Human Population

The Next Half Century

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By 2050, the human population will probably be larger by 2 to 4 billion people, growing more slowly (declining in the more developed regions), more urban, especially in less developed regions, and older than in the 20th century. Two major demographic uncertainties in the next 50 years are international migration and the structure of families. Economies, nonhuman environments, and cultures (including values, religions, and politics) strongly influence demographic changes. Hence, human choices—individual and collective—will have demographic effects, intentional or otherwise.

It is a convenient but potentially dangerous fiction to treat population projections as independent factors in economic, environmental, cultural, and political scenarios, as if population processes were autonomous. Belief in this fiction is encouraged by conventional population projections, which ignore food, water, housing, education, health, physical infrastructure, religion, values, institutions, laws, family structure, domestic and international order, and the physical and biological environment. The United Nations Population Division formally recognizes the impact of other biological species on humans explicitly only when quantifying the devastating demographic effects of HIV and AIDS. The absence from population projection algorithms of many influential external variables indicates scientific ignorance of how these variables influence demographic rates rather than a lack of influence (*1*).

Demographic projections stimulate fears of overpopulation in some people and fears of demographic decline and cultural extinction in others (*2*). This chapter does not attempt to assess the implications of likely demographic changes for health, nutrition, prosperity, international security, the physical, chemical and biological environment, or human values. Other chapters

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in this book cover such topics. Our objective here is to review current projections for the next half century to frame later contributions.

Past Population

In about 300 years, Earth's population grew more than 10-fold, from 600 million people in 1700 to 6.3 billion in 2003 (3). These and all demographic statistics are estimates; repeated qualifications of uncertainty will be omitted. It took from the beginning of time until about 1927 to put the first 2 billion people on the planet; less than 50 years to add the next 2 billion people (by 1974); and just 25 years to add the next 2 billion (by 1999). The population doubled in the most recent 40 years. Never before the second half of the 20th century had any person lived through a doubling of global population. Now some have lived through a tripling. The human species lacks any prior experience with such rapid growth and large numbers of its own species.

From 1750 to 1950, Europe and the New World experienced the most rapid population growth of any region, while the populations of most of Asia and Africa grew very slowly. Since 1950, rapid population growth shifted from Western countries to Africa, the Middle East, and Asia.

The most important demographic event in history occurred around 1965–70. The global population growth rate reached its all-time peak of about 2.1 percent per year (pa). It then gradually fell to 1.2 percent pa by 2002 (4). The global **total fertility rate** fell from 5 children per woman per lifetime in 1950–55 to 2.7 children in 2000–05. The absolute annual increase in population peaked around 1990 at 86 million and has fallen to 77 million. In 1960, five countries had total fertility rates at or below the level required to replace the population in the long run. By 2000, there were 64 such countries; together they included about 44 percent of all people (4, 5). Concurrent trends included worldwide efforts to make contraception and reproductive health services available, improvements in the survival of infants and children, widespread economic development and integration, movements of women into the paid labor market, increases in primary and secondary education for boys and girls, and other cultural changes.

KEY TERM

Total fertility rate is the number of children an average woman would have in her lifetime at present age-specific fertility rates. It is calculated by counting the average number of children borne per woman of every given age in the year of interest and totaling up these averages for all ages.

Worldwide urbanization, which has taken place for at least two centuries, accelerated greatly in the 20th century. In 1800, roughly 2 percent of people lived in cities; in 1900, 12 percent; in 2000, more than 47 percent, and nearly 10 percent of those city dwellers lived in cities of 10 million people or larger. Between 1800 and 1900, the number of city dwellers rose more than 11-fold, from 18 million to 200 million; between 1900 and 2000, the number of city dwellers rose another 14-fold or more, from 200 million to 2.9 billion. In 1900, no cities had 10 million people or more. By 1950, one city did: New York. In 2000, 19 cities had 10 million people or more. Of those 19 cities, only four (Tokyo, Osaka, New York, and Los Angeles) were in industrialized countries (6).

Demographic Projections of the Next 50 Years

Projections of future global population prepared by the United Nations Population Division, the World Bank, the United States Census Bureau, and some research institutions assume business as usual (7–9). They include recurrent catastrophes to the extent that such catastrophes are reflected in past trends of **vital rates**, but exclude

KEY TERM

The term vital rates refers to birth rates and death rates.

catastrophes of which there is no prior experience, such as thermonuclear holocaust or abrupt, severe climate change. The following summary relies mainly on the United Nations Population Division's urbanization forecasts (*6*) and *World Population Prospects: The 2002 Revision* (*4*).

Estimates of present levels of demographic variables are based on measurements taken in recent years, rather than global current measurements. Using these estimates, the United Nations (UN) prepares several different alternative population projections, including low-, medium-, high-, and constant-fertility scenarios or variants. According to the medium variant, the world's population is expected to grow from 6.3 billion in 2003 to 8.9 billion in 2050. Whereas the first absolute increase by 1 billion people took from the beginning of time until about 1800, the increase by 1 billion people from 6.3 billion to 7.3 billion is projected to require 13 to 14 years. The anticipated increase, by 2050, of 2.6 billion over 2003's population exceeds the total population of the world in 1950, which was 2.5 billion.

Current absolute and relative global population growth rates are far higher than any experienced before World War II. The annual addition of 77 million people poses formidable challenges of food, housing, education, health, employment, political organization, and public order. Virtually all of the increase is and will be in economically less-developed regions.

More than half of the annual increase currently occurs in six countries, from most to least: India, China, Pakistan, Bangladesh, Nigeria, and the United States. Of the total annual increase, the United States accounts for 4 percent.

Were fertility to remain at present levels, the population would grow to 12.8 billion by 2050—more than double its present size. The medium projection of 8.9 billion people in 2050 assumes that efforts to make means of family planning available to women and couples will continue and will succeed. It also assumes that after 2010, high-risk behaviors related to AIDS will become less frequent and chances of infection among those engaging in high-risk behaviors will decline. The UN's 2002 estimate of 8.9 billion people in 2050 is 0.4 billion lower than that in their 2000 medium variant. About half of the decrease in the projection for 2050 is due to fewer projected births and about half to more projected deaths, notably from AIDS.

Global statistics conceal vastly different stories in different parts of the world. In 2000, about 1.2 billion people lived in economically rich, more-developed regions: Europe, North America, Australia, New Zealand, and Japan. The remaining 4.9 billion lived in economically poor, less-developed regions. The current annual growth rate of global population is 1.22 percent, but wealthier regions' population currently increases 0.25 percent annually while poor regions' population grows 1.46 percent annually—nearly six times faster. The population of the least-developed regions—the 49 countries where the world's poorest 670 million people lived in 2000—increases annually by 2.41 percent. By 2050, the annual growth rate of global population is projected to be 0.33 percent. The poor countries' population will still be increasing 0.4 percent annually, whereas the population of the rich countries will have been declining for 20 years and will then be falling at −0.14 percent pa.

Thirty of the more developed countries are expected to have lower populations in 2050 than today, including Japan (expected to be 14 percent smaller), Italy (22 percent smaller), and the Russian Federation (29 percent smaller). By contrast, the population of today's poor countries is projected to rise to 7.7 billion in 2050 from 4.9 billion in 2000. Fertility in the less-developed regions is expected to fall to replacement level in 2030–35, but to remain above 2 children per woman by 2050 because some of the least-developed countries will still have total fertility rates well above replacement level. The

population of these high-fertility poor countries will be an increasing proportion of the population of the less developed regions.

The world's average population density of 45 people/km^2 in 2000 is projected to rise to 66 people/km^2 by 2050. Globally, perhaps 10 percent of land is arable, so population densities per unit of arable land are roughly 10 times higher. In the rich countries, the population density was 23 people/km^2 in 2000—half the global average—and was projected not to change at all by 2050. In the poor countries, the population density was 59 people/km^2 in 2000 and was projected to rise to 93 people/km^2 in 2050. For comparison, the population density of Liechtenstein was 204 people/km^2 in 2000 and that of the United States was 30. A population density of 93 people/km^2 over the entire developing world will pose unprecedented problems of land use and preservation.

According to these projections, the ratio of population density in the poor countries to that in the rich countries is projected to rise from 2.6 in 2000 to 4.0 in 2050. Over the same interval, while the population density of Europe is projected to drop from 32 to 27 people/km^2, that of Africa is projected to rise from 26 to 60 people/km^2. The ratio of population density in Africa to that in Europe is projected to rise from 0.8 in 2000 to 2.2 in 2050. It seems plausible to anticipate increasing human effects on the natural environment in Africa and increasing pressure of migrants from Africa to Europe.

The difference in the population growth rate between rich and poor countries affects both population size and age structure. If a population grows slowly, the number of births each year nearly balances the number of deaths. Because most deaths occur at older ages, the numbers of individuals in different age groups are roughly equal up to older ages. The so-called population pyramid of a slowly growing population resembles a column (Figure 1, middle row left) (*10*). If a population grows rapidly, each birth cohort is larger than its predecessor and the population pyramid is triangular (Figure 1, middle row right). The projected difference in age structures between the European Union versus North Africa and western Asia (Figure 1, bottom) has obvious implications for the supplies of military personnel and ratios of elderly to middle-aged.

Inequality in the face of death between rich and poor will decrease but remain large if survival improves everywhere as anticipated in the coming half century. Global life expectancy in 2000–05 is estimated at 65 years; in 2045–50, it is projected at 74 years. Over the same interval, life expectancy in the rich countries is expected to rise from 76 years to 82 years and in the poor countries from 63 years to 73 years. The average infant born in a poor country had a chance of dying before age 1 that was 8.1 times higher than that in a rich country in 2000–05; the same ratio is projected to be 5.2 in 2045–50.

Despite higher death rates, poor countries' populations grow faster than those of rich because birth rates in poor countries are much higher. At current birth rates, during her lifetime, the average woman in the poor countries bears nearly twice as many children (2.9) as in the rich countries (1.6). By 2050, according to the medium variant, the total fertility rate in today's poor countries will drop to 2.0. The total fertility rate in today's more developed countries is projected to rise to almost 1.9 children per woman, as timing effects (beginning childbearing at later ages) that currently depress the total fertility rate cease to operate.

Urbanization will continue to be an important trend. In the coming decade, more than half of all people will live in cities for the first time in human history. Almost all population growth in the next half century will occur in cities in poor countries while the world's rural population will remain flat—near 3 billion people. The United Nations Population Division projects urban population only as far as 2030 (*6*). Its figures on urbanization disguise major ambiguities and variations among countries, primarily because of differences in definitions of the terms *cities* and *urban*. Nevertheless, the trend toward urbanization is clear. Of the projected 2.2 billion increase in population from 2000 to 2030, 2.1 billion will

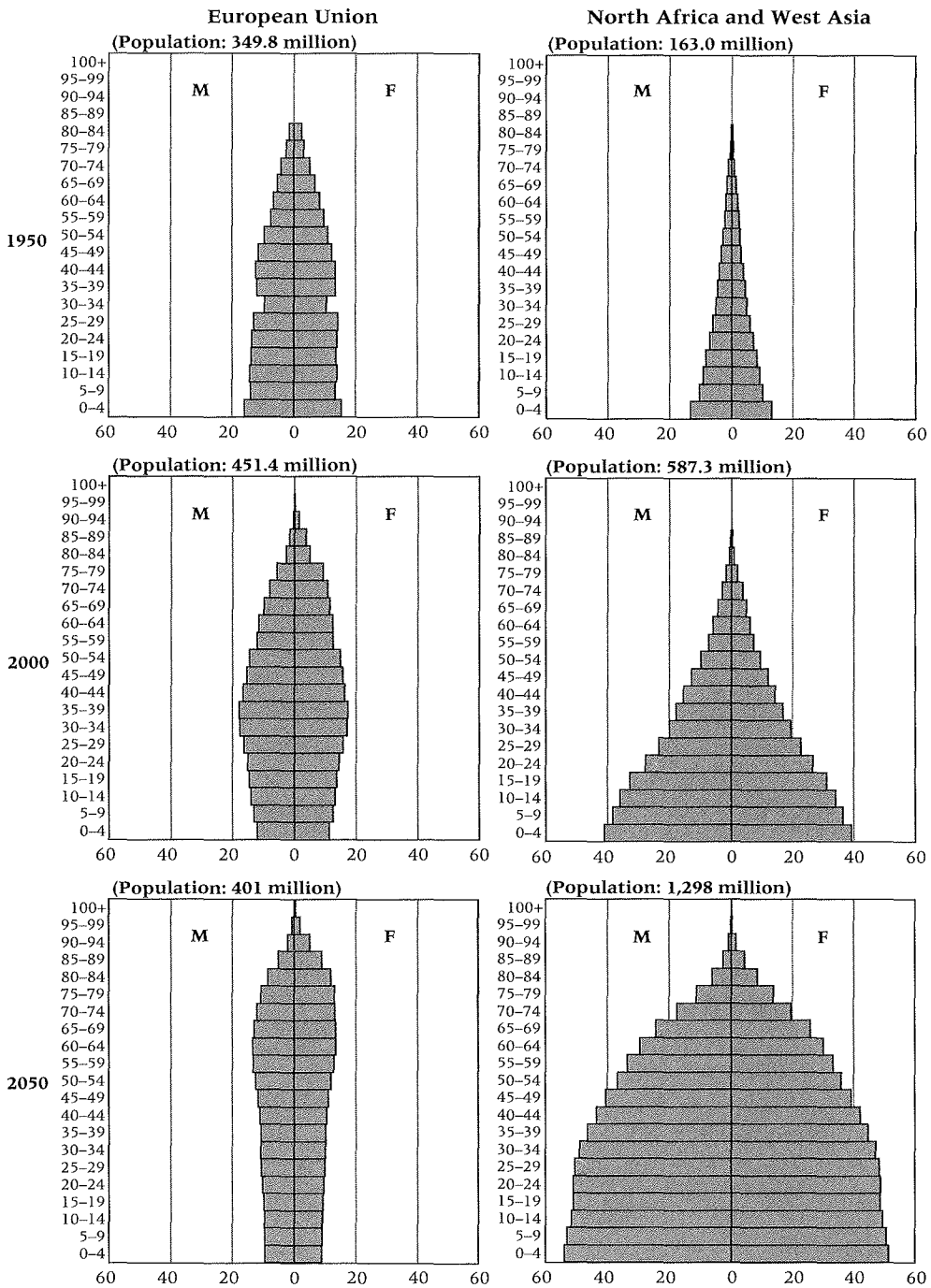

FIGURE 1. Population size and age distribution for 1950, 2000, and 2050 in an anticipated enlarged European Union of 25 countries and in 25 countries of North Africa and West Asia between India's western border and the Atlantic Ocean. The figure excludes countries of central Asia that were part of the former Soviet Union, those of Muslim black Africa, and Israel (10). Horizontal scale gives million persons separately by sex; vertical scale gives age groups in increments of 5 years.

be in urban areas, and all but 0.1 billion of that urban increase will be in developing countries. The annual rate of increase of urban population over the next 30 years, 1.8 percent, is nearly twice the projected annual rate of increase of global population during that period.

The urban population of developing regions will grow rapidly as people migrate from rural to existing urban areas and transform rural settlements into cities. The rural population of the rich countries peaked around 1950 and has slowly declined since then. The rural population of the

presently poor countries is expected to peak around 2025 and then gradually decline. Urbanization of the rich countries will continue, with city dwellers rising from 75 percent of people in 2000 to 83 percent in 2030. Over the same period, urbanization of the poor countries will rise from 40 percent to 56 percent, similar to the level of urbanization in the rich countries in 1950.

The coming half century will also see a dramatic aging of the population, which means that a higher proportion of the population will be in elderly age groups. The proportion of children aged 4 years and under peaked in 1955 at 14.5 percent and gradually declined to 10.2 percent in 2000. By contrast, the proportion of people aged 60 years and older gradually increased from a low of 8.1 percent in 1960 to 10.0 percent in 2000. Each group constitutes about 10 percent of humanity today. The 20th century will probably be the last in which younger people outnumbered older ones. Children aged 0 to 4 are projected to decline to 6.6 percent of global population by 2050, whereas people aged 60 years and older are projected to more than double, to 21.4 percent. By 2050, there will be 3.2 people aged 60 years or older for every child 4 years old or younger.

This reversal in the numerical dominances of old and young reflects improved survival and reduced fertility. Improved survival raised the global average length of life from perhaps 30 years at the beginning of the 20th century to 65 years at the beginning of the 21st. Reduced fertility rates added smaller cohorts to the younger age groups.

Because the populations of the poor countries have been growing more rapidly than those of the rich, they have a much higher fraction of people under the age of 15 years (33 percent versus 18 percent in 2000). By 2050, in the medium variant, these fractions will drop to 21 percent and 16 percent in poor and rich countries, respectively. The global fraction of the elderly population (aged 65 years or more) will rise from 7 percent in 2000 to 16 percent by 2050. Over the same period, the elderly fraction will rise from 5 to 14 percent in the presently poor countries and from 14 to 26 percent in the rich countries.

Though the fraction of children in the population will decrease by more in the poor countries than in the rich, the fraction of elderly will increase by more in the rich countries than in the poor. Both shifts will have consequences for spending on the young and the old. Slowly growing populations have a higher **elderly dependency ratio** (the ratio of the number of people aged 65 and older to the number aged 15 to 64), while rapidly growing populations have a higher youth dependency ratio (the ratio of the number of people aged 0 to 14 to the number aged 15 to 64).

KEY TERM

The **elderly dependency ratio** is the ratio of people 65 and over to the population aged 15–64. A high ratio is interpreted to mean that those of working age face a greater burden in supporting the aging population, but that interpretation depends heavily on the age of retirement from work and the health of the elderly.

The elderly dependency ratio rose from 1950 to 2000 rapidly in the more developed countries, slightly less rapidly in the United States, and still less rapidly in the world as a whole. The ratio rose only slightly in the less-developed countries, and hardly at all in the least-developed countries. After 2010, in the more developed countries, the United States, and the less-developed countries, the elderly dependency ratio will increase much faster than in the past; this acceleration will be greater in the more developed countries and the United States. The least-developed countries will experience a slow increase in the elderly dependency ratio after 2020 and, by 2050, will be

approaching the elderly dependency ratio found in the more-developed countries in 1950.

Demographic Uncertainties: Migration and the Family

According to the United Nations Population Division, "International migration is the component of population dynamics most difficult to project reliably. This occurs in part because the data available on past trends are sparse and partial, and in part because the movement of people across international boundaries, which is a response to rapidly changing economic, geopolitical or security factors, is subject to a great deal of volatility" (*11*). The UN's 2002 medium variant posits migration from less- to more-developed regions of 2.6 million people annually during 1995–2000, declining to nearly 2.0 million by 2025–30, and remaining constant at that level until 2050. The United States is anticipated to increase by 1.1 million of these 2 million migrants annually, more than five times the number expected to be added to the next largest recipient, Germany (at 211,000 migrants annually). The major sending countries are expected to be China, Mexico, India, the Philippines, and Indonesia, in decreasing order.

International migration is likely to remain important for specific countries, including the United States. In the mid-1990s, about 125 million people (2 percent of world population) resided outside of their country of birth or citizenship. In 1990, only 11 countries in the world had more than 2 million migrants; collectively they had almost 70 million migrants. The largest numbers of migrants were in the United States (19.6 million), India (8.7 million), Pakistan (7.3 million), France (5.9 million), and Germany (5.0 million). The countries with the highest percentage of international migrants in the total population were countries with relatively small populations. In the United Arab Emirates, Andorra, Kuwait, Monaco, and Qatar, 64 to 90 percent of the population were immigrants.

Predicting international migration is difficult. Predicting change in family structure is even more difficult. Goldscheider (*12*) suggested that the fall in fertility during the demographic transition weakened the ties between men and women based on parenthood and that the rise in divorce and cohabitation is weakening the ties between fathers and children. Nonmarital births increased as a percentage of all births in the United States from 5.3 percent in 1960 to 33.0 percent in 1999. In 1999, the United States had 1.3 million births to unmarried women (*13*). In 1998, Iceland, Norway, Sweden, Denmark, France, the United Kingdom, and Finland all had higher proportions of nonmarital births than the United States. By contrast, in Germany, Italy, Greece, and Japan, less than 15 percent of births were nonmarital (*13*). Among United States women aged 15 to 29 years at first birth, when that first birth was conceived before marriage, the fraction who married before the birth fell from 60 percent in 1960–64 to 23 percent in 1990–94 (*14*). By 1994, about 40 percent of children in the United States did not live with their biological father (*12*).

In the United States, the number of widowed males aged 55 to 64 per thousand married persons fell from 149 in 1900 to 35 in 2000, whereas the number of divorced men aged 55 to 64 per thousand married persons rose from 7 to 129. Divorced men became more frequent than widowed men between 1970 and 1980. Divorced women became more frequent than widowed women between 1990 and 2000. By 2000, the number of divorced and widowed persons aged 55 to 64 per thousand married persons was 164 men and 426 women (2.6 such women for each such man) (*15*). Remarriages and stepfamilies are becoming increasingly common.

Three factors set the stage for further major changes in families: fertility falling to very low levels; increasing longevity; and changing mores of marriage, cohabitation, and divorce. In a population with one child per family, no children have siblings. In the next generation, the children of

those children have no cousins, aunts, or uncles. If adults live 80 years and bear children between age 20 and 30 on average, then the parents will have decades of life after their children have reached adulthood and their children will have decades of life with elderly parents. The full effects on marriage, child bearing, and child rearing of greater equality between the sexes in education; earnings; and social, legal, and political rights have yet to be felt or understood.

References and Notes

1. J. E. Cohen, *How Many People Can the Earth Support?* (W. W. Norton, New York, 1995).

2. L. Shriver, *Popul. Dev. Rev.* 29 (no. 2), 153 (2003).

3. United States Census Bureau, *Historical Estimates of World Population* (online). Available at www.census.gov/ipc/www/worldhis.html (cited 21 June 2003).

4. United Nations Population Division, *World Population Prospects: The 2002 Revision, Highlights* (online database). ESA/P/WP.180, revised 26 February 2003, p. vi. Available at: http://esa.un.org/unpp/ (consulted 1–30 June 2003).

5. United Nations Population Division, *Partnership and Reproductive Behaviour in Low-Fertility Countries*, ESA/P/WP.177, revised May 2003. Available at www.un.org/esa/population/publications/reprobehavior/partrepro.pdf (cited 29 June 2003).

6. United Nations Population Division, *World Urbanization Prospects: The 2001 Revision.* ESA/P/WP.173. (United Nations, New York, 2002).

7. J. Bongaarts, R. A. Bulatao, Eds. *Beyond Six Billion: Forecasting the World's Population* (National Academy Press, Washington, DC, 2002).

8. J. E. Cohen, in *Seismic Shifts: The Economic Impact of Demographic Change*, J. S. Little, R. K. Triest, Eds., Federal Reserve Bank of Boston, conference series no. 46, 11–13 June 2001 (Federal Reserve Bank of Boston, Boston, MA, 2001), pp. 83–113.

9. J. E. Cohen, in *What the Future Holds: Insights from Social Science*, R. N. Cooper, R. Layard, Eds. (MIT Press, Cambridge, MA, 2002), pp. 29–75.

10. P. Demeny, *Popul. Dev. Rev.* 29 (no. 1), 1 (2003).

11. United Nations Population Division, *World Population Prospects: The 1998 Revision: Volume III: Analytical Report.* ESA/P/WP.156, revised 18 November 1999 (United Nations, New York, 1999).

12. F. K. Goldscheider, *Futurist* 32, 527 (2000).

13. S. J. Ventura, C. A. Bachrach, *National Vital Statistics Reports* 48 (no. 16, revised), 18 October 2000. Available at www.cdc.gov/nchs/data/nvsr/nvsr48/nvs48_16.pdf (cited 25 June 2003).

14. A. Bachu, *Current Population Reports;* P23–197 (U.S. Census Bureau, Washington, DC, 1999).

15. P. Uhlenberg, in *United Nations, Department for Economic and Social Information and Policy Analysis, 1994. Ageing and the Family.* Proceedings of the United Nations International Conference on Ageing Populations in the Context of the Family, ST/ESA/SER.R/124 (United Nations, New York, 1994), pp. 121–127.

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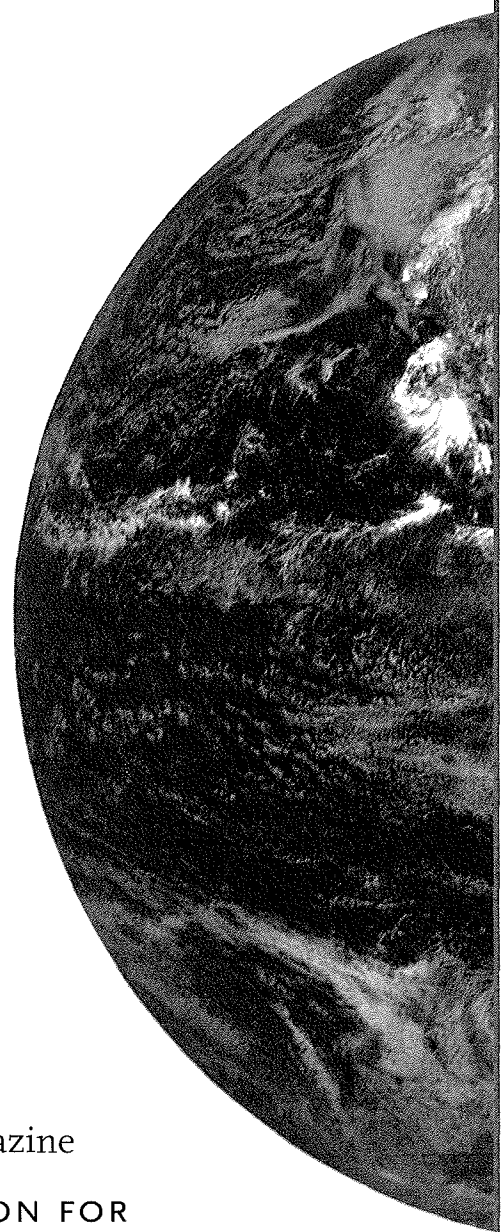

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