U.S. POPULATION, ENERGY & CLIMATE CHANGE

Center for Environment & Population

U.S. Population, Energy & Climate Change

By Victoria D. Markham

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Acknowledgements

Special thanks to Kara DiFrancesco and Mercedes Bravo who contributed to the research and writing of this report, and to Martha Farnsworth Riche, Brian O'Neill and Nadia Steinzor for their expertise and insights. The Center for Environment and Population (CEP) is grateful to the Compton Foundation, Richard and Rhoda Goldman Fund, New-Land Foundation, Wallace Global Fund, Winslow Foundation, and an anonymous donor for their invaluable support of this project.

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About This Report

This report is the first in a series of publications on *U.S. Population, Energy and Climate Change* by the Center for Environment and Population (CEP). The series contains brief, easy-to-read reports, fact sheets, and briefing materials on population and climate change trends in the U.S. and globally. Activities are also being conducted to integrate the information into U.S. policy and public action at the local, national and international levels.

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U.S. Population, Energy & Climate Change

Introduction

There is growing evidence that population, linked to energy use and greenhouse gas emissions, is a key factor in global climatic change.[1] In the climate change equation, population is the "big multiplier" – particularly when linked with resource consumption – because it intensifies the rate, scale, and scope of both the root causes and effects of climate change in the United States (U.S.), and worldwide.

Within the global context, the U.S. stands out for two reasons: it has by far the *largest population* amongst other industrialized nations, the *only* sizable one with *significant population growth*, and; it uses *more energy* than any other country and is the largest *carbon dioxide* (CO_2) *greenhouse gas emitter* amongst industrialized nations worldwide.[2]

This unique combination – America's high population numbers and growth, together with its high rates of per capita energy consumption and pollution – makes the U.S. pivotal in the national and global population-climate change debate.

In simple terms, the U.S. is the world's largest developed nation, consumes energy and resources at very high rates, and is growing rapidly. This has major implications for global climate change because the American population's energy consuming habits are so disproportionate to that of other nations'. *While the U.S. represents about 5% of the global population, it consumes about 25% of the world's energy, and generates 5 times the world average of CO_2 emissions.* **Because Americans are high resource consumers in a country with a large, rapidly growing population base, *the U.S. has a much bigger "per-person" impact on global climate change than any other nation*.** With about 8,000 people added daily in the U.S., and 3 million people added each year, there's real potential to reach 1 billion high-energy-consuming Americans by 2100. Meeting the energy demands of this large and rapidly growing population that consumes elevated levels of resources and energy – while at the same time reducing the greenhouse gas emissions contributing to climate change – will prove daunting in the coming decades. Even now we are seeing its effects.

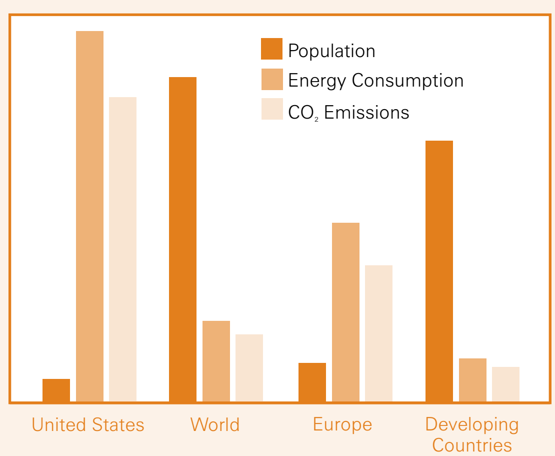
The relationship between U.S. population trends and global climate change is characterized by several key elements. These include U.S. demographic factors – relatively high population numbers and rapid growth; high and increasing density in coastal and metropolitan areas; an increase in energy-consuming households, and; a large "Baby Boomer" population – coupled with high per-capita energy use, fossil fuel burning, land and vehicle use. *These are all linked, and their unique combination makes the U.S. one of the world's most important players in population and climate change.*

While the U.S. "population and climate change" connection is complex, it manifests itself in two primary ways:

- first, **population is related to the <u>causes</u> of climate change**, mainly through high per capita energy use and greenhouse gas emissions (the "carbon footprint") and;
- second, **population factors can exacerbate climate change's <u>effects</u>** by placing more pressures on the natural resource base at specific sites, for example, when there is high population density and continued rapid growth in coastal, urban, suburban, or ecologically vulnerable areas of the U.S.

In addition, gains made in addressing climate change can be made much more difficult – in some cases even offset altogether – by these population factors, when combined with high per capita natural resource consumption.

U.S.-World Population & Climate Change



Energy consumption in total kilograms of oil equivalent (Kgoe), and CO_2 emissions in metric tons, per person.

Source: US Census Bureau, US Energy Information Administration, World Resources Institute, 2008

Introduction

We often see "population growth" and "climate change" as being separate, rather than making the connection between the two – and this is particularly true in the U.S. The issues are, however, inextricably linked and must be understood and addressed at the same time, as they relate to one another, as two sides of the same coin. This science-based report helps to make that connection, providing the basic information needed to better understand these issues, and to take first steps to effectively address them, as they are associated. It can be used as a tool to demonstrate how U.S. population and resource consumption trends are linked to climatic change, in the U.S. and globally.

America's Role in Global Climate Change

The world's leading scientists agree that unprecedented changes to the climate of the U.S. and the planet are underway, due in large part to human-induced factors.[3] Over the past five decades humans have played *the* dominant role in the world's changing climate, mainly through the generation of "greenhouse gases" like carbon dioxide (CO_2), with "metropolitanization" (metro area and suburban growth) and land use changes also playing an important part.[4]

The *effects* of climate change are felt both worldwide and here in the nation. Globally, the 11 warmest years on record have all occurred in the past 13 years,[5] and 2006 was the U.S.' warmest year on record.[6] Average annual U.S. temperatures are over two degrees Fahrenheit higher than a century ago.[7] There is increased frequency of severe weather events (such as rainstorms, heat waves and hurricanes), and major shifts in U.S. growing seasons and in the ranges of plant and animal species. Climatic change is causing the spread of vector-borne diseases rarely seen in the U.S., such as malaria and dengue fever.[8] The nation's freshwater resources are more prone to drought and the consequences of less mountain snow pack. Glaciers are retreating, sea ice is melting, and sea level is rising.[9]

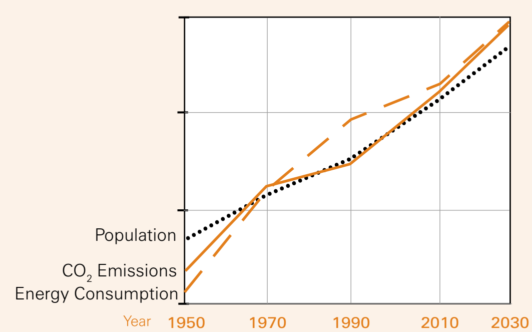
Yet, how is the "U.S. population" – its growth, density, movement, composition and per-person natural resource consumption – connected to climate change in the country, and globally? Today 98% of the world's population growth is in developing countries, a growth trend that is expected to continue well into this century.[10] With most population growth occurring in other parts of the world, why focus on the U.S.? *And why is America in the hot seat of "population-climate change" impacts worldwide?*

The most recent scientific data reveals the answer, showing that *the links between population and climate change are particularly acute when you look at the U.S. case within the global arena. In short, while America has about 1/20th of the world's population, it consumes about 1/4th of the world's energy.*[11] And, Americans produce almost 20 tons of CO_2 per person per year – about *five times the world average* – of 4 tons of CO_2 per person a year, and also substantially larger than 8 tons of CO_2 per person per year for Europeans, and 2 tons for developing countries.[12]

These trends in U.S. population, energy consumption, and CO_2 emissions are expected to continue, and even rise, in the foreseeable future. The U.S. population is expected to double in one generation, by 2076, and even reach 1 billion in some of our lifetimes.[13] On the energy side, while U.S. greenhouse gas emissions rose about 15% from 1990 to 2006,[14] by 2020 they are predicted to increase by nearly 30% under a "business as usual" scenario.[15]

Taking into account how climate change works – as a "global commons", where the planet's air and emissions over a specific location, like the U.S., typically move halfway around the world a week later – America's unique "population and energy" profile place it front and center in relation to the world's climatic changes.[16]

U.S. Population, CO_2 Emissions, & Energy Consumption Per Capita



Projections based on mid-range data estimates. CO_2 emissions in metric tons, and energy consumption in Btus, per person.

Source: US Census Bureau, US EIA, WRI, 2008

Summary

U.S. contributions to climate change are associated with human population through a combination of factors, including: the number of people and rate of population growth; where and how they live and consume natural resources, and; energy consumption patterns and type of energy used to meet the demand.

These factors when taken individually may have small impacts, however, *when combined as they are in the U.S., contribute significantly to the world's climate change causes and effects.* To understand how population affects climate change, it is critical to grasp ***which*** key U.S. population and energy/resource-use factors are involved:

U.S. Population Factors Linked to Climate Change

The four population factors in the U.S. most closely associated with climate change include:

- **Population *size and growth rate***
- **Population density: *where the U.S. population lives* (Metropolitan areas, Coast, South and West regions)**
- **Per capita resource use: *how the U.S. population lives* (Land use, Vehicles, Households)**
- **Population *composition* (Age, Baby Boomers, Income)**

Population size and growth rate: the U.S. has by far the *largest population* amongst industrialized nations in the world[17] – it is the third most populous country in the world after China (1.3 billion) and India (1.1 billion) – and is the *only large developed nation experiencing significant population growth*.[18] The U.S. population has more than doubled since 1950, and will double again in 70 years.[19] Today the U.S. is home to over 304 million people; this number is expected to reach 400 million by 2043, with potential to reach the billion mark this century.[20] This is important because it shows the U.S. has a relatively high number of people, with rapid growth that is expected to continue throughout this century, and high levels of per capita energy, land and forest consumption – all of which are closely linked to climate change.

Population density *(where the population is distributed and growing)* **and per capita resource use** *(how the U.S. population lives)* on a day-to-day basis are linked to climate change because, these factors: a) intensify land use changes that directly affect climate change; b) increase per-capita energy use (i.e. households and transportation) or each person's "carbon footprint"; c) transform carbon "sinks" into carbon sources, and; d) create "heat islands". Key issues include:

- **"Metropolitanization"**, or, the *growth in cities and surrounding suburban areas*, characterizes the nation's population growth trends consistently over the past century. By 2000, *half of all Americans lived in suburban areas, and 4 out of 5 lived in broader metropolitan areas*.[21] Most important with regard to the population and climate change link is that growth outside cities in the suburban and surrounding "exurban" areas far outpaces growth within cities. As a result of this trend, land in the U.S. is converted for development at about twice the rate of population growth[22], and each American effectively occupies 20% more developed land (for housing, schools, shopping, roads, and other uses) than he/she did 20 years ago.[23] This is important in this context because the *way* land is most often developed today in the U.S. to accommodate much of the growth is through **"sprawl development"**. This is characterized by spread-out rather than clustered residential and commercial land development, and is the nation's *most predominant form of land use change today.* It results in a marked *increase in vehicle use and road systems*, and in a *rise in the number and energy-consumption level of households – all associated with high levels of energy use and fossil fuel burning.* It also leads to rapid loss of forest and agricultural land which would otherwise act as "carbon sinks" (see page 9).

- **"Households"** *(and what is used within them) is a key demographic factor in the rise of U.S. per capita energy use and climate change.* In recent decades there has been a major increase in: the *number of households* (with fewer people per house and the number of second homes on the rise); *house size* (square footage), and; *amount of land* around each. Each of these factors translate into more energy use and CO_2 emissions per person. Also, *where* the households are placed (in sprawling rather than clustered communities) and *amount of energy used in each residence* are key.[24] **The U.S. residential sector is the largest such energy use sector worldwide,** and **household appliances** (refrigerators, microwaves, dishwashers, air conditioning and heating units) **are the fastest growing energy consumers nationwide, after cars**.[25]

Summary

In developed nations like the U.S., home appliances now consume 30% of all electricity used, emitting 12% of global greenhouse gases.[26] By 2015 household energy use is expected to rise by 15%.[27]

- **Densely populated U.S. coasts** is a key factor in relation to climatic change because more people are susceptible to the *effects* of climate change there. *Over half (53%) of all U.S. residents now live within 50 miles of the coast* – on just 17% of the nation's total land area – *where they are most vulnerable to sea level rise and the severe weather events (such as hurricanes and flooding) associated with climate change.*[28] Population density on U.S. coasts is five times that of other parts of the country.[29] An additional 27 million people, accounting for about half of the projected overall U.S. population increase, are expected to move to the coastal areas in the next 15 years alone.[30] And, over 80 million people annually visit the coast for recreation, temporarily yet significantly swelling coastal populations and pressures on the area's natural resources.[31]

- The **South and West** are the nation's *most heavily populated and fastest growing regions* – they now contain over half (59%) of the entire U.S. population – and these trends are expected to continue in coming decades. *The South and West are among the nation's "population-climate change hotspots"* because of their combination of population numbers and growth, *and* ecological vulnerabilities (as associated with the coastal areas of the South and freshwater resources in the West). For example, of the nation's top ten fastest growing states, half are in the *coastal South*, and four are in the *arid West* – both areas of exceptional ecological sensitivity to climate change impacts of sea level rise and altered temperatures that affect freshwater sources.[32] (See "In Your Region", pages 19-20).

Population composition: The "make-up" of a population (i.e., its "age" or "income") often determines where and how people live, move, vacation and consume resources and energy – and these are all linked to climate change. For example:

- The nation's **"Baby Boomers"**, the largest ever of this particular U.S. demographic (26% of the total U.S. population) are wealthier, spend more money, drive more vehicles and miles, have more homes per-capita including second homes, and *use more energy per capita than any generation before them.*[33]

America's Growing Carbon Footprint

A "carbon footprint" is a measure of the impact that human activities have on the environment in terms of greenhouse gases produced, measured in units of carbon dioxide (CO_2). It is used to conceptualize impact in contributing to climate change. Experts say America's carbon footprint is expanding, and that with a growing population and expanding economy, America's "settlement area" is widening. As it does, Americans are driving more, building more, consuming more energy, and emitting more carbon.

Sources: Weidmann & Minx, 2008; Brookings Institution, 2008.

- The **"youth"** of America's population is critical because they represent a large demographic whom – in a departure from generations before them – are making key personal "choices" regarding resource and energy consumption *and* family size, taking into consideration climate change impacts and overall "environmental sustainability".

- **Income** is closely associated with energy consumption and pollution in the U.S. Statistics show that generally the more affluent a person is, the more resource and energy consumption and pollution they are responsible for. For example, in America, rising income generally results in a greater number of larger houses, more vehicle use and aviation travel, and, the associated increase in fossil fuel burning and CO_2 emissions. U.S. per capita income is nearly $40,000 in contrast to $26,000 for other developed nations, and $4,000 for less developed nations. On the flip side, affluence can facilitate positive trends in that it makes the typically more expensive energy-efficient technologies (i.e. hybrid vehicles and appliances) more accessible, but only to those who can afford them.

For more details on this Summary, see page 9.

Summary

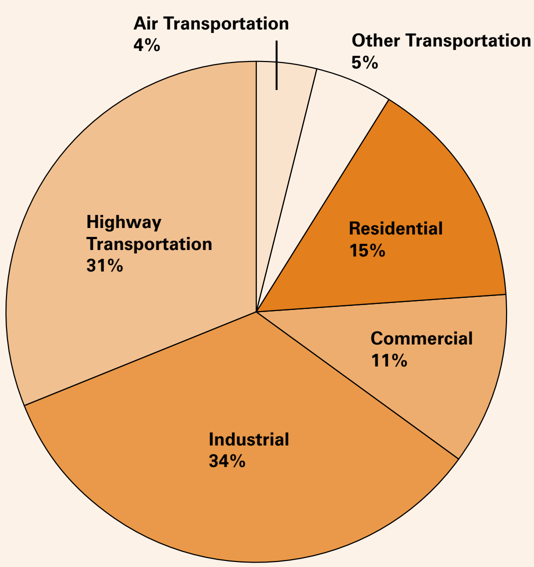
U.S. Energy Use, Population, and Climate Change

There are two main factors that link U.S. energy issues to population and climate change:

- **The nation's energy use, relative to it's population size**
- **The greenhouse gas carbon dioxide (CO_2) emissions, per capita**

These energy issues are important in this context because the U.S. is the **single largest carbon dioxide (CO_2) emitter of the industrialized nations in the world**, accounting for nearly a quarter of all global emissions.[34] These are predicted to increase by 30% by 2020.[35] With about **5% of the global population, the U.S. consumes approximately 25% of the world's energy.**[36] The nation has the **highest oil consumption worldwide**, and is projected to use 43% more oil than current levels by 2025. **The U.S. residential sector is the largest single consumer of that particular type of energy use worldwide,** with American homes generating 25% of global home-related greenhouse gas emissions.[37] The **commercial and transportation sectors are projected to be the fastest growing U.S. energy use sectors** from 2005 to 2030, with 1.4% and 0.7% annual growth, respectively.[38] This has major implications for future increases in fossil fuel burning and CO_2 emissions.

U.S. Energy Use by Sector, 2006



Source: US EIA, 2008.

The Effects: Climate Change and Population

An important link between population and climate change is from climate change's "*effects,*" i.e., through increased severity and frequency of major storms, sea level rise, or increased droughts which are *all occurring in some of the most heavily populated and fastest growing areas in the U.S.* (such as the coasts, and the South and West regions). The main effects include:

- **altered weather and seasonal patterns**
- **rising sea levels**
- **less available freshwater**
- **habitat and biodiversity loss**
- **human health threats**

These are all occurring at present to varying degrees, and are predicted to continue for the foreseeable future under a "business as usual" scenario. For example, the average **temperature increase in the U.S.** over the next 100 years is predicted to be 5-9ºF.[39] Temperature increases by 2100 are predicted to vary by region and season, with a 4-5ºF average increase across the Northeast and Midwest, a slightly lower 3-4ºF average increase in much of the South and West, and the greatest warming, 10ºF in winter, predicted for Alaska.[40] **Sea level rise and more severe weather events** that will impact the heavily populated coastal areas are predicted, particularly in the U.S. Mid-Atlantic and Gulf Coasts. **Freshwater resources** in the U.S., especially throughout the West, are being severely affected by climate change-driven drought and reduction of mountain ice pack. **Ecological and biodiversity** changes triggered by climate change could render 15-37% of all sampled plant and animal species extinct by 2050, both worldwide and in the U.S.[41]

For more details on this Summary, see page 14.

In More Detail

In this section, the main U.S. population, energy use and climate change factors are described in more detail.

Population and Energy-Use Factors Linked to Climate Change

Metropolitanization and Land Use

America's current population growth, movement and distribution, *and* the manner in which people consume land, have created fundamental changes in how land has been used in the nation today. This is particularly true in recent decades, and as such has contributed to climate change uniquely occurring in our lifetimes. The type of **"land use change"** that is central here is directly linked to **growth trends in the nation's metropolitan areas** (a result of the nation's century-long movement from being primarily rural to urban and suburban), and, the subsequent "development" that has taken place for residential, commercial, and related infrastructure. *This **"metropolitanization"** of the nation is characterized by the expansion of cities and suburbs outwards, and the subsequent loss of farmland, forests, prairies, wetlands, natural coastal areas, and the remaining open spaces.*[42]

America's land-use changes from population growth and associated development result in three main trends that have significant consequences, *all of which are closely associated with climate change:*

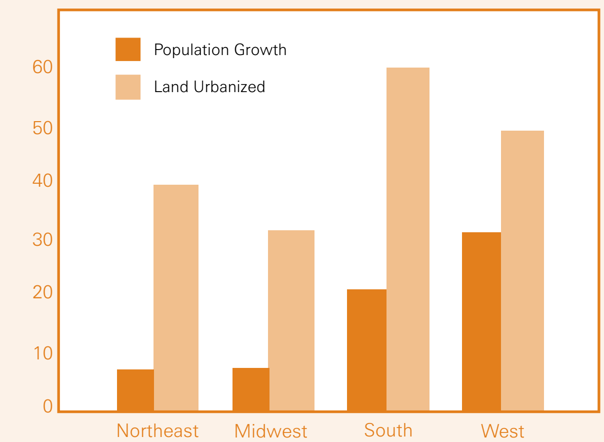
- **Sprawl development**
- **Increase in vehicle use and road systems**
- **Increase in number and energy consumption of households**

Sprawl Development

Much of the nation's land conversion for development in the past few decades (for residential and related services) has triggered an entire set of unique land use patterns, called "sprawl". This expansive development generally occurs around city and town centers, and into surrounding neighborhoods and rural areas. The amount of land utilized for these sprawling metropolitan areas has increased faster than their populations are growing. Nationwide, during the 1980's and 1990's population grew by 17%, yet the amount of developed land grew 47%.[43] By 2030, half of the buildings in which we live, work, and shop will have been built after 2000.[44]

Sprawl is characterized by high amounts of land development per unit of human activity. It is reflected in low-density residential subdivisions, commercial strips,

U.S. Population & Urbanization



Source: Fulton, W., et al, ***Who Sprawls Most? How Growth Patterns Differ Across the US, 1982-97***. Brookings Institution, 2001

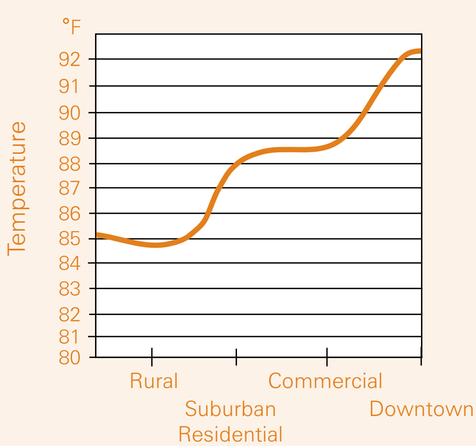
large retail complexes surrounded by acres of parking, office parks far from homes and shops, and a growing network of roads linking them together. This type of development often spurs everyday activities that are linked to global warming, including:

- increases in per capita vehicle use and miles traveled, because of the large area that sprawling communities cover
- relatively high energy use and fossil fuel burning from increased use of vehicles and from more, larger, homes to maintain, heat and cool
- open land/space development for residential and other infrastructure
- high levels of traffic congestion[45]

Sprawl development involves the conversion of all types of land, including terrestrial and aquatic ecosystems (such as forests and wetlands), and farmland. Many of these land "uses" prior to the development are considered **"carbon sinks"** because they naturally soak up more carbon than they emit. Such carbon sinks help regulate CO_2, the main greenhouse gas contributing to climate change. However, when these lands are developed, not only are the areas that formerly ***stored* carbon** (such as the forests) eliminated, but they also tend to be replaced with land uses (such as roads, parking lots, suburban residential areas) that contribute to or become **"carbon sources"**, or net ***emitters*** of greenhouse gases into the atmosphere. This is a good example of how the "U.S. population's demand for land to support growth" scenario plays out across the nation, and is a key part of the climate change equation.

Another key factor is how densely populated and fast growing U.S. metropolitan areas contribute to climate change by increasing their **"heat island effect"** – where temperatures in urban and suburban areas are 2 to 10ºF hotter than nearby rural areas.[46] The heat island effect results from several factors, including: displacing trees and vegetation whose shade and evaporation rates have natural cooling abilities; the trapping of heat between tall buildings and narrow streets that reduce air flow, and; the addition of waste heat from vehicles, factories and air conditioners into the surrounding air. The elevated temperatures often increase peak energy demand for air conditioning, which in turn causes more burning of fossil fuels that contribute to climate change, and exacerbates heat-related illnesses and mortality.[47]

URBAN HEAT ISLAND EFFECT



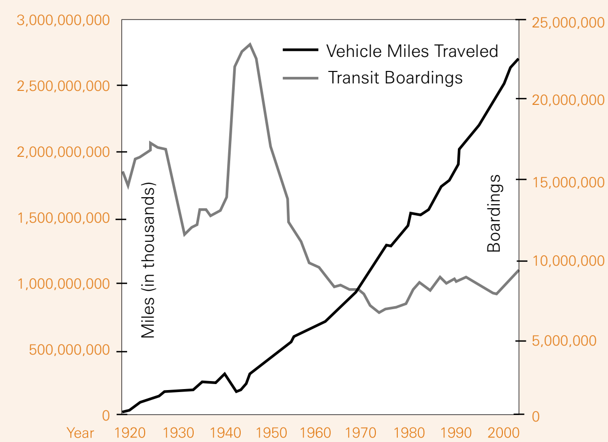
Source: US Environmental Protection Agency, 2008

Increase in Vehicle Use and Road Systems

The U.S. population's shift into suburban and exurban areas has created modern land use changes that by nature require more vehicle use and increased amounts of construction and land transformed to build new highways, roads, and parking lots. Over 81,000 miles of highway have been built from 1995-2004, bringing the total to more than 4 million miles.[48]

More vehicles are on the road, and the amount of American's driving time has increased at a rapid rate. The number of vehicle miles traveled rose by nearly 2.5% annually during the 1990s (with a marked increase in the final years of the decade), reaching nearly 3 trillion miles annually for the nation as a whole by 2000.[49] *And, the average miles traveled (and fossil fuels burned) is growing faster than the population: from 1995-2004 when the U.S. population grew by less than 10%, the transportation miles traveled by Americans increased by 23%.*[50]

U.S. VEHICLE USE



Source: APTA & FHWA, 2008

With more people taking more and longer trips as part of daily life, and, a growing number of cars on the road, *congestion has also increased*. The average U.S. traveler now spends 47 hours each year stuck in traffic delays during rush hour, compared to just 16 hours two decades ago. There are also now ten times more urban areas (51) with more than 20 hours of annual rush hour delays.[51]

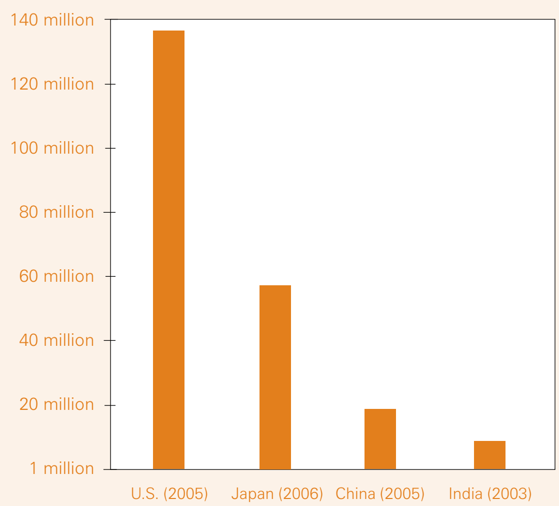
Looking at the environmental impacts, these trends have contributed to increased fossil fuel combustion, and higher greenhouse gas emissions. ***The transportation sector*** *uses 15% more energy today – primarily from petroleum – than it did a decade ago.*[52] *It now accounts for one-third of all U.S. carbon dioxide (CO_2) emissions.*[53] This reflects an annual increase of over 2% during the 1990's.[54] Most (41%) of the CO_2 emissions created by the transportation sector are emitted from the miles Americans travel on highways.[55] In addition, an estimated 2.3 billion gallons of fuel are wasted every year from idling in traffic, nearly 80% more than in the early 1990s.[56]

In More Detail

Gasoline price rises are due in part to increased demand for oil and a reduction in stocks, as well as disruptions in supply, such as the damages caused by storms such as Hurricane Katrina and Rita in the year 2005. Although high gas and oil prices may lead to a decrease in miles driven and a shift towards more efficient forms of transportation, they can also pose a threat to passing climate change legislation which would further increase gas prices.

Even the *U.S. population's increasing use of air travel is related to climate change.* In the last decade, the total miles traveled by U.S. aircrafts has increased 40%, and by 2025 U.S. air traffic is expected to rise by 60%. In addition to producing significant greenhouse gases, scientists say that the impact of carbon emissions from airplanes in the upper atmosphere is amplified and at least twice as harmful to the environment as those on sea level. [57]

Vehicle Ownership by Country



Source: International Road Federation, 2008

Increase in Number and Energy Consumption of Households

"Households," and the resources and energy Americans consume to support them, is an important demographic variable in calculating population's climate change linkages.

Every household has a minimum number of possessions, occupies a certain amount of space, and emits certain waste and/or pollutants. However, the extent of environmental stress, including climate change, that is linked to "households" depends on three main factors: **household size** (the number of people within a given household) **/number of households; size of homes** (square footage of a house), and; the **amount of land surrounding and used to build homes.**

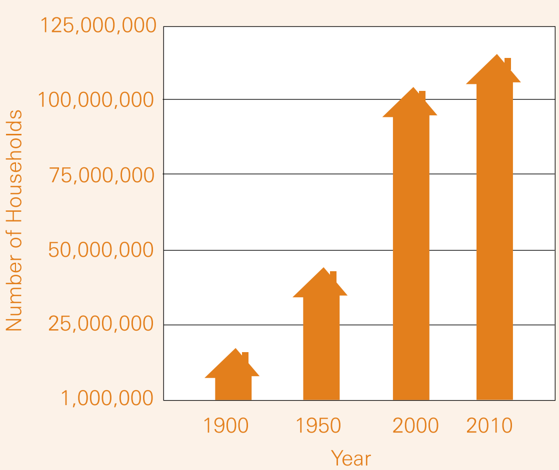
In recent decades, while the average U.S. household size has decreased, *the number of households has increased significantly, and the amount of "living space" in and around homes has risen.* The number of people per household was 2.6 people in 2000, down from 3.1 in 1970 (or one fewer person for every two households),[58] and as a result, the number of households has increased markedly. In 2000, there were nearly 14 million more housing units nationwide than a decade earlier.[59] Between 1970 and 2000, average household size declined from 3.1 to 2.6 persons (one fewer person for every two households), resulting in demand for new housing units in addition to that already needed to keep pace with population growth.[60] *Smaller household size in the face of population growth is one reason behind a nationwide building boom: between 2000 and 2006, 10 million new housing units were built.*[61] In addition, the number of second homes is at an all time high: second home ownership increased from 5,537,000 units to 6,489,000 units, a 17% increase or 2.7% annual increase from 1999 to 2005.[62]

The average size of new, single-family homes has expanded steadily, reaching more than 2,300 square feet by 2004. Nearly 40% of new single-family homes are over 2,400 square feet, double the proportion in 1987.[63]

With more people living in *"super-sized" houses that occupy more land, the amount of resources (from lumber to plastic) used for new construction is rapidly on the rise, and more energy is consumed for heating and cooling (thus more fossil fuels burned).* With many houses built in new sprawling communities – rather than clustered or city-based development that often uses existing "footprints" to build new homes – development begins from scratch, and there is higher resource use, and fragmentation of open space. Data shows that increases in the average "lot" sizes, on which new houses are built, are prevalent in many suburban areas.[64] About 55% of farmland developed since 1994 has gone to houses built on lots ten acres or larger.[65] More than 3,000 square miles of land is converted annually to residential development over one acre in size.[66]

Energy use within each household is also a key population-climate change link. **The U.S. residential sector is the largest of that energy use sector worldwide, and household appliances are the fastest growing energy consumers nationwide**.[67]

GROWTH IN U.S. HOUSEHOLDS



Source: US Census Bureau, 2008

Population and the U.S. Coasts

One key link between population and climate change in the U.S. is the high concentration of Americans who live and recreate in coastal areas, because it means more people are then vulnerable to the ***effects*** *of climate change (such as sea level rise and strong weather events like storms).*[68] Over half (53%) of all Americans now live within 50 miles of the U.S. coasts. An additional 27 million people (accounting for about half of the projected U.S. population increase) are expected to move there in the next 15 years alone, and, there are higher growth rates on the coasts than the inland areas of the U.S.[69] As a result, **the U.S. coastal zone represents a "hot spot" for population and climate change vulnerability**.[70]

The "coastal vulnerabilities" associated with climate change include sea level rise, shoreline erosion, flooding, coastal storms, and degradation of coral reefs and marine ecosystem health.[71] These all, in turn, affect the dense and fast growing coastal populations in the form of health, accessibility and availability, and property. If global warming continues as it is, major coastal urban/metropolitan areas built near sea level (including New York, Boston, Washington DC and Miami) will be at risk from the expected sea level rise of 18-20 inches above current levels by 2100 (see box, page 13). Low lying infrastructure in these areas such as buildings, roads, power lines, airports, trains and subway systems are subject to flooding. Where land is already sinking (such as along the Gulf Coast including New Orleans, LA and Galveston, TX) sea level rise will likely be faster. Recreational areas enjoyed by millions, including New Jersey and California beaches, Long Island and the Hamptons, Cape Cod, Nantucket, North Carolina and Florida's Gold Coast will be subject to beach erosion.[72]

U.S. Energy Consumption by Income Level and Square Feet of Household

Household income level	Square feet of home	Energy consumption of household (million Btus)
$15,000 - $19,999	1,500	81
$30,000 - $39,999	1,700	87
$75,000 - $99,999	2,700	113
$100,000 or more	3,400	136

Source: US Energy Information Administration, 2008

Experts now say that even if storm intensity and frequency associated with climate change does not increase, *the expected growth and density in the U.S. coastal population, in combination with its associated land development and the anticipated increase in flooding from sea level rise, will undoubtedly cause property losses to increase.*[73]

U.S. Coastal Metro Areas Most Affected by Sea Level Rise

The US coastal areas most vulnerable to future sea level rise are those with "low relief" which are already experiencing rapid erosion rates, from the Northeast to the Gulf Coast.

Source: US Global Change Research Program, 2008

Population Composition: Age and Income

The composition of a population – its age, income, educational level, culture/race, and other characteristics – can determine where and how people live, move, vacation, and develop land. Many of these demographic factors can be linked to climate change.

"Age" is a prime example of how demographic factors can have major implications for climate change in the U.S., and it applies to both the younger and older segments of the population.

***Youth* are key in the population and climate change equation.** The young demographic in the nation today aged 0-24 is about 35%, and those aged 24-44 are an additional 30%.[74] This large segment of the American population is critical because they are uniquely positioned to make key choices that will affect the nation's future with regard to climate change, and various population factors. Their choices with regard to **fertility** (how many children they decide to have) and **resource and energy consumption** (including energy, vehicle, transportation and land "use", recycling, etc) are key. The decisions they make both individually, collectively as consumers, in academia, research, business and industry, and, as voters at the local to national levels, will all determine trends in population and climate change throughout this century.

***Baby Boomers* are a key demographic for resource and energy consumption.** The trend towards *aging* of the U.S. population as the proportion of older people increases is also significant in relation to climate change. *Today's older population is larger than it has ever been in the nation's history,* and the overall median age in 2000 (35.3 years) was also higher than it has ever been.[75]

This segment of the population, the nation's *"Baby Boomers"* (born between 1946 and 1964), represent over 78 million or 26% of the total U.S. population.[76] They are *wealthier, spend more money, consume more resources including energy, have more homes per capita, and move more often than any generation before them.*[77] **This is important because they represent both a large percent of the total American population *and* high energy consumption, the combination of which is significant in terms of climate and environmental impact.**

In addition, a substantial share of America's population age 65 and older moves to and settles in "retirement magnet" states such as Arizona, Florida, and Nevada, where pressure on natural resources (especially water), and high energy demand, is already evident. Over the next quarter century, the proportion of elderly Americans is projected to double in at least 14 states in the coastal South and arid West.[78]

***Income* is critical to resource and energy use** because *resource and energy consumption is often associated with level of income, or affluence.* Evidence shows that as a whole, those more affluent in the population consume more energy resources and generate more waste and pollution than do lower-income populations.

The median household income in the U.S. was about $44,000 in 2004.[79] In international dollars America has a per capita income of nearly $40,000, compared to about $26,000 for more developed countries, $4,000 for developing countries, and $9,000 globally.[80]

In America, rising income generally brings about greater motor vehicle use, resulting in more road-building, air pollution, and the CO_2 emissions that cause climate change. And, relative to their share of world population, Americans consume disproportionately high amounts of meat and dairy products, which require more land, water, and energy (and produce more wastes) compared to diets based on grains and vegetables.[81]

On the flip side, however, affluence can facilitate positive trends by encouraging the consumption of goods that are environmentally sound. People with higher levels of disposable income are often more inclined to purchase more expensive, energy efficient "hybrid" vehicles, appliances, and lighting, and to purchase higher priced yet more energy-efficient solar powered panels, recycled paper, organic foods, and other environmentally-friendly products as they are generally not yet priced for mass consumption at all income levels.

Climate Change and Population: Effects and Impacts

The relationship between population and climate change is very complex, however, in simple terms: the *U.S. population contributes both to the **causes** of climate change* (through, for example, accumulated land use changes, high per capita energy use and greenhouse gas emissions), and its ***effects*** (where, for example, there are large and/or rapidly growing population concentrations in areas that are particularly vulnerable to the effects of climate change – such as the coastal or arid areas of the U.S.).

This section describes the major environmental and health related "effects" relating to climate change with regard to its population linkages. They include:

- **altered weather and seasonal patterns**
- **habitat and biodiversity loss**
- **rising sea levels**
- **less available freshwater**
- **human health threats**

Climate Change in Alaska

The state of Alaska is experiencing some of the most profound climate change impacts now occurring in the nation. Permafrost thawing is causing the ground to subside 16-33 feet in parts of interior Alaska, and the permafrost surface has warmed by about 3.5 °F since the 1960s. Summer days without snow have increased from fewer than 80 in the 1950s to more than 100 in the 1990s. Sea-ice extent has shrunk by about 5% over the past 40 years, and the area covered by sea ice declined by about 6% from 1978 to 1995. A study of 67 glaciers shows that between the mid-1950s and mid-1990s the glaciers thinned by an average of about 1.6 feet per year, and the rate of thinning had increased to nearly 6 feet more recently. The state's annual average temperatures have warmed up to 1.8 °F per decade over the last three decades, and winter warming has been as high as 3 °F per decade.

The consequences of global warming for wildlife species will be severe. An example is the polar bear, which has been placed on the U.S. Endangered Species List. It has been designated by the U.S. Interior Department as "threatened with extinction because of shrinking sea ice", ***making it the first creature added to the endangered species list primarily because of global warming.*** Experts say that two-thirds of the polar bear's habitat may disappear by 2050. Polar bears are dependent on hunting ringed seals and other prey from sea ice. They are so unsuccessful on land that they spend their summers fasting, losing more than 2 pounds a day. This "forced fast" is now about three weeks longer than it was 30 years ago. This gives the bears less time to hunt and build up the fat reserves they need to survive until ice re-forms in the fall and they can resume hunting. As bears have become thinner, the reproductive rates of females and survival rates of cubs have declined. As Arctic ice breaks up earlier and earlier, bears now come ashore roughly 22 lbs. lighter and in poorer condition. The bears' reduced body condition can lead to lower reproduction rates, which in the long run could lead to local extinction.[102]

Altered Weather and Seasonal Patterns

A main impact of climate change is seen in altered weather and seasonal patterns throughout the U.S. Some of these changes are with us today, and others are predicted by experts to occur in the future, depending on population factors linked to people's energy and resource consumption, and whether or not greenhouse gases continue to be generated in a business as usual scenario.

One of the weather-related changes now occurring and expected to continue is an altered water cycle resulting from higher atmospheric temperatures.[82] With higher temperatures, *more precipitation will fall as rain, and less as snow.* Both reduced snow pack and earlier snowmelt could reduce river and stream flow in the spring and summer, times when supplies are needed most, particularly for irrigation.[83] In some parts of the country, such as in the West and parts of New England, snow already remains on the ground for a shorter time than in past decades.[84] (See page 17).

Greater fluctuation in precipitation also contributes to a *wider disparity between wet and dry seasons*, making planning for water supplies and use more difficult. Although overall precipitation is predicted to increase in arid states, decreases in summer months are also likely.[85] Similarly, *extreme weather events would be more common*. Higher temperatures and more rain falling on snow would result in rapid thawing, which in turn could spur flash floods as water rushes into rivers and streams or across dry land.[86]

Nationwide, more rain can *increase pollutant runoff* from agricultural fields and pavement in urban areas into water systems, a significant problem today. Higher temperatures could be exacerbated as pavement for roads, parking lots, and residential and commercial areas (which retain and radiate heat more than natural areas) spreads along with development and population growth. Reduced ice cover will mean that more heat will be absorbed rather than reflected by land and water. *Warm, wet conditions also foster carriers or "vectors" (such as mosquitoes) that spread diseases like West Nile virus, malaria, and dengue fever.*[87] (See box, page 18).

Rises in food prices are partly brought about by climate change because it hampers agricultural production through altered weather patterns and record droughts around the world, including the U.S. South and Southwest. In addition, increased food demand from a growing population, increased gas prices, and increased speculative demand for biofuels whose crops are being planting in place of staples such as rice, wheat, and corn have all driven up the price of food.

Hurricane Katrina: Population and Climate Change Converge on the Coast

Hurricane Katrina's effect on the U.S. Gulf Coast in 2005 demonstrated the hazards of severe weather events on heavily populated and developed coastal areas. For example, climate change appears to be associated with the increased intensity of hurricanes. The number of severe (Category 4 and 5) hurricanes, like Katrina, has nearly doubled worldwide, from 10 annually in the 1970s to 18 annually in 1990. Such storms made up 35% of all hurricanes in the past decade, compared to 20% in the 1970s.[108] One cause of this change is thought to be rising ocean temperatures. Since 1970, the temperature of the world's oceans has risen one degree Fahrenheit, while the tracking of temperatures in the Atlantic Ocean shows a steady increase in the last several decades.[109] Because warm surface waters are a source of energy for hurricanes, this trend has probably contributed to the shift toward stronger hurricanes.[110]

Habitat and Biodiversity Loss

The main cause of biodiversity loss in the U.S. is "habitat loss" from land use changes for rapidly occurring, widespread development across the country, extraction of energy resources, and other means. *These are all linked to increases in population numbers and people's consumption of land and other resources.* Most (85%) of the species known to be at risk for extinction in the U.S. are from habitat loss and alteration.[88]

Climate change is already having many impacts on the biological diversity of plant and animal species in the U.S. Among them is its effect on the *composition and range of the nation's forests.* An increase of 2°F over a period of 100 years, well within the range of current predictions, can force some tree species' ideal range to shift about 200 miles northwards.[89] As temperatures and moisture levels increase, some forests will expand, in particular southern types (such as oak, hickory, and cypress).[90] The tree line in alpine regions could also move higher, and New England's sugar maples are moving northward. Drier soil conditions would decrease the range and density of some forests, which could be replaced with more extensive grasslands and pasture.[91] Increased precipitation could spur the growth of trees and vegetation, but heat could spur the loss of nutrients.[92]

Spring is arriving sooner now than in the past, and many indicators show spring is occurring 1-3 weeks earlier than usual.[93] In New England, for example, this is shown by data on river flow and runoff, last-frost dates, air temperature, snow melt, and leafing and flowering patterns.[94]

Changes in freshwater temperature are also a factor. An increase of 4-5ºF over the next 70 years could reduce habitat of coldwater fish by one-fourth to one-third nationwide.[95] Higher water temperatures are also linked with the bleaching and die-off of coral reefs, and algal blooms which deprive aquatic life of oxygen and light.

Whether and how species adapt to climate change will depend on the pace and geography of the climatic shifts, how the composition and location of habitats are altered, and the availability of habitat. *Many species are already adjusting their migration, breeding, and feeding habits in order to survive.* But because all parts of an ecosystem do not adjust to climate shifts in the same way, many species could face a lack of food-base, or inadequate habitat. For example, some butterfly species are moving northwards in response to temperature increases in their home ranges, while egg laying among certain birds and the budding of some trees now occur earlier than in previous decades.[96]

This is also particularly evident in the Arctic (including Alaska), where retreating sea ice is making it harder for seals and polar bears – now on the U.S. Endangered Species list for threat of extinction – to find food.[97] (see box, page 14).

The species most vulnerable to climate change will be those with habitat needs afforded only by certain ecosystem types. It will be especially hard for wildlife to adjust in the face of human population and development, since fragmented, built environments prevent migration to new habitats. Another key population factor here is that, given current patterns of land use, there will likely be less habitat available, even if birds and animals can reach it.[98]

Another key population factor here is that sprawl development "fragments" or breaks up wildlife habitat. This can have detrimental effects on wildlife as well as diminish the services performed by ecosystems, such as the ability of wetlands to filter waste and control flooding. As this development paves over land, it compacts soils, increases flooding and polluting chemical runoff, and reduces groundwater reserves.[99] *And, forecasts show considerable expansion of sprawling development in the future, with significant implications for ecosystems.* For example, forest and prime farmland made up most (60%) of the acreage developed nationwide during the 1980s and 1990s.[100] At current population growth and rates of sprawling development the U.S. could lose 23 million acres of forest land to development by 2050, primarily due to increases in residential areas.[101]

Species Threatened by Climate Change

Plant and animal species in the U.S. and globally are being affected by what researchers call the "double hit" of habitat loss and climate change. The polar bear is the first species ever to be placed on the U.S. Endangered Species List due to climate change (see box, page 14). Yet many other species are also at risk. For example, climate change is pushing one in eight bird species globally to extinction because of the combination of widespread habitat loss and the severe droughts, forest fires, and extreme weather events brought about by global warming.

In addition, one third of the planet's reef-building corals, including those off the U.S. coasts, are threatened with extinction. Built over millions of years, coral reefs are home to more than 25% of marine species, making them the most biologically diverse of marine ecosystems. Corals produce reefs in shallow tropical and sub-tropical seas and are highly sensitive to changes in their environment. Researchers have identified the main threats to corals as climate change and localized stresses from destructive fishing, declining water quality from pollution, and the degradation of coastal habitats. Climate change causes rising water temperatures and more intense solar radiation, which lead to coral bleaching and disease often resulting in mass coral mortality.

Source: IUCN, 2008

Rising Sea Levels

With over half of the U.S. population already living in coastal areas and millions more moving there each year, predictions of sea level rise resulting from climate change is a major concern. The sea level rise due to global warming is the result of higher water temperatures (which expands water volume), and the addition of freshwater from melting glaciers and ice.

The greatest sea level changes are expected along the heavily populated U.S. Mid-Atlantic and Gulf Coasts because of sea level rise and the simultaneous occurrence of land subsidence from natural geological change. In these regions, studies predict that a *one foot rise in sea level is likely by 2050, and as much as a four foot rise is possible in the coming century.*[103] Rates of sea level rise are also expected to be considerably higher in the future than they have been in the past. (See box, page 13).

In the next 60 years, 25% of buildings within 500 feet of the U.S. coastline could be lost because of coastal erosion. Half of these structures are on the U.S. Atlantic Coast, and the remainder along the Gulf and Pacific Coasts and the Great Lakes.[104] *Flood damages could increase by 36-58% with a one-foot rise, and by 100-200% with a three-foot rise.*[105]

Sea level rise would also increase *salt intrusion into rivers, streams, and aquifers* and the salinization of water supplies. This is already a problem because of groundwater pumping and the alteration of natural water flows to satisfy growing demand.[106]

It is also estimated that a two-foot rise in sea level could eliminate an estimated 17-43% of U.S. wetlands.[107] Somewhat paradoxically, the structures erected to protect populated coastal areas from shoreline erosion (such as seawalls, dikes, and bulkheads) often prevent wetlands and marshes (which serve as natural buffers from the sea and storms) from "migrating" and re-forming further inland as sea levels rise.

Freshwater Resources, Population and Climate Change

Although people may more commonly link climate change's effect on water with rising sea levels, the affect of climate change on freshwater resources is also a serious concern.[111] Across the U.S., in all regions, climate change is affecting freshwater resources, mainly through:

- **Increased temperatures and evaporation rates**
- **Decreases in the volume of snow pack and glaciers (a critical supply of freshwater during spring melting)**
- **Decreased rainfall and increased drought conditions**

Population's linkages to water resources and climate change play out differently in each U.S. region, and each region has tremendous, unique, water-related pressures related both to water quality and quantity (see ***"U.S. National Report on Population and the Environment"***, www.cepnet.org). Yet these issues are particularly widespread and pervasive in the American West. There *the nation's driest states have become some of our fastest-growing, exacerbating issues resulting from limited water availability.*[112] **Water, not land, is the limiting resource in the West, and rapid growth continues in those areas where experts say there is already a lack of water to sustain the current and expected future population influx.**

For example, a major, prolonged drought combined with rapid population growth in urban areas like Las Vegas has stressed nearby Lake Mead, and the rest of the Colorado Basin, which provides water to farmers and cities located from Colorado to Southern California. Now, there are fears that global warming could drastically reduce the Colorado River's flow, even as the Southwest continues to expand in population.

Also in another part of the West, the steady decrease in the Sierra Nevada mountain ice pack that provides most of Northern California's water was recently at its lowest level in 20 years, and current models suggest 30-70% of the snow pack will disappear by the second half of this century. A new National Academies report on the Colorado River Basin says the combination of limited Colorado River basin water supplies, increasing population demands, warmer temperatures, and the prospect of climatic change-induced droughts point to a future in which the potential for people-water conflicts will become ever-present. *Over the past few decades, the driest states in the U.S. have become some of the fastest growing, while ongoing drought has brought the flow of the Colorado River to its lowest since measurements began 85 years ago*. "We have to find a new way of meeting the needs of all this population that's turning up, and still satisfy all our recreational and environmental demands", says one Colorado official – a sentiment held by many Western states' water managers.[113]

Human Health Threats

One of the most acute affects of climate change that is associated with the U.S. population relate to people's health. *Major health issues associated with climate change include increased frequency of heat waves (which are of special concern for the elderly and the poor) and extreme weather events, posing dangers of drought and flooding; increasing risk of food-borne and waterborne infectious diseases; more severe air pollution due to higher temperatures, and; migration of vector-borne and zoonotic diseases (e.g., Lyme disease, West Nile virus, malaria and dengue fever) with changing seasonal patterns.*[114]

There are direct and indirect health impacts associated with climate change: direct and indirect effects. *Direct effects* occur when weather associated with a changing climate produce health effects (e.g., heat-related mortality and morbidity resulting from elevated temperatures). *Indirect effects* are health impacts caused by climate change through an intermediary pathway, for example, when elevated average temperatures alter the distribution of habitat suitable for a disease vector, expanding the range of the disease vector and the population potentially at risk.

For example, **direct health effects** include extreme temperatures, particularly in urban areas often suffering from the "heat island" effect, which can dramatically impact human health. Chicago may see a 25% increase in the frequency of heat waves and Los Angeles a four-to-eight-fold increase in heat wave days by the end of the century. Extreme temperatures pose a greater risk to certain populations such as the elderly, young children, the poor, and people with health conditions such as heart problems or asthma.

Indirect health effects include higher average temperatures, and rain patterns that could prolong disease transmissions seasons in locations where diseases already exist, and, introduce diseases into previously untouched areas. West Nile virus, never seen in North America before 1999, had infected more than 21,000 people in the U.S. and Canada by 2006. Lyme disease, the most common vector-borne disease now in the U.S., is predicted to significantly expand its range north into Canada due to the influence of climate change. Asthmatics and other sensitive and susceptible sub-populations may suffer from air quality problems exacerbated by climate change. For example, warmer temperatures could increase the reaction of chemicals that produces ground-level ozone (O_3), the main component in smog, which is harmful to human health. Similarly, elevated average temperatures could prolong the pollen season or result in greater pollen production, exacerbating symptoms of allergy sufferers.

Climate Change' s Top 10 Health Effects

A wide variety of potential environmental changes associated with climate change could have negative health impacts. The ten most serious health effects related to climate change follows. They are mortality and morbidity associated with:

- Extreme temperatures (e.g., heat waves)
- Exacerbated air quality problems due to higher temperatures (e.g., ozone/photochemical smog)
- Prolonged and/or increase severity of allergy season due to elevated average temperatures, resulting in higher aeroallergen levels
- Altered transmission of infectious disease through expansion of suitable habitat range or conditions for vector survival
- Effects on food production via climatic influences on plant pests and diseases
- Intensified drought events and resulting famine
- Population displacement due to crop failure, water shortages, natural disasters
- Destruction of health, transportation, and communication infrastructure due to natural disasters
- Human conflicts over increasingly scarce and valuable natural resources
- Increase in level and ambient temperature of oceans, which can affect human health by increasing vulnerability to waterborne pathogens[115]

In Your Region: U.S. Population & Climate Change

This section describes each U.S. region and its distinctive characteristics in relation to population and climate change.

Northeast

- The Northeast is the **most densely populated region in the nation** (337 persons per square mile).[116]
- It has the **lowest energy consumption** (268 million Btus) [117], **CO_2 emissions** (15.0 metric tons)[118], and **vehicle miles traveled** (8,263)[119] **per capita in the nation**.
- Temperature increases spurred by climate change in the Northeast may render areas such as Boston, MA and Portsmouth, NH to have temperatures similar to Richmond, VA or Atlanta, GA, by 2100.[120]
- Currently, changes in the Northeast's seasonal weather patterns are affecting the fall foliage and winter recreation industries, garden zones, species' habitats, and lake "ice-outs". Spring in the Northeast now occurs 1-3 weeks earlier on average than 30 years ago.[121]
- The predicted temperature rise of 4°F could contribute to the loss of 50-70% of sugar maples and 40-50% of spruce in some parts of the region.[122]
- Higher temperatures and precipitation are associated with the spread of Lyme disease and equine encephalitis, and increases in health-damaging smog.[123]
- Rising water temperatures could reduce the productivity of Atlantic lobster fisheries in the southern part of their range, and reduce the populations of trout and other species in the Northeast's brooks and streams.[124]

South

- The South has the **largest numerical population of all U.S. regions**,[125] and is the second-fastest growing.[126] (Two Southern states had the nation's first and third largest numerical increases: Texas (3 million) and Florida (2.2 million) from 2000-2007.[127])
- It also has the **highest number and percent increase of new housing units**, with nearly 70% single-family homes.[128]
- The South has the **highest energy consumption** (401 million Btus)[129], second highest CO_2 emissions (23.2 metric tons),[130] and **highest vehicle miles traveled** (11,590)[131] **per capita in the nation**.
- In the last 20 years, more than half of the nation's costliest weather-related disasters (in particular hurricanes and floods) occurred in the South.[132]
- In the past 100 years, annual rainfall has increased 20-30% across several southern states, including Alabama, Arkansas, Louisiana, Mississippi, South Carolina, and Tennessee.[133]
- In the Chesapeake Bay, sea level could be 27 inches higher in 2100 than it was in 1990, reflecting double the rate of the rise recorded during the 20th century.[134]
- Rising seas could make water systems in the Everglades saltier – high levels of salinity have already been linked to the die-off of 100,000 acres of sea grass beds and the decline of coral reefs in Florida.[135]

In Your Region: U.S. Population & Climate Change

Midwest

- The Midwest is the nation's second least densely populated region (87 persons per square mile).[136] It is the second slowest growing U.S. region.[137] Still, metropolitan areas around cities are growing rapidly, at the national rate.[138]
- It has the second highest energy consumption (357 million Btus), [139] highest CO_2 emissions (23.6 metric tons),[140] and second highest vehicle miles traveled (10,292)[141] per capita in the nation.
- Despite the prediction of more rainfall in the Midwest, higher temperatures and evaporation could combine to result in a net decline in water levels in the Great Lakes by the end of the 21st century, possibly by as much as 1.5–8 feet.[142]
- A five-foot drop in the Great Lakes would result in 20–40% less flow into the St. Lawrence Seaway, increasing the costs and difficulty of navigation and commerce.[143]
- A 2-4°F temperature increase in the Midwest could increase concentrations of ozone and smog by 8% and pose considerable health threats.[144]
- More than half of all prairie ponds in the Midwest could permanently dry up by 2060, reducing the number of breeding ducks by half.[145]
- Although overall the productivity of the nation's agricultural center could improve due to more rain and higher levels of carbon dioxide, the mix of crops in particular areas could also shift and yields of some (such as corn) could decline.[146] Growth might also be offset by the expansion of weeds, the reduced nutritional value of rangeland grasses, and drier soil conditions from higher temperatures.[147]

West

- The West is the country's **fastest growing region, increasing by one and a half times the national rate**.[148] California is the largest state in numerical terms (36.6 million residents), accounting for over 50% of the West's, and 12% of the nation's total population.[149] Nevada is the nation's fastest growing state, with population increases of over 3.5% per year, from 2000-2007.[150]
- **Seven of the top ten fastest growing U.S. cities** (in Arizona, Nevada, and California)[151] **and five of the top six fastest growing metro areas** (St. George, UT; Greeley, CO.; Bend,OR; Las Vegas-Paradise, NV; and Provo-Orem,UT) **are in the West**.[152]
- The West has the second lowest energy consumption (280 million Btus),[153] CO_2 emissions (15.7 metric tons),[154] and vehicle miles traveled (8,868)[155] per capita in the U.S.
- Some of the western states' relatively low per capita energy use compared with other U.S. region is uniquely achieved through a combination of aggressive energy-reduction policies, hydropower, and mild weather.[156]
- The greatest warming observed in the nation is in Alaska, where temperatures have increased 4-7°F in the last century, and the growing season has increased more than 14 days since the 1950s.[157]
- In September 2007, the extent of Arctic sea ice in the summer reached a record low, shattering all previous lows since satellite record-keeping began nearly 30 years ago. (By the early 2000s the Arctic sea ice had already melted back12-15% beyond its normal minimum summer ice extent). Experts now say we may be about to reach a threshold beyond which the sea ice may not be able to recover.[158]
- In California and Nevada, the snow season decreased 16 days between the 1950s and the 1990s.[159]
- By 2050, the snow line in mountains of the Pacific Northwest could be more than 1,000 feet above where it is today, forcing the dying off of much spruce, fir, and pine.[160]
- Along the West coast, butterflies are leaving the southern ends of their natural range and moving north and to higher altitudes in search of tolerable climate conditions.[161]

Conclusion

This science-based report provides a *first step to understanding the linkages between population and climate change in the U.S.* While the scientific evidence shows that America is a major contributor to global climate change, so, too, is it poised to be a world leader in terms of solutions. *The next step is to determine which policy, research and public-outreach options are the best viable responses to this new age of U.S. population and climate changes.* Here are some important considerations:

■ **"Environmental sustainability"** – the ability to create indefinitely a healthy natural resource base on which all our lives depend – **is central in addressing climate change.** As part of this, *Americans at all levels, from individuals to national leaders, must think* ***"inclusively", placing climate change, environmental sustainability, <u>and</u> population in the same frame.*** Science demonstrates that the issues manifest themselves in this way, and the approach and solutions should reflect that in order to be effective.

In response, Americans must make strategic choices both in their individual lives, and collectively as a nation – from the local community to national levels – in order to balance the increasing pressures of human activity and their climate change impacts in our nation and the world.

Now Americans are showing keen, widespread interest in these issues as food and gas prices rise, water becomes more scarce, and the effects of climate change are all around us. But we have to think differently and make the connections, rather than seeing them as individual occurances, which is now the norm.

This requires a multi-faceted approach: **Americans must seriously choose to reduce energy use and greenhouse gas emissions, *<u>and</u>* take steps to put population and demography on the table as a way to address climate change.** Right now, this inclusive approach is not being taken and this is curtailing efforts to curb climate change, stabilize population growth, and ensure environmental sustainability.[162] This muti-faceted approach is the only way to effectively address the global and national climate change challenge, from both sides of the same "population and climate change" coin.

This involves making policy shift making **"environmental sustainability" a U.S. national priority.** On the "energy" and "resource consumption" side, this includes everyday individual consumer choices to be energy efficient, as well as local, state and federal governments' commitment, concrete plans, and financial incentives for energy efficiency and greenhouse gas reduction. There should be local-national plans and tax/ financial incentives for energy efficient mass transport, household appliances, heating and cooling, and building codes. Federal research for new energy efficient technologies should be a priority, and such products should be made available to all Americans at every price point.

On the "population side", this includes acknowledging that population factors, including per capita resource consumption and the population growth trends as mentioned in this report, are part and parcel of the U.S. and global climate change challenges, and solutions. International and national policies on climate change must include population and demographic factors as a core part – not just a sideline or introduction – in their considerations. And, the approach must include attention to population, in the U.S. and globally, as an essential part of halting and even adapting to climate change. There are many ways to do this, and they need to be addressed.

In addition, the numbers of young people in or entering their childbearing years in the U.S. already guarantee a certain amount of growth. At the same time, a large unmet demand for reproductive healthcare and family planning, in the U.S. and worldwide, by those who would like to limit their family size, is another source of growth. Providing good quality reproductive healthcare and family planning, easily accessible and affordable, to those who voluntarily wish to choose the number of children they have, would contribute to sustainability.

As part of all these efforts to achieve environmental sustainability, people's choices and focusing on audiences such as "youth" as the nation's future decision makers can be a powerful combined strategy to help curb climate change and turn things around for the short and long term.

■ **"Choices" are a central part of the climate change solution.** A population can have impacts on the environment or climate change through the sheer numbers of individuals consuming a natural resource (like energy sources, water, forests, land, marine life). Yet, it is not always a straight-forward "cause and effect" relationship.

For example, 20,000 people in one town can have a very different environmental impact than that same number in another town. This is based on decisions made about, say, the way land is developed (with "cluster development" vs. sprawl); type of transport or energy used (mass transit vs. single person vehicle road travel, energy efficient cars and appliances, Smart Growth "walking friendly" town development), or; industry used (polluting or not, i.e. emitting small vs. large amounts

Conclusion

of CO_2). *So, while large numbers of people are critically important in the climate change equation, the same numbers of people do not always have equally detrimental climate impacts.* A shift in individual and collective *choices* about the type of and scale of energy and resource consumption can make a big difference as to whether the outcome is environmentally sustainable or not.

■ **Youth in the U.S. play a key part in the population and climate change debate, both in terms of the challenges, and the solutions.** In 2007, 34% of the U.S. population was aged 0-24 and 20% were aged 25-39. This important demographic of young people is currently over half of the U.S. population, and predicted to grow 0.5% annually, and 7% by 2020.[163] ***Youth are critical because they are in the position of making important choices both about population*** (the number of children to have) ***and climate change*** (as energy consumers, whether to recycle, which vehicles to drive, whether to use mass transportation, where to live, etc., and, as potential pollution emitters).

Unlike any generation before them, they are beginning to take *"climate change"* and other *"environmental sustainability" issues into account when making significant "life choices" – about natural resource and energy consumption, recycling, where to live, what to drive, and how many children to have.* These are small, everyday, as well as major, life transforming choices that all make a difference in maintaining a balance between people and the natural resource base on which all life depends.

Youth also represent the segment of the population whose votes and decisions in the social, reproductive healthcare, business, industry, policy and local to national political arenas, will have a bigger impact than ever before on the future trends in both climate change and population trends.

Their decisions represent both sides of the population and climate change "coin" in terms of choices and possible outcomes. It is their generation that will likely make the most difference in the future of our planet and nation, because the issues they are faced with are unlike any generations before them.

In addition, local to international government policies, business and corporate practices, and economic and social factors also have significant roles in population's environmental impacts. These, and individual choices, are often mitigating factors, and all must be part of the solutions. *Yet, while all these activities can change the future course of "business as usual" with regard to global warming, we must also* ***"adapt" to the inevitabilities of climate change and to the population momentum already in place.***

■ **"Adaptation" is a key factor** because some degree of future climate change will occur regardless of future greenhouse gas emissions. Adapting to or coping with climate change will therefore become necessary in certain U.S. regions, socioeconomic and environmental systems.

Here, population is also key, because the need for adaptation will most likely be increased by growing populations in areas vulnerable to extreme events, and the nation's per capita resouce use.[164] Thus, population factors must be a core part of the U.S. adaptive strategy to climate change.

Human-induced climate change represents a new challenge, and may require adaptation approaches to changes that are potentially larger and faster than past experiences with recorded natural climatic variability. All climate-sensitive systems of society and the natural environment (including agriculture, forestry, water resources, human health, coastal settlements, and natural ecosystems) will need to adapt to a changing climate or possibly face diminished productivity, functioning and health. In unmanaged natural systems, adaptation is not planned but occurs when forced to do so. For example, as the climate warms, tree and animal species may migrate northward to remain in suitable climatic conditions and habitat (to the extent that human barriers, such as roads and cities, allow such migration).[165]

In human society, however, much of adaptation may be planned and undertaken by private decision makers and by public agencies or governments. Yet, there are individuals and groups within all societies that have insufficient capacity to adapt to climate change, and high adaptive capacity does not necessarily translate into actions that reduce vulnerability. For example, despite a high capacity to adapt to heat stress through relatively inexpensive adaptations, residents in urban areas in some parts of the world continue to experience high levels of mortality.[166]

Regarding ecosystems, and on species diversity in particular, effects are expected to be negative overall. Although biological systems have an inherent capacity to adapt to changes in environmental conditions, given the rapid rate of projected climate change that is largely human-induced, "adaptive capacity" is likely to be exceeded for many species. The ability of ecosystems to adapt to climate change is severely limited by the effects of highly populated urban/suburban areas, barriers to wildlife's migration paths, and fragmentation of ecosystems, all of which have already critically stressed ecosystems independent of climate change itself.[167]

Conclusion

There is still much to understand about how population and climate change trends relate to adaptive strategies. This report will be a tool for better understanding the dynamics of that relationship. Looking forward, some scientists are predicting how U.S. populations will have to adapt to climatic changes, including, for example, a shift in the New England communities centered on winter recreation-based activities, to accommodate less snow days and more mild weather recreation and activities. And, more and more people are re-thinking moving to U.S. coastal areas, where they are more vulnerable to extreme weather events and less able to receive real estate and house insurance.

On a broader scale, a new and emerging field of science which combines "population and climate change" is beginning to take hold in the U.S. and internationally. Scientists are looking at how the formerly disparate fields of "population and demography" overlap with the "environmental" and "climate change" sciences. This work will help to inform policymakers, business, industry, and the public on a new, combined, approach to these issues. This is especially important because it reflects and responds to the changes now occuring in the U.S. and globally. The merging of these two fields is an important first step for all of us to better understand and effectively address "population and climate change" as two components that are inextricably linked.

Finally, as we consider what to do, "allocation" issues emerge as we try to keep pace with more and more people, their increasing energy needs, and, all depending on a limited natural resource base. As energy demands increase in the U.S. and globally, how do we choose between the increasingly competing needs of humans, the environment, and species? How will we decide how natural resources are allocated – so we can all have the energy, food, and shelter we need – and, so there is sufficient "space" left for healthy ecosystem and species' functioning, particularly because our own health is dependent on a sustainable environment.

The climatic changes are happening all around us. So what are we willing to change, or give up…is it the world's climate, as we know it? plentiful water supplies? land? species? or, do we have to make different policy, lifestyle, business, or industry choices in order to respond to these changes?

As we look to the future, we must remember that past decisions about resource allocation are not necessarily suitable to today's U.S. and global population, climatic, and broader ecological changes. For example, most of the energy sources we have today grew out of the needs of people years ago, when the country's – and world's – population numbers and energy use were much less than they are now.

As for next steps, there are many. We need to be aware of the population and climate change challenges we face, and apply sound, science-based planning to our approaches for addressing the trends in the coming years. The country's "population-climate change hot spots" need to be identified so we can begin to address the issues where they are most urgently needed. America's role as a major player in the global community must be discussed and addressed at the local, state, regional and national levels, and in international arenas. Local communities must be given the tools to better understand growth and the climate change-related impacts in their locales. Children, students and young leaders in the nation must be educated and enabled to face these critical issues as their lives unfold.

With the help of this report we can decipher some of the main population-climate change challenges. We must consider them, along with their costs and consequences, and identify the gaps in knowledge, what is needed to fill them, and how we can act on the issues.

Now we can begin a new inclusive strategy, with new ideas and new models, to address our changing nation and world – so we can achieve a healthy, sustainable planet for all generations.

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