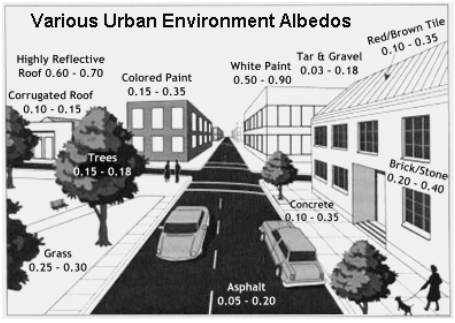
### Indirect Effect

- Light-colored surfaces in a neighborhood alter surface energy balance; result in lower ambient temperature
- Vegetation in a neighborhood reduces ambient temperature by **evapotranspiration**

## *Methodology: Energy and Air-Quality Analysis*




Akbari, LBNL




Albedo measures the fraction of incident solar energy reflected by surfaces. Low albedo means that larger amounts of solar energy are absorbed, and higher surface temperatures result.

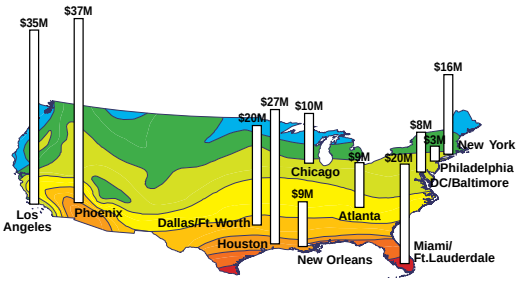

From the Philadelphia Energy Coordinating Agency

## Reflective Pavements are Cooler

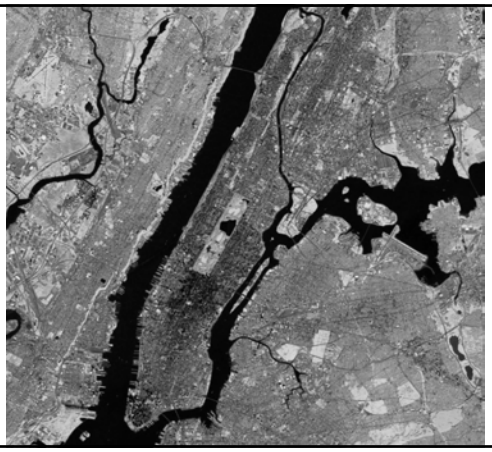
- **Fresh asphalt**
  **Albedo: 0.05**
  **Temperature: 123°F**
- **Aged asphalt**
  **Albedo: 0.15**
  **Temperature: 115°F**
- **Prototype asphalt coating**
  **Albedo: 0.51**
  **Temperature: 88°F**

Akbari, LBNL

## *Potential National Savings from Changing Roof Reflectivity*




Akbari, LBNL



## *Objectives of A Cool City Project*

- *Phase 1: Research on design and feasibility of residential roof-top demonstration projects;* demographic analysis and identification of "hot" neighborhoods through thermal imagery; selection of methods for test projects
- *Phase 2: Implementation and documentation;* measurement of energy consumption in demonstration buildings; preliminary assessment of air quality and public health impacts of UHI mitigation
- *Phase 3: Analysis of results and community outreach:* Including an economic impact assessment of energy savings and benefits of cool roofing techniques, on an individual building and the community scale.


IMG_0056


IMG_0057


IMG_0058


IMG_0059

Urban Green Roofs Projects

***Habitat and Biodiversity Loss: The Sixth Extinction***

As the human population and land development increases, more and more habitats are impacted. Today, we may be losing 30,000 species a year -- a rate much “faster than at any time since the last great extinction 65 million years ago that wiped out most of the dinosaurs. Estimated rate is 1,000 - 10,000 times above normal “background level.”

American Museum of Natural History

***Native New Yorkers: Some endangered local species***

Animals including the otter, mink, wolves, water shrews, bobolinks, meadowlarks, bog turtles, mole salamanders.

Plants including the northern wild Monkshood; Swamp pink; Seabeach Amaranth, Houghton's Goldenrod, eastern Prairie fringed Orchid, American hart's-tongue Fern, etc.

Courtesy Jeffrey Lovich, US Geological Survey

*Public Spaces & Public Life*