Buildings and the Environment:
The Numbers
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Most of us have a general understanding that buildings and the process of development have a pretty big impact on the environment. But what are those impacts and just how significant are they?
For this article, we have attempted to track down a wide range of statistics on the impacts of buildings on the environment. Most of these are fairly sobering—though there are a few bright spots here and there. The hope is that accurate information on the impacts of buildings and development on the environment can be used to help make the case for green building. And by establishing where we are today, we can check on progress (or lack thereof) over time.
Recognizing that there are often very different statistics on a particular issue from different sources, we have sought out the most objective sources. Just as important, we list those sources so that readers can decide how much salt they have to ingest with particular numbers.
The information presented here is organized into the five major environmental impact categories we use in our Bibliography: 1) land-use and communities; 2) site and water; 3) energy; 4) indoor environment; and 5) resources and materials.

1. Land Use and Communities

How much land is there in the U.S. and how is it used?

• Total land area in U.S. (excluding Alaska): 1.94 billion acres
• Breakdown of U.S. land area (1997):
Federal land: 402 million acres (20.7%)
Water areas: 50.0 million acres (2.6%)
Privately owned rural land: 1.39 billion acres (71.6%)
"Developed" land: 98 million acres (5.1%)
(Developed land is defined as "large urban and built-up areas, small built-up areas, and rural transportation land.")
Source: "1997 National Resources Inventory," USDA Natural Resources Conservation Service, 1999, revised December 2000

How much land is protected?

• Federal lands designated as "wilderness": 628 separate land parcels, totaling 105 million acres (between 4.4% and 5.4% of the U.S. land area, depending on exact definition of wilderness)
Source: www.wilderness.net
• Private land protected by The Nature Conservancy:
In the U.S.: 12.1 million acres (an area the size of New Jersey and Delaware together)
Outside the U.S.: 61.8 million acres (slightly larger than Georgia)
Source: TNC Web site, www.nature.org

How rapidly is development occurring?

• Developed land in U.S. (excluding Alaska): 98.2 million acres (1997)
• Increase in developed land area from 1982 to 1997: 34%
• Average annual increase in developed land area: 2.3% (1982–97); 2.6% (1992–97)
Source: "1997 National Resources Inventory," USDA Natural Resources Conservation Service, 1999, revised December 2000
• Increase in urbanized land relative to population growth: 2.65 times the rate of population growth (average in the 34 metropolitan areas with populations of more than one million people from 1950 to 1990)
Source: Our Built and Natural Environments , U.S. EPA, 2000

What is the total paved area in the U.S.?

• Miles of public roadway in the U.S.: 4 million
• Total area of public roadway in the U.S.: 24,500 square miles (more than half the area of Pennsylvania)
Source: "Highway Statistics 1997," Federal Highway Administration, U.S. Department of Transportation (tables HM-53, HM-60) with shoulder-width assumptions as follows: minor arterial and larger highways – 12' per side; urban collector, urban local, and rural major collector highway – 10'; rural major collector – 10'; rural minor collector – 8'; and rural local road – 2'.
• Total area of parking and driveways: 10,900 square miles
Source: EBN Vol. 5, No. 1, page 13, updated with 1999 Census data
• Total pavement surface (including unpaved but highly compressed roadway): 35,400 square miles (about the size of Illinois)
Source: Derived from above

How dependent are we on automobiles?

• Annual average growth in vehicle miles traveled from 1980 to 1996: 3.1% (compared to average population growth of 1%).
Source: U.S. EPA's report citing "Highway Statistics," U.S. DOT FHA
• Average length of work trips: 11.6 miles (1995), a 36% increase since 1980
Source: "Our Nation's Travel: 1995 NPTS Early Results Report," U.S. DOT FHA, 1997
• Mass transit ridership: 9.4 billion mass transit trips
(Mass transit ridership has increased faster than highway use for each of the past three years but is still far below the 1946 peak of 23.4 billion trips.)
Source: The Washington Post , April 27, 2001
• Time an average commuter spends stuck in traffic: 36 hours a year, up from just 11 hours in 1982
• Traffic congestion for 68 cities in 1999: 4.5 billion hours, representing 6.8 billion gallons of wasted fuel and $78 billion in lost productivity
Source: "2001 Urban Mobility Report," Texas Transportation Institute, Texas A&M University, College Station

And What to Do About It . . .

Green development addresses and seeks to mitigate the broad land-use impacts of land development. By clustering buildings, by mixing commercial and residential uses, by focusing development around public transit routes, by providing for bicycle and pedestrian commuting, and by creating cohesive neighborhoods we can reduce many of the negative impacts associated with conventional development. As more examples emerge that demonstrate the benefits of responsible land development, people will become less willing to put up with the sprawl and lost productivity from commuting that are so prevalent in much of the country.

2. Site and Water

How many species are endangered?

• Number of species of plants and animals native to the U.S.: 20,500
• U.S. plants and animals threatened with extinction: 32% (1% presumed extinct, 7% critically imperiled, 9% imperiled, 15% vulnerable)
• Percentage of freshwater mussels species threatened in U.S.: 67.9%
Source: "1997 Species Report Card: The Status of U.S. Plants and Animals," The Nature Conservancy

How many brownfields are there in the U.S?

• Estimated total number of brownfield sites in the U.S.: 425,000
Source: U.S. Government Accounting Office, see U.S. Department of Housing and Urban Development: www.hud.gov/bfields
• Urban land area in brownfields (for 16,500 sites in 126 of our largest cities): Over 47,000 acres
Source: "Recycling America's Land, A National Report on Brownfields Redevelopment," U.S. Conference of Mayors, 1998

How are our wetlands doing?

• Wetlands lost in the lower 48 states between the late 1700s and the mid-1980s: More than half (53%)
Source: "Our Built and Natural Environments—Status and Trends of Wetlands in the Coterminous United States," U.S. EPA, 1991

How much water do we use?

• Total water use in the U.S.: 124 trillion (124 x 10^{12}) gallons per year
Breakdown of total U.S. water use: 12.2% domestic and commercial (15 trillion gallons per year); 8.2% industrial; 38.7% electricity generation; 40.9% irrigation and livestock

Source: U.S. Geological Service, 1995 data
• Average U.S. household use: 146,000 gallons per year (42% indoors, 58% outdoors)
Source: "Residential End Uses of Water Study," American Water Works Association Research Foundation, 1999

What are the impacts of combined sewage overflows*?

• U.S. communities with combined sewer systems: 950 (ranging from large cities like New York and Philadelphia to small communities of several thousand people)
• People in the U.S. living in communities with combined sewer systems: 42 million
• Average number of combined sewer overflow events per year in the U.S.: 40,000
• Discharges containing raw sewage in the U.S. each year through CSO systems: 1.2 trillion gallons (18 days' worth of Niagara Falls flow volume!)
*Combined sewage overflows (CSOs) occur when sewers designed to carry both sewage and stormwater to sewage treatment plants are overloaded due to storm events and the combined wastes flow directly into surface waters.
Sources: U.S. News & World Report , June 12, 2000, and U.S. EPA Office of Wastewater Management (www.epa.gov/owm/cso.htm)

And What to Do About It . . .

Green development and building can be carried out in a manner that concentrates impacts on land that has already been degraded, while preserving open space and wildlife habitat. Ecologically degraded land can be restored as part of the development process to support native ecosystems. Green buildings should use water resources efficiently—indoors and out—and maximize infiltration of stormwater on-site.

3. Energy

How much energy do we consume in the United States?

• Energy consumption in the U.S. for the year 2000: 98.8 quads
(1 quad = 10^{15} Btu), a 1.7% increase over 1999 and an all-time record (10th year in a row in which energy consumption increased)

How much energy do we import?

• Total energy imports in 2000: 28.5 quads, another record
• Total petroleum imports: 57.0% of petroleum products supplied
(net imports, 51.6%, were somewhat lower due to limited exports of domestic petroleum).

How energy-efficient is the U.S. economy?

• Energy consumption per dollar of gross domestic product in 2000 (1996 dollars): 10,600 Btus, down from 18,380 Btus in 1973 (the energy intensity of our economy has declined by 42% since 1973)
• Estimated total annual energy use reduction from 42% intensity decline: 72 quads
• Portion of energy intensity decline that can be attributed to real energy efficiency improvements: 54 quads (This estimate is based on the fact that about three-quarters of the 72 quads cited above is attributable to real energy efficiency improvements, and about one-quarter is due to structural changes and fuel switching.)
• Representative building-related energy efficiency gains:
Average electricity use of new refrigerators (1999): 685 kWh/yr, down from 1725 kWh/yr in 1972, a near tripling of efficiency
Average efficiency rating (SEER) of new central air conditioners (1998): 10.9, up from 7.0 in 1976, a 56% increase in efficiency
Sale of compact fluorescent lamps (CFLs) in North America: 82 million, nearly a fivefold increase since 1990
Source (last 5 statistics): "Energy Efficiency Progress and Potential" fact sheet, American Council for Energy Efficient Economy, www.aceee.org
How much energy do buildings in the U.S. consume?
• Residential and commercial buildings for the year 2000: 36.4% of total U.S. primary energy consumption
(The rest is used by industry, 36.5%, and transportation, 27.0%—total building energy consumption is actually higher than 36.4%, as some of the industrial energy use is for cooling, heating, or illuminating industrial buildings.)

How much U.S. electrical consumption is for buildings?

• Residential and commercial buildings accounted for 65.2% of total U.S. electricity consumption in 2000 (most of the rest is for industry—some building-related).
Source: All energy data above, except where noted, from Monthly Energy Review , March 2001, Energy Information Administration, U.S. Department of Energy

To what degree do buildings contribute to global warming?

• Percentage of U.S. CO_2 emissions associated with residential- and commercial-sector energy consumption, 1999: 36% (including CO_2 emissions from cement production)
• Percentage of total U.S. greenhouse gas emissions associated with residential- and commercial-sector energy consumption, 1999: 30% (including building-related share of methane emissions)
Source: "Emissions of Greenhouse Gases in the United States 1999," Energy Information Administration, U.S. Department of Energy, October 2000
How much energy comes from renewable sources?

• Non-hydro renewable power production capacity (1998): 15,250 MW, the approximate output of 15 large power plants (not including distributed electricity production, which cannot easily be tracked and generally appears as energy conservation)
• Total annual U.S. PV module shipments (1998): 50.6 MW (peak)
• Increase in annual U.S. PV module shipments, 1987-98: 640%
• Average annual increase in PV module shipments, 1987-98: 20.5%
Source: Renewable Energy Annual 1999 , Energy Information Administration, U.S. Department of Energy, March 2000

And What to Do About It . . .

Buildings dominate energy consumption in the United States, either directly by way of a structure's operation or indirectly by way of the building's impact on patterns of land development and transportation. Of all the aspects of green building and development, energy is the one for which we have the greatest understanding and can most easily achieve measurable improvement. Note that it is really the impacts of energy use that we are trying to avoid, not the energy itself. Thus, reducing certain energy uses—say, from coal or oil—might be a higher priority than reducing some others, such as solar-generated electricity.

4. Indoor Environment

How much time do Americans spend indoors?

• Average time Americans spend indoors: Greater than 90%
Source: November 2, 2000 press release, American College of Allergy, Asthma & Immunology

How big a problem is asthma?

• Number of asthma sufferers in the U.S.: More than 17 million
Source: U.S. Centers for Disease Control, December 1998
• Increase in the prevalence of asthma from 1980 to 1994: 75%
Source: American Journal of Respiratory and Critical Care Medicine , 1998, 158:320-334
• Increase in the prevalence of asthma between 1982 and 1994: 42% for males; 81% for females
Source: "Trends in Asthma Morbidity and Mortality," American Lung Association, Epidemiology and Statistics Unit, November 1998
• Annual deaths from asthma in the U.S. (1997): 5,300
Source: National Vital Statistics Report (1997), Vol. 47, No. 4, U.S. Centers for Disease Control
• Annual U.S. direct health care costs for asthma: More than $9.8 billion (plus indirect costs from lost productivity of $2.8 billion)
Source: Trends in Asthma Morbidity and Mortality," American Lung Association, Epidemiology and Statistics Unit, November 1998

• Number of school days missed annually in the U.S. from asthma: 10 million
Source: "Asthma: A Concern for Minority Populations," National Institute of Allergy and Infections Disease, January 1997

How big a problem are allergies in the U.S.?

• Number of people in the U.S. affected by allergies: 38%
Source: July 1999 report, American College of Allergy, Asthma and Immunology
• U.S. health care costs attributed to sinusitis in 1996: $5.8 billion
Source: Journal of Allergy and Clinical Immunology , 1999, 103:408-14

And What to Do About It . . .

Our health and well-being are inextricably linked to the buildings in which we spend the vast majority of our time. The resources expended and productivity lost due to indoor environmental quality problems have a huge impact on our economy and the well-being of millions of people. A systems approach to solving these problems is needed, in which architects, builders, building managers, building scientists, and medical professionals work closely together. We need to begin using the best current practices for ensuring good indoor environmental quality, and we need to develop a comprehensive research agenda so that we can gain a better understanding of how buildings influence occupant health—and what to do about it.

5. Resources and Materials

How many buildings are there in the U.S.?

• Number of commercial buildings: 4.6 million
Median building age: 30.5 years
Average square footage: 12,800 ft^2
Portion of commercial floor space for office and retail and service buildings: 39%
"Youngest" buildings: Warehouses and enclosed malls
"Oldest" buildings: Retail space
Source: "1995 Commercial Buildings Energy Consumption Survey," Energy Information Administration, U.S. Department of Energy
• Number of U.S. commercial buildings constructed annually: 170,000
• Number of U.S. commercial buildings demolished annually: 44,000
Source: "A Characterization of Building-Related Construction and Demolition Debris in the United States," U.S. EPA, 1998
• Number of homes in U.S.: 101.5 million housing units, 63.8 million of which are single-family detached
Housing units built prior to 1970: 54.8 million
Units located in suburbs or rural areas: 64 million
Source: "1997 Residential Energy Consumption Survey," Energy Information Administration, U.S. Department of Energy, November 1999

• Number of new homes built annually (1999): 1.6 million (1.3 million of which were single-family detached)
Source: National Association of Home Builders
• Number of housing units demolished annually: 245,000
Source: "A Characterization of Building-Related Construction and Demolition Debris in the United States," U.S. EPA, 1998

Are we becoming more or less efficient in use of building materials?

• Average house size (1999): 2,250 ft ^{2}, up from 1,100 ft ^{2} in the 1940s and 1950s
Increase in average house size, 1950 to 1999: 105%
Square area of living space per occupant (1997): 800 ft ^{2}, up from 290 ft ^{2} in 1950
Source: U.S. Bureau of the Census
• Area of forest required to provide for each U.S. citizen's annual wood needs: 1.7 acres, compared to global average of 0.7 acres
• Total annual wood fiber use in North America for OSB, MDF and particleboard (1998): 29 million tons
• Estimated total annual surplus straw in North America: 19.5 million tons
Source: Forest Products Journal , January 2001, pp. 10-21

How much land is certified based on Forest Stewardship Council standards?

• Certified area in the U.S. (June 2000): 8.2 million acres, up from 1.6 million acres in 1997
• Certified area worldwide (2000): 47.2 million acres, up from 1.8 million acres in 1994
Source: U.S. Forest Stewardship Council, www.fscus.org

How much waste is generated by construction and demolition?

• Total annual U.S. C&D waste generation: 136 million tons
(not including any waste associated with infrastructure, such as roads, bridges, etc.)
Portion from demolition and renovation: 92%
Portion recovered (recycled or reused): 20 to 30%, mostly concrete, asphalt, metals, and some wood
Source: "A Characterization of Building-Related Construction and Demolition Debris in the United States," U.S. EPA, 1998

What types of materials are we using to construct buildings (homes)?

• Type of envelope: Wood light-frame: 88%; masonry block: 10%; Post-and-beam, log, SIPs, ICF, and cold-formed steel: less than 1% each
• Type of siding:
Wood and stucco (from 1995 to 1999): Down from 41% to 30%
Vinyl (from 1995 to 1999): Up from 30% to 39%
Source: NAHB Research Center's Annual Builder Survey results
• CCA-treated lumber, timber and other products: (1996): 5.6 billion board feet
Source: American Wood Preservers Institute
• Portion of U.S. outdoor residential decking and railing market for woodfiber-plastic composite (2000): 8%, up from 2% in 1997
Source: Smith, P. M. "The U.S. Woodfiber-Plastic Decking Market," Proceedings of the 6th International Conference on Woodfiber-Plastic Composites, 2001

How prevalent are natural building systems (adobe, straw bale, rammed earth, etc.)?

• Rough estimate for current number of projects per year: 5,000
Source: David Eisenberg, Development Center for Appropriate Technology

How much PVC (vinyl) is used in construction?

• Total annual U.S. PVC use (1998): 14.7 billion pounds
• Vinyl used in construction annually: More than 7 billion pounds
Source: The Vinyl Institute

How many tons of ozone-depleting compounds are used in U.S. buildings?

• Percentage of ozone-depleting substances used annually in the U.S. that are used for building construction and systems: 60%
• CFCs used to replace leaking or otherwise emitted refrigerants from older equipment in buildings: 7,000 tons annually
• HCFCs used for new and existing equipment in buildings: 120,000 tons annually (90% of this is HCFC-22 or R-22, which has an ozone depletion potential of 0.055 relative to CFC-11.)
• HCFCs used for foam building insulation: 75,000 tons annually
(75% of this is HCFC-141b, which has an ODP of 0.11 and is scheduled for production phase-out in 2003. EPA assumes that 90% of these blowing agents will be emitted over the life of the foam.)
Source: Estimates for 2000 from a computer model maintained by the U.S. EPA's Alternative Emissions and Reductions Branch, Global Programs Division

And What to Do About It . . .

Through careful design and material selection, the impacts that buildings have on the environment can be significantly reduced. Among our most important actions should

be full utilization of existing buildings (including a focus on their operational efficiency); design of smaller, more space-efficient houses; design of more flexible/adaptable new buildings; and increased use of less resource- intensive building materials and systems. Beyond size and material efficiency, we should specify products that carry minimum environmental burdens, including FSC-certified wood products, recycled-content products, and low-embodied-energy, minimally processed materials. We should also try to minimize use of high-environmental-impact materials, such as PVC, CCA-treated wood, and products made with ozone-depleting substances.

Summing Up

Statistics on the impact of buildings on the environment are sobering. There's no getting around it. While the numbers presented here could discourage some (the problems are just too mammoth to do anything about), they could be seen to others as representing tremendous opportunity. After all, the worse our starting point, the greater the potential for improvement. It is in that spirit that we have assembled this collection of numbers and statistics—not to discourage, but to inspire.
We have a long way to go in lessening the impact of buildings on the environment. But for many in the mainstream building industry, recognizing just how significant these impacts are is a necessary starting point in the journey toward improvement. Pass these numbers along, let us know of other statistics that will further help to inform our industry. And keep up your good work in turning some of the negative trends around.

– Alex Wilson and Peter Yost

Table of Metric Conversions:

1 acre = 0.40 hectares
1 square foot = 0.093 square meters
1 square mile = 2.59 square kilometers
1 mile = 1.61 kilometers
1 gallon = 3.79 liters -or- 0.0038 cubic meters
1 pound = 0.45 kilograms
1 ton = 0.91 tonnes
1 Btu = 1,055 joules