

HUMAN POPULATION GROWS UP

BY JOEL E. COHEN

As we swell toward nine billion in the next half a century, humanity will undergo historic changes in the balance between young and old, rich and poor, urban and rural. Our choices now and in the years ahead will determine how well we cope with our coming of age

THE YEAR 2005 is the midpoint of a decade that spans three unique, important transitions in the history of humankind. Before 2000, young people always outnumbered old people. From 2000 forward, old people will outnumber young people. Until approximately 2007, rural people will have always outnumbered urban people. From approximately 2007 forward, urban people will outnumber rural people. From 2003 on, the median woman worldwide had, and will continue to have, too few or just enough children during her lifetime to replace herself and the father in the following generation.

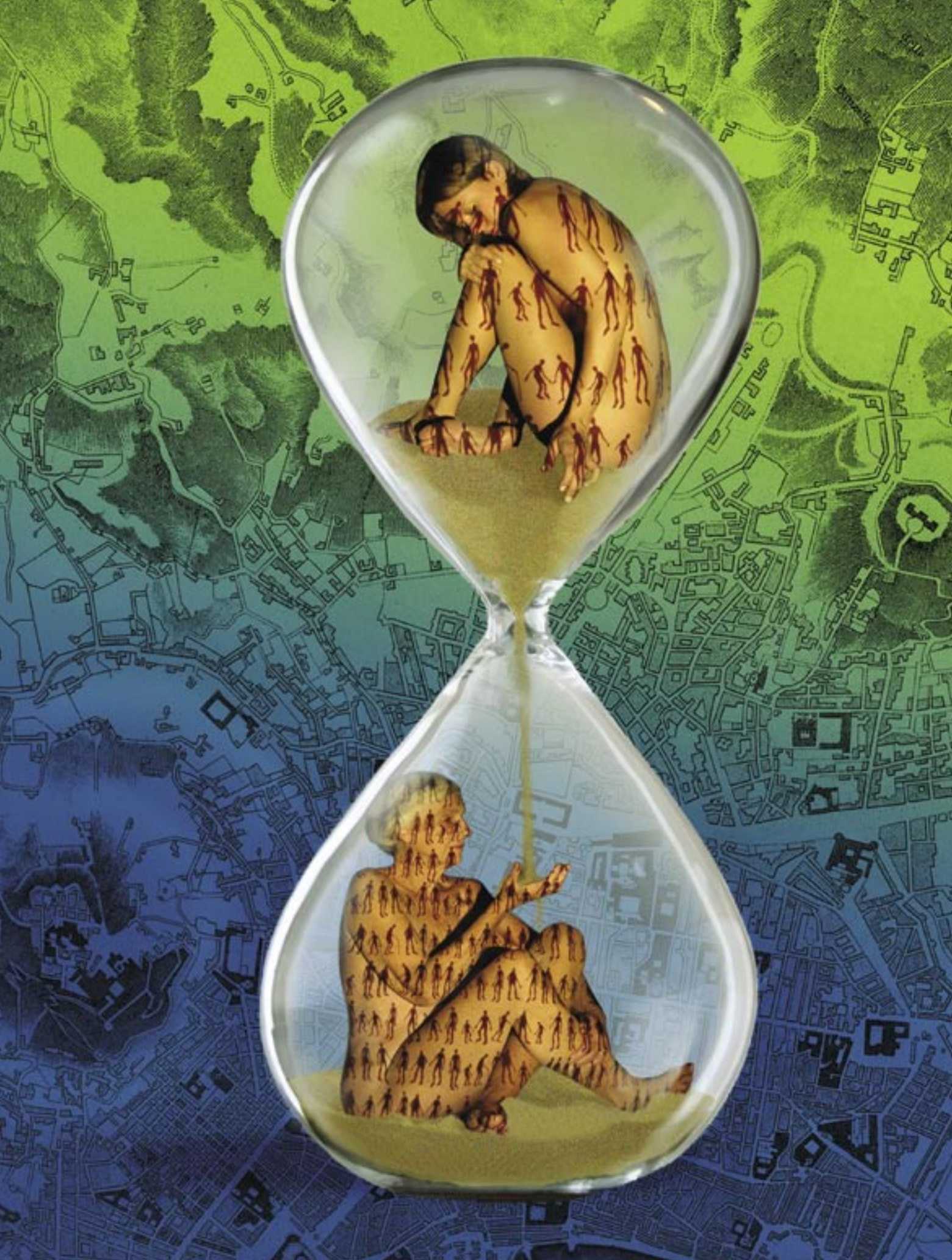
The century with 2000 as its midpoint marks three additional unique, important transitions in human history. First, no person who died before 1930 had lived through a doubling of the human population. Nor is any person born in 2050 or later likely to live through a doubling of the human population. In contrast, everyone 45 years old or older today has seen more than a doubling of

human numbers from three billion in 1960 to 6.5 billion in 2005. The peak population growth rate ever reached, about 2.1 percent a year, occurred between 1965 and 1970. Human population never grew with such speed before the 20th century and is never again likely to grow with such speed. Our descendants will look back on the late 1960s peak as the most significant demographic event in the history of the human population even though those of us who lived through it did not recognize it at the time.

Second, the dramatic fall since 1970 of the global population growth rate to 1.1 or 1.2 percent a year today resulted primarily from choices by billions of couples around the world to limit the number of children born. Global human population growth rates have probably risen and fallen numerous times in the past. The great plagues and wars of the 14th century, for example, reduced not only the growth rate but also the absolute size of global popula-

HUMANITY IN TRANSITION to a new stage of life will have to face new challenges.

JUDITH S. LARSEN



tion, both largely involuntary changes. Never before the 20th century has a fall in the global population growth rate been voluntary.

Finally, the last half a century saw, and the next half a century will see, an enormous shift in the demographic balance between the more developed regions of the world and the less developed ones. Whereas in 1950 the less developed regions had roughly twice the population of the more developed ones, by 2050 the ratio will exceed six to one.

These colossal changes in the composition and dynamics of the human population by and large escape public notice. Occasionally, one or another symptom of these profound shifts does attract political attention. Proposed Social Security reforms in the U.S., however, often fail to recognize the fundamental population aging, while debates in Europe and the U.S. over immigration policy often overlook the differences in population growth rates between these regions and their southern neighbors.

In this article, I will focus on the four major underlying trends expected to dominate changes in the human population in the coming half-century and some of their long-term implications. The population will be bigger, slower-growing, more

urban, and older than in the 20th century. Of course, precise projections remain highly uncertain. Small changes in assumed fertility rates have enormous effects on the projected total numbers of people, for example. Despite such caveats, the projections do suggest some of the problems that humanity will have to face over the next 50 years.

Rapid but Slowing Growth

ALTHOUGH THE RATE of population growth has fallen since the 1970s, the logic of compounding means that current levels of global population growth are still greater than any experienced prior to World War II. Whereas the first absolute increase in population by one billion people took from the beginning of time until the early 19th century, one billion people will be added to today's population in only 13 to 14 years. By 2050 the world's population is projected to reach 9.1 billion, plus or minus two billion people, depending on future birth and death rates. This anticipated increase of 2.6 billion people by 2050 over the 6.5 billion people of 2005 exceeds the total population of the world in 1950, which was 2.5 billion.

In short, rapid population growth has not ended. Human numbers currently increase by 74 million to 76 million people annually, the equivalent of adding another U.S. to the world every four years. But most of the increases are not occurring in countries with the wealth of the U.S. Between 2005 and 2050 population will at least triple in Afghanistan, Burkina Faso, Burundi, Chad, Congo, Democratic Republic of the Congo, East Timor, Guinea-Bissau, Liberia, Mali, Niger and Uganda. These countries are among the poorest on Earth.

Virtually all population growth in the next 45 years is expected to happen in today's economically less developed regions. Despite higher death rates at every age, poor countries' populations grow faster than rich countries' populations because birth rates in poor countries are much higher. At present, the average woman bears nearly twice as many children (2.9) in the poor countries as in the rich countries (1.6 children per woman).

Half the global increase will be accounted for by just nine nations. Listed in order of their anticipated contribution, they are India, Pakistan, Nigeria, Democratic Republic of the Congo, Bangladesh, Uganda, the U.S., Ethiopia and China. The only rich country on the list is the U.S., where roughly one third of population growth is driven by a high rate of immigration [see box on page 54].

In contrast, 51 countries or areas, most of them economically more developed, will lose population between now and 2050. Germany is expected to drop from 83 million to 79 million people, Italy from 58 million to 51 million, Japan from 128 million to 112 million and, most dramatically, the Russian Federation from 143 million to 112 million. Thereafter Russia will be slightly smaller in population than Japan.

Slowing population growth everywhere means that the 20th century was probably the last in human history in which younger people outnumbered older ones. The proportion of all people who were children aged four years and younger

CROSSROADS FOR POPULATION

THE PROBLEM:

- Rapid population growth will boost human numbers by nearly 50 percent, from 6.5 billion now to 9.1 billion in 2050. Virtually all this growth will happen in existing or new cities in developing countries. During the same period, many richer nations will lose population. Falling fertility and increasing longevity worldwide will expand the proportion of potentially dependent elderly people.

THE PLAN:

- Create a bigger pie, and fewer forks, and better manners: Intensify human productive capacity through investment in education, health and technology. Increase access to reproductive health care and contraception to voluntarily slow population growth. Improve the terms of people's interactions by reforming economic, political, civil and social institutions, policies and practices and achieving greater social and legal equity.



Niger's population will grow 258 percent by 2050.

POPULATION

Global population projections depend on assumptions about human choices.

The medium projection of **9.1 billion** people in 2050 assumes fertility will continue its downward trend

If women had, on average, just one-half child more than assumed, 2050 population would be **10.6 billion**

With one-half child less per woman, it would be **7.7 billion**

If 2005 fertility rates remained constant to 2050, population would reach **11.7 billion**



peaked in 1955 at 14.5 percent and gradually declined to 9.5 percent by 2005, whereas the fraction of people aged 60 years and older increased from a low of 8.1 percent in 1960 to 10.4 percent in 2005. Around 2000 each group constituted about 10 percent of humanity. Now and henceforth the elderly have the numerical upper hand.

This crossover in the proportions of young and old reflects both improved survival and reduced fertility. The average life span grew from perhaps 30 years at the beginning of the 20th century to more than 65 years at the beginning of the 21st century. The more powerful influence, however, is reduced fertility, adding smaller numbers to the younger age groups.

The graying of the population is not proceeding uniformly around the globe. In 2050 nearly one person in three will be 60 years or older in the more developed regions and one person in five in the less developed zones. But in 11 of the least developed countries—Afghanistan, Angola, Burundi, Chad, Democratic Republic of the Congo, Equatorial Guinea, Guinea-Bissau, Liberia, Mali, Niger and Uganda—half the population will be aged 23 years or younger.

If recent trends continue as projected to 2050, virtually all of the world's population growth will be in urban areas. In effect, the poor countries will have to build the equivalent of a city of more than one million people each week for the next 45 years.

Although long-term demographic projections to 2050 and beyond are routine, economic models are not well developed for long-term projection. They are vulnerable to unpredictable changes in institutions and technology and to shifts in the dominance of regions and economic sectors. Most models do, however, predict that the world will become richer. In the brightest scenarios, the ratio of per capita income in industrial nations to that in developing nations could drop from an

estimated 16 to 1 in 1990 to between 6.6 to 1 and 2.8 to 1 in 2050. These gains are not assured. Other models predict stagnating poverty.

Projections of billions more people in developing countries and more elderly people everywhere, coupled with hopes of economic growth especially for the world's poor, raise concerns in some quarters about the sustainability of present and future populations.

Beyond Human Carrying Capacity

IN THE SHORT TERM, our planet can provide room and food, at least at a subsistence level, for 50 percent more people than are alive now because humans are already growing enough cereal grains to feed 10 billion people a vegetarian diet. But as demographer-sociologist Kingsley Davis observed in 1991, "There is no country in the world in which people

THE AUTHOR

JOEL E. COHEN

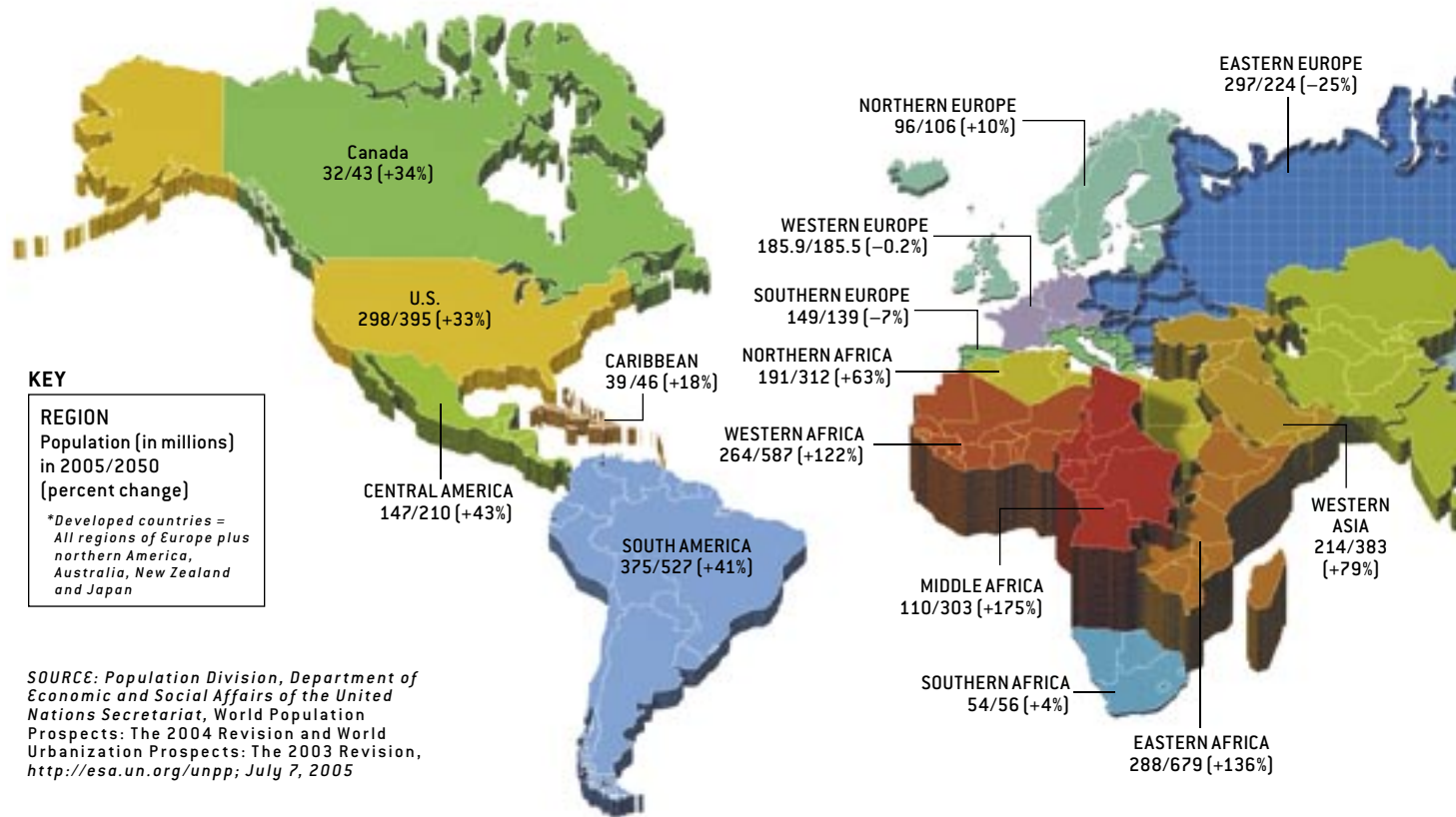
COHEN is Professor of Populations and head of the Laboratory of Populations at the Rockefeller University and Columbia University. He studies the population biology, demography, ecology and epidemiology of human and nonhuman populations using mathematics, statistics and computation. Author, co-author or editor of a dozen books and author of more than 320 papers, he has won the Tyler Prize for Environmental Achievement, the Nordberg Prize for excellence in writing in the population sciences, and the Fred L. Soper Prize of the Pan American Health Organization for his work on Chagas' disease. He enjoys playing the piano and being father to "the two best children in the world."

GLOBAL POPULATION IN TRANSITION

Uneven growth will further shift the population balance between rich and poor nations. In 2005 developed* countries are home to 1.2 billion of the world's 6.5 billion people; less developed countries are home to the other

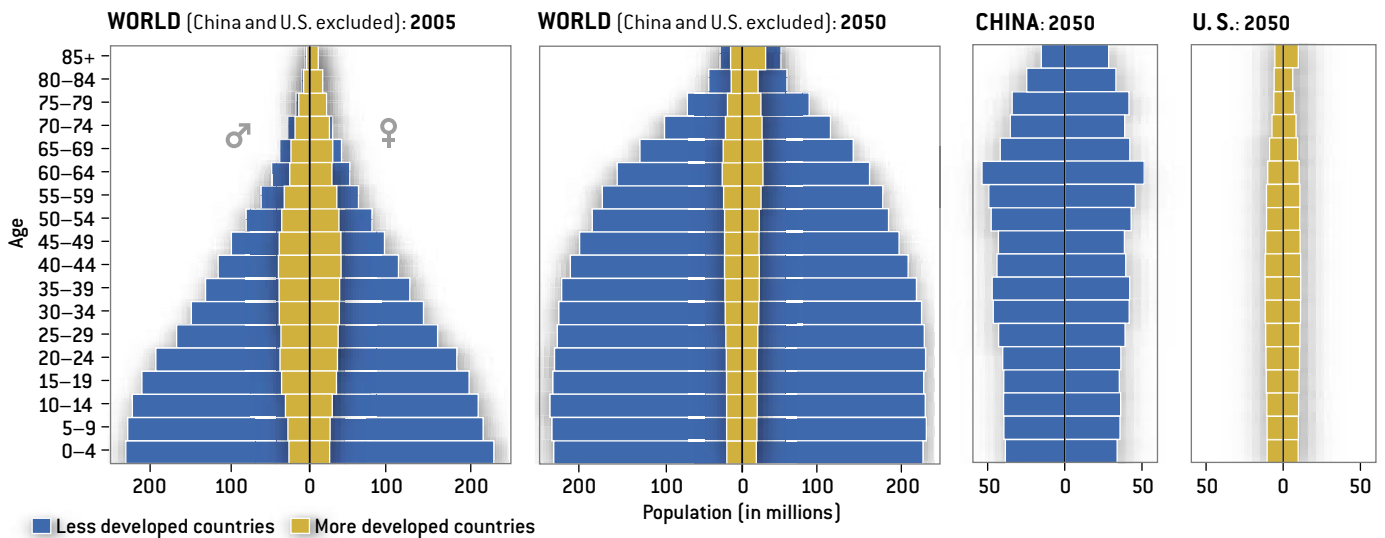
5.3 billion. In 2050 the rich countries will still have about 1.2 billion people, but the poor countries will grow to 7.9 billion. Falling fertility rates will cause some rich nations to begin losing population from 2010 onward. Fertility will

SOURCE FOR URBAN POPULATION GRAPH: CITIES TRANSFORMED: DEMOGRAPHIC CHANGE AND ITS IMPLICATIONS IN THE DEVELOPING WORLD, BY M. R. MONTGOMERY ET AL., NATIONAL ACADEMIES PRESS, 2003



KEY
REGION
 Population (in millions) in 2005/2050 (percent change)
 *Developed countries = All regions of Europe plus northern America, Australia, New Zealand and Japan

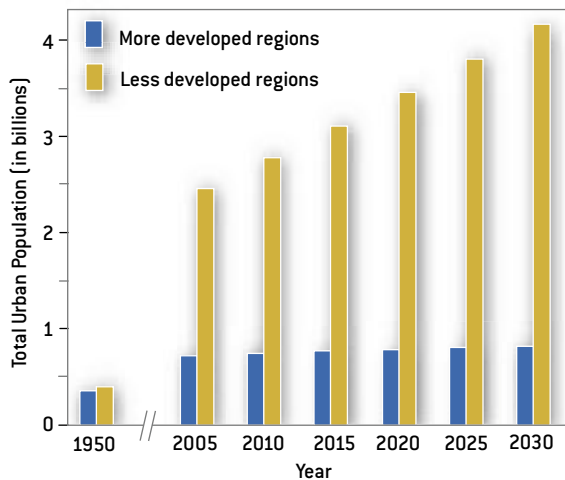
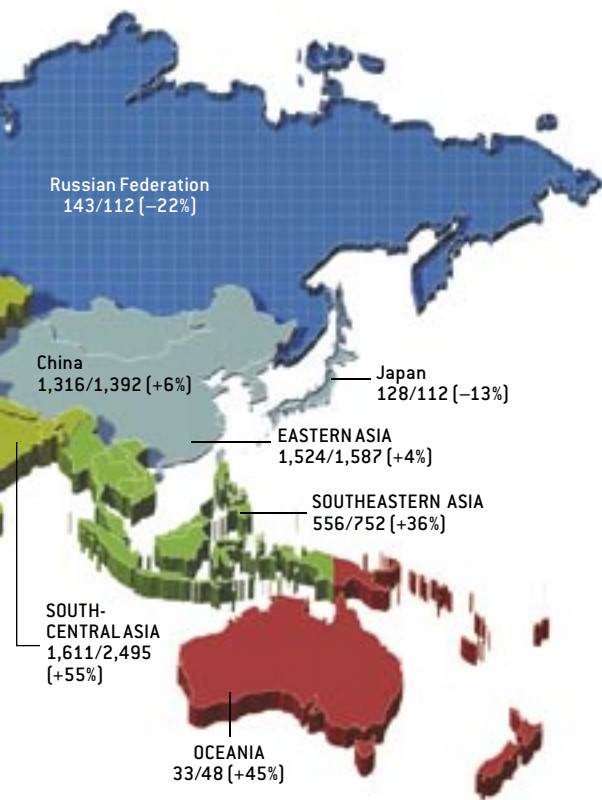
SOURCE: Population Division, Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2004 Revision and World Urbanization Prospects: The 2003 Revision, <http://esa.un.org/unpp>; July 7, 2005



AGE STRUCTURE of populations is also shaped by fertility differences. In less developed countries, where population is growing rapidly, each new birth cohort is larger than its predecessor and the population resembles a broadly based pyramid. In more developed countries, where fertility is low and survival at old ages is high, the pyramid looks like a column that will

become more top-heavy in the next 45 years. China and the U.S. are exceptions in their categories: China's long-standing one-child policy gives it a population structure more like that of the developed countries, and substantial immigration keeps the U.S. "younger" than most developed countries.

also drop, on average, in developing countries, to a replacement level of 2.1 children per woman by around 2035, although birth rates in some of the poorest countries will remain higher.



URBAN POPULATIONS grow much faster in poor countries than in rich ones, according to projections displayed by national income level. About 60 percent of the developing countries' urban growth will result from the excess of births over deaths and the rest from migration of rural people to urban areas.

are satisfied with having barely enough to eat.” The question is whether 2050’s billions of people can live with freedom of choice and material prosperity, however freedom and prosperity may be defined by those alive in 2050, and whether their children and their children’s offspring will be able to continue to live with freedom and prosperity, however they may define them in the future. That is the question of sustainability.

This worry is as old as recorded history. Cuneiform tablets from 1600 B.C. showed that the Babylonians feared the world was already too full of people. In 1798 Thomas Malthus renewed these concerns, as did Donella Meadows in her 1972 book *The Limits to Growth*. While some people have fretted about too many people, optimists have offered reassurance that deities or technology will provide for humankind’s well-being.

Early efforts to calculate Earth’s human carrying capacity assumed that a necessary condition for a sustainable human society could be measured in units of land. In the first known quantitative reckoning, Antoni van Leeuwenhoek estimated in 1679 that the inhabited area of Earth was 13,385 times larger than Holland and that Holland’s population then was about one million people. Assuming that “the inhabited part of the earth is as densely populated as Holland, though it cannot well be so inhabited,” he wrote, “the inhabited earth being 13,385 times larger than Holland yields ... 13,385,000,000 human beings on the earth,” or an upper limit of roughly 13.4 billion.

Continuing this tradition, in 2002 Mathis Wackernagel, an author of the “ecological footprint” concept, and his colleagues sought to quantify the amount of land humans used to supply resources and to absorb wastes. Their preliminary assessment concluded that humanity used 70 percent of the global biosphere’s capacity in 1961 and 120 percent in 1999. In other words, by 1999 people were exploiting the environment faster than it could regenerate itself, they claimed, a situation that is clearly unsustainable.

This approach has many problems. Perhaps the most serious is its attempt to establish a necessary condition for the sustainability of human society in terms of the single dimension of biologically productive land area. For instance, to translate energy use into land units, Wackernagel and his colleagues calculated the area of forests that would be needed to absorb the carbon dioxide produced in generating the energy. This approach fails for energy generation technologies that do not emit carbon dioxide, such as solar panels, hydropower or nuclear plants. Converting all energy production to nuclear energy would change the dilemma from too much CO₂ to too much spent nuclear fuel. The problem of sustainability remains, but biologically productive land area is not a useful indicator of it.

Other one-dimensional quantities that have been proposed as ceilings on human carrying capacity include water, energy, food and various chemical elements required for food production. The difficulty with every single index of human carrying capacity is that its meaning depends on the value of other factors. If water is scarce and energy is abundant, for example, it is easy to desalinate and transport water; if energy is expensive, desalination and transport may be impractical.

Attempts to quantify Earth’s human carrying capacity or a sustainable human population size face the challenge of understanding the constraints imposed by nature, the choices faced by people and the interactions between them. Some of the constraints imposed by nature are dealt with elsewhere in this issue. Here I will draw attention to the questions of human choice involved in assessing sustainability.

What will humans desire and what will they accept as the average level and distribution of material well-being in 2050 and beyond? What

BRYAN CHRISTIE DESIGN (map); JEN CHRISTIANSEN (graphs)

THE MIGRATION WILD CARD



MIGRATION HAS LITTLE immediate effect on global population size but may accelerate the slowing of population growth. Migrants who move from high-fertility to low-fertility regions or their descendants often adopt the reduced-fertility patterns of their new home, with some time delay. From 2005 to 2050, the more developed regions are projected to have about 2.2 million more immigrants than emigrants a year, and the U.S. is expected to receive about half of these.

More than most demographic variables, future international migration is subject to intentional policy choices by national governments, making it difficult to predict. Assuming that recent levels of migration continue, the 98 million net migrants expected to move to the developed regions during 2005–2050 would more than offset the projected loss of 73 million people in those countries from an excess of deaths over births. Different international migration scenarios would not greatly affect the sharp rise in the rich countries' proportion of dependent elderly projected for the coming century, although they could dramatically affect population size.

In 2000, for example, the U.S. Census Bureau projected the nation's numbers in 2050 with different levels of immigration. Results ranged from 328 million, representing a 20 percent population increase with zero immigration, to 553 million, representing an 80 percent increase with the highest level of immigration—hypothetical net annual immigration rising to 2.8 million by 2050. Regardless of migration, though, the U.S. ratio of elderly to working-age people will rise steeply from 2010 until around 2035 and will gradually increase thereafter. By 2050 it is projected to reach 39 percent with zero immigration and 30 percent with the highest immigration. —J.E.C.

technologies will be used? What domestic and international political institutions will be used to resolve conflicts? What economic arrangements will provide credit, regulate trade, set standards and fund investments? What social and demographic arrangements will influence birth, health, education, marriage, migration and death? What physical, chemical and biological environments will people want to live in? What level of

variability will people be willing to live with? (If people do not mind seeing human population size drop by billions when the climate becomes unfavorable, they may regard a much larger population as sustainable when the climate is favorable.) What level of risk are people willing to live with? (Are mud slides, hurricanes or floods acceptable risks or not? The answer will influence the area of land viewed as habitable.) What time horizon is assumed? Finally, and significantly, what will people's values and tastes be in the future? As anthropologist Donald L. Hardesty noted in 1977, "A plot of land may have a low carrying capacity, not because of low soil fertility but because it is sacred or inhabited by ghosts."

Most published estimates of Earth's human carrying capacity uncritically assumed answers to one or more of these questions. In my book *How Many People Can the Earth Support?* I collected and analyzed more than five dozen of these estimates published from 1679 onward. Those made in just the past half a century ranged from less than one billion to more than 1,000 billion. These estimates are political numbers, intended to persuade people, one way or another: either that too many humans are already on Earth or that there is no problem with continuing rapid population growth.

Scientific numbers are intended to describe reality. Because no estimates of human carrying capacity have explicitly addressed the questions raised above, taking into account the diversity of views about their answers in different societies and cultures, no scientific estimates of sustainable human population size can be said to exist.

Too often attention to long-term sustainability is a diversion from the immediate problem of making tomorrow better than today, a task that does offer much room for science and constructive action. Let us therefore briefly consider two major demographic trends, urbanization and aging, and some of the choices they present.

Boom or Bomb?

MANY MAJOR CITIES were established in regions of exceptional agricultural productivity, typically the floodplains of rivers, or in coastal zones and islands with favorable access to marine food resources and maritime commerce. If the world's urban population roughly doubles in the next half a century, from three billion to six billion, while the world's rural population remains roughly constant at three billion, and if many cities expand in area rather than increasing in density, fertile agricultural lands around those cities could be removed from production, and the waters around coastal or island cities could face a growing challenge from urban waste.

Right now the most densely settled half of the planet's population lives on 2 to 3 percent of all ice-free land. If cities double in area as well as population by 2050, urban areas could grow to occupy 6 percent of land. Withdrawing that amount mostly from the 10 to 15 percent of land considered arable could have a notable impact on agricultural production. Planning cities to avoid consuming arable land would greatly reduce the effect of their population growth on food produc-

tion, a goal very much in the urbanites' interest because the cities will need to be provisioned.

Unless urban food gardening surges, on average each rural person will have to shift from feeding herself (most of the world's agricultural workers are women) and one city dweller today to feeding herself and two urbanites in less than half a century. If the intensity of rural agricultural production increases, the demand for food, along with the technology supplied by the growing cities to the rural regions, may ultimately lift the rural agrarian population from poverty, as happened in many rich countries. On the other hand, if more chemical fertilizers and biocides are applied to raise yields, the rise in food production could put huge strains on the environment.

For city dwellers, urbanization threatens frightening hazards from infectious disease unless adequate sanitation measures supply clean water and remove wastes. Yet cities also concentrate opportunities for educational and cultural enrichment, access to health care, and diverse employment. Therefore, if half the urban infrastructure that will exist in the world of 2050 must be built in the next 45 years, the opportunity to design, construct, operate and maintain new cities better than old ones is enormous, exciting and challenging.

Urbanization will interact with the transformation of human societies by aging. Cities raise the economic premium paid to younger, better-educated workers whereas the mobility they promote often weakens traditional kin networks that provide familial support to elderly people. An older, uneducated woman who could have familial support and productive work in agriculture if she lived in a rural area might have difficulty finding both a livelihood and social support in a city.

After 2010, most countries will experience a sharp acceleration in the rate of increase of the elderly dependency ratio—the ratio of the number of people aged 65 and older to the number aged 15 to 64. The shift will come first and most acutely in the more developed countries, whereas the least developed countries will experience a slow increase in elderly dependency after 2020. By 2050 the elderly dependency ratio of the least developed countries will approach that of the more developed countries in 1950.

Extrapolating directly from age to economic and social burdens is unreliable, however. The economic burden imposed by elderly people will depend on their health, on the economic institutions available to offer them work, and on the social institutions on hand to support their care.

Trends in the health of the elderly are positive overall, despite severe problems in some economies in transition and re-

gions afflicted by AIDS. The rate of chronic disability among elderly Americans, for example, declined rapidly between 1982 and 1999. As a result, by 1999, 25 percent fewer elderly Americans were chronically disabled than would have been expected if the U.S. disability rate had remained constant since 1982.

Because an older person relies first on his or her spouse in case of difficulty (if there is a spouse), marital status is also a key influence on living conditions among the elderly. Married elderly people are more likely to be maintained at home rather than institutionalized compared with single, widowed or divorced persons.

The sustainability of the elderly population depends in complex ways not only on age, gender and marital status but also on the availability of supportive offspring and on socioeconomic status—notably educational attainment. Better education in youth is associated with better health in old age. Consequently, one obvious strategy to improve the sustainability of the coming wave of older people is to invest in educating youth today, including education in those behaviors that preserve health and promote the stability of marriage. Another obvious strategy is

to invest in the economic and social institutions that facilitate economic productivity and social engagement among elderly people.

No one knows the path to sustainability because no one knows the destination, if there is one. But we do know much that we could do today to make tomorrow better than it would be if we do not put our knowledge to work. As economist Robert Cassen remarked, “Virtually everything that needs doing from a population point of view needs doing anyway.” SA

One agricultural worker today feeds herself and one city dweller on average. In 2050 she will have to feed herself and two urbanites.



MORE TO EXPLORE

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