

Where next?

Malcolm Potts*

*Bixby Center, Population, Health and Sustainability, University of California,
University Hall, Berkeley, CA 94720, USA*

This paper provides a personal perspective on the rich discussions at the *Bixby Forum*. The size, rate of growth and age structure of the human population interact with many other key factors, from environmental change to governance. While the details of future interactions are sometimes difficult to predict, taken together they pose sombre threats to a socially and economically sustainable future for the rich and to any realistic possibility of lifting the world's bottom two billion people out of poverty. Adaptive changes will be needed to cope with an ageing population in countries with low fertility or below, but these are achievable. More worrying, continued rapid population growth in many of the least developed countries could lead to hunger, a failure of education to keep pace with growing numbers, and conflict. The assumption that the demographic transition from high to low birth rates occurs as a result of exogenous social and economic forces is being replaced by a clearer understanding of the many barriers that separate women from the knowledge and technologies they need to manage their childbearing within a human rights framework. The forum ended with a clear consensus that much more emphasis needs to be given to meeting the need for family planning and to investing in education.

Keywords: demographic transition; failed states; family planning; global warming; social capital; war

1. INTRODUCTION

Two compelling messages have come out of the preceding papers and discussions accompanying their presentation at *The Bixby Forum on the World in 2050: a Scientific Investigation of the Impact of Global Population Growth on a Divided World* (Bixby Forum 2009).

- (i) Rapid population growth in the least developed regions of the world, along with increasing consumption in the rich and newly rich nations, poses profound threats to further human development, to the natural environment and to peace and security.
- (ii) There is a large and growing unmet need for family planning, and any sensible set of policies to create a healthy, sustainable, peaceful world must emphasize the urgent need to invest in family planning. Much is known about how to make voluntary family planning accessible to the community. Modern contraception and safe abortion, backed up by correct information, can slow population growth even in illiterate communities living on one to two dollars a day. In turn, slower population growth interacts synergistically with other efforts to improve education, build human capital and improve the status of women around the world.

The *Bixby Forum* involved experts from many disciplines.¹ Cross-disciplinary thinking is rewarding but difficult. No one person can absorb and begin to

evaluate all scientific facts and speculations from fields as diverse as global warming, demographic theory, operations research in resource-poor settings, energy use or national security. Yet global problems demand analysis, and such analysis has to attempt to draw together data from many sources.

This overview is necessarily a personal perspective. I have tried to sift out what is most important and fill in some critical gaps. Inevitably, with such a broad subject as *The World in 2050*, the papers presented in this volume could not cover everything, for example, global warming was discussed at length but not encapsulated in a single presentation or paper.

2. INTERACTIONS

The theme behind *The World in 2050* is cross-disciplinary par excellence. It is the interaction between the variety of changes induced by human activities that make predicting further changes more difficult. This interaction greatly magnifies the threats human activity poses to sustaining the quality of life now enjoyed by the northern economies. It also makes extremely difficult lifting the world's two billion poorest people in the south out of abject poverty. Academics in many disciplines are cognizant of the importance of population size and structure, but they tend to develop linear models of the impact of population change within their own areas of expertise. Economists often do not have the tools to focus on the impacts of changes caused by population growth, which take a generation to manifest themselves. By contrast, biologists look at changes taking decades, centuries, millennia or even millions of years. Scientists, for good reason, are reluctant to speculate beyond the

*pottsmalcolm@gmail.com

One contribution of 14 to a Theme Issue 'The impact of population growth on tomorrow's world'.

facts they can verify in their own respective disciplines. However, when the interactions between different impacts of rapid population growth are explored, then the picture becomes sombre in the extreme. For example, projected increases in population in Africa have the potential to turn some countries into failed states. Physicists and astronomers, who easily handle big numbers and understand exponential growth, make particularly interesting commentators on population growth. It is the Astronomer Royal, Lord Rees (Rees 2004) who has had the courage to add to his book *Our final century*, the subtitle *Will the human race survive the twenty-first century?*

In contrast with all preceding ages, human activity has now overtaken natural geological and biological processes as the primary driver of global change. The pace of change is unprecedented, and the projected impact of interactions among economic growth, human population and other living systems is mind boggling. An analysis of 5487 known species of mammals, published a few months after the forum (Schipper *et al.* 2008), painted 'a bleak picture of the global status of mammals worldwide. We estimate that one in four species is threatened with extinction and that the population of one in two is declining'. Three-quarters of all fisheries are harvested at or beyond their maximum sustainable yield. Livestock numbers in Africa have tripled in the past half century and the worldwide contribution to greenhouse gases (GHGs) from methane released from cattle and goats may now exceed that of CO₂ and other greenhouse emissions from road vehicles (Steinfeld *et al.* 2006). The biggest man-made construction on Earth is no longer the Pyramids, the Great Wall of China or the Hoover Dam, but the Fresh Kills waste dump on Staten Island. Built on millions of tons of solid waste from New York, it covers 12 km² and, in parts, is taller than the Statue of Liberty. But solid waste is a small problem in comparison to the unseen but climate-changing gaseous waste resulting from energy production.

Since 1950, global industrial production has increased eightfold. In the brief interval between 1998 and 2007 the world used almost one-sixth of all the coal ever extracted from the Earth since the dawn of history. Oil production up to 1970 had doubled every decade for a century. Dawe (2008) estimates: 'the approximately twenty-nine billion barrels (of oil) mankind collectively manages to consume in a given year is roughly equivalent to the amount of oil which would have taken a staggering nine million years to accumulate'. There is debate among scientists on the exact amount of carbon-based fuels that can be extracted and on the time when peak use followed by an inevitable decline will occur. Some commentators place the peak use of oil closer and the peak consumption of coal further away than Nehring (2009) has done, but a decade here and a decade there are of little consequence in the overall picture. The area under the curve presented by Nehring (figure 1) to summarize possible future use of coal, if burnt, would produce sufficient CO₂ to drive the most pessimistic scenario of global warming. It is also clear that

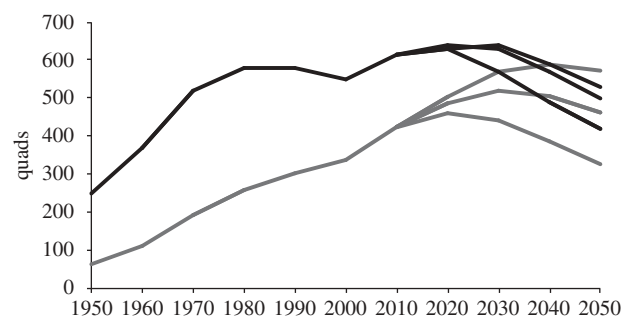


Figure 1. Actual and projected (high, medium and low) world energy production, 1950–2050. Black lines, *per capita*; grey lines, total.

by 2050, global energy consumption *per capita* will increase by less than 10 per cent of current levels. This implies that, even if the north uses energy more efficiently in the coming decades, the south will not be able to find the fossil fuels to drive industrialization and affluent life styles in the way the north did.

When the environmental impact of human activity first received widespread attention in the 1970s (Meadows *et al.* 1972), the fear was that economic growth would grind to a halt owing to lack of resources—the spigot feeding the economy would fail. Today, it is apparent not that we will run out of fossil fuels but that we will run out of the capacity of the atmosphere to absorb the GHGs produced by burning fossil fuels. The drain will block before the spigot fails. In the forum, John Harte summarized the current evidence for global warming, emphasizing that 'all the observed climate change phenomena are consistent with the predictions of climate science for GHG-induced warming'. He added that no alternative potential explanation of climate, other than GHGs, yields the observed 'fingerprint'. He argued, 'a credible skeptic would need to explain both what the alternative cause of observed changes is and how it could be that GHGs are not having the effects that all current scientific understanding says they should have'. It has been suggested that variations in the sun's heat output could account for the recent rise in global temperature, but if that were the case then the stratosphere should be getting hotter. If, on the other hand, GHGs gases are reflecting more of the sun's heat back to the Earth's surface, then the stratosphere should be cooling—and observation shows the stratosphere is indeed cooling.

Human-induced changes in the atmosphere over the course of the twentieth century raised global temperatures by 0.7°C. The direct effect of a doubling of CO₂ content in the twenty-first century can be predicted to raise temperatures by another 1.2°C. Even if GHG emissions could be stabilized at today's levels, CO₂ levels and temperatures will continue to rise for some time into the future.

On the whole, most climate models pay attention to population in simplistic ways, working only with the United Nations (UN) medium population projections. More complex models show important interactions between population growth, ageing urbanization and GHGs.

The real scientific problem, however, is that the primary and relatively predictable rise in temperature owing to GHGs will bring in its train a number of indirect effects. These indirect effects, such as changes in cloud cover, are both more difficult to predict and also potentially more threatening. For example, changes in cloud cover might reflect more heat back to the surface of the Earth, or cause cooling by allowing more heat to escape. The land exposed by melting Arctic ice will reflect less sunlight and accelerate warming, and perhaps also release gigatons of methane from the tundra. These difficult to predict secondary effects of global warming create what scientists call an asymmetrical uncertainty, or, as probabilities are often displayed as curves and graphs, a 'fat-tailed distribution'. Such indirect effects could add as little as an additional 0.3°C to the 1.2°C predicted for direct effects, or much as 3.4°C to give a total rise of 4.6°C . One of the many consequences of asymmetrical uncertainty is that cost-effectiveness analyses of possible interventions become extremely difficult, or virtually impossible. What is clear is that the 0.3°C additional rise would cause many disruptions and hardships, but such a temperature increase could be accommodated and would be survivable. The higher range could devastate food production and have geopolitical impacts of enormous importance.

The Food and Agriculture Organization tends to make linear projections of food production.² Grain prices are rising and global stocks are falling. In China, Pakistan and parts of the USA, 'fossil' water in deep aquifers is being used but not replenished. The erosion of arable land continues, especially in parts of Africa. Grain is being diverted to ethanol production and 'the grain required to fill a 25 gallon sport utility vehicle (SUV) tank with ethanol would feed one person for a year' (Brown 2009). More grain will also be used to feed livestock as the newly affluent countries are switching to eating more animal protein. But it is the interactions with other global changes that are likely to be most significant. If much of the Himalayan ice pack melts, then the Indus, Ganges, Yellow River, Mekong and Yangtze Rivers could all turn into brief flash floods interspersed with long, dry intervals. In turn, this could destroy the agricultural output on which well over one billion people depend today—a population that will have risen even further by 2050. If global warming were to reach as high as 4.6°C , then it would bring drought, deforestation and desertification on a huge scale to sub-Saharan Africa, where further population increase will be the most rapid. Also, to this threatening mix of changes needs to be added the prospect of more failed states and of civil and inter-state conflict (Thayer 2009).

The population growth factor is highly relevant to global warming and food security in the coming decades. In the west, and especially in the USA, slower population growth would also slow the increase in GHG emissions. The US population now at 300 million could reach in 2050 between 450 and 500 million. Every unintended birth prevented in the US will permit the rest of the world to breathe a little easier. The impact on climate change of slowing

population growth in the least developed countries is more difficult to evaluate. The Chinese one-child family may have averted 300 million births, and in doing so it contributed to the amazing pace of the country's economic growth. If birth rates slow and hundreds of millions of people are lifted out of poverty, then, although the final population may be smaller, the consumption of this now more affluent group could be greater than that of a larger population that had remained at subsistence economic levels.

The World Health Organization (WHO) estimates that the temperature changes that have occurred since 1970 were responsible for perhaps 150 000 excess deaths annually in the year 2000 (WHO 2009). This number is likely to rise substantially as the twenty-first century unfolds. Costello *et al.* (2009) consider 'climate change is the biggest global health threat of the twenty first century'. What is unchallengeable is that the deleterious effects of global warming, while generated mainly by northern GHGs, will fall disproportionately on the people of the south. By 2050, the average temperatures in the Sahel could equal today's highest measurements. Pressure by subsistence farmers on fragile ecosystems, combined with the economic activity of the north, driving further demand for tropical forest products, could accelerate environmental destruction. Such stresses are likely to increase the global conflict over resources. In such settings, even if these were evidence-based policies to maintain food production or to preserve the environment, a collapse of governance would make their implementation impossible.

3. POPULATION GROWTH AND DECLINE

The scale of changes in world population is difficult to grasp, and both academic and media attention to these changes has been fickle and confusing. Some insights that may seem self-evident still need to be emphasized. In the forum discussions, David Canning pointed out that population growth driven by high fertility is very different from population growth driven by falling mortality. The declines in mortality that have taken place in the past 60 years are one of the triumphs of the modern world. Longer life permits more return on any investment made in education and a higher level of savings as individuals look towards a longer retirement (Turner 2009b). There is never any benefit from high mortality, and high morbidity in childhood reduces substantially the benefit that can accrue from education.

Current population growth is mainly driven by declines in mortality, especially childhood mortality. The facts are simple: the current growth in human population continues to be extremely rapid. In 2008, there were 58 million deaths and 136 million births each year and the growth in world population in that one year (78 million) exceeded the population of Turkey (74.8 million) and was only slightly less than the population of Germany (82.2 million). By 2050, 99 per cent of the growth in the world's population that will have taken place since 2010 will have been in the least developed countries, where even today the rapid expansion in numbers of

people is outrunning the growth in educational opportunities.

The Bixby Forum occurred a few days before the 200th anniversary of the birth of Charles Darwin, and it is useful to compare rates of population growth today with those in the nineteenth century. When Darwin was born in 1809, there were fewer than one billion people in the whole world. When his book *On the origin of species* was published in 1859 there were 1.17 billion in the whole world, while today almost as many people now live in India (1.14 billion) (Cameron 1993). In Darwin's lifetime, the population of North America increased from under 20 million at his birth to around 75 million at his death in 1882. This growth of a population in that vast, resource-rich continent was driven by both the natural increase in births over deaths and massive immigration. Globally, the rate of global population increase between 1950 and 2000 has been almost 10 times as rapid as it was in the nineteenth century. Between 1975 and 2050 (an interval similar to the 73 years Darwin was alive), the population of the single small country of Uganda will have exploded from under 11 million to between 80 and over 100 million. This growth will be entirely the result of natural increase rather than immigration. Uganda is a fertile country, but it is no bigger than Oregon or Wyoming. The economy is better than that of many other African countries, but the absolute number of people living in poverty is increasing. Unrestrained population growth at this unprecedented level promises to overwhelm all other aspects of development. Uganda might possibly feed itself, but it certainly will not find employment for its burgeoning population.

Other countries face even more severe consequences of rapid population growth. Turner (2009a) worries, 'how Niger is going to feed a population growing from 11 million today to 50 million in 2050 in a semi-arid country which may be facing adverse climate change, is unclear'. Niger is one of the poorest countries in the world, with a *per capita* income of \$180. Only 12 per cent of the country can sustain rain-fed agriculture, and water scarcity and degradation of land will increase with global warming. Cereal output is falling and already 36 per cent to 50 per cent of children are malnourished. Only 15 per cent of Nigerien women even have any primary school education. There appears to be no plausible way the country can begin to feed itself.

Will disease slow population growth? The greatest incidence of the HIV/AIDS epidemic is limited to relatively few countries, nearly all in Africa. Uganda, which has suffered terribly from one of the earliest AIDS epidemics, continues to experience rapid population growth in spite of the disease. As Bongaarts (2009) writes, 'no country is expected to see a decline in its population size between 2005 and 2050 due to AIDS mortality'. Possibly other pandemics will arise if pathogens jump across from other mammalian species as the rain forests are cut down, or if intensive farming practices juxtapose people and animals, but diseases are unlikely to reduce population size.

Wars within and between states could well become more common. Once again, Uganda can be used to

illustrate the interaction between rapid population growth and violence. Already, the Lord's Resistance Army terrorizes parts of the country's north, manipulating armed teenagers to murder, mutilate and sexually assault the local population. It is likely that with three times the population in 2050, with increasing pressure on resources, education and work opportunities, there will be more—not fewer—warriors joining the Lord's Resistance Army, or its analogue.

When we look at population projections for some of the least developed countries and reflect on the possible interactions between population growth and other factors from global warming to civil war, then the possibility of greater poverty and more hunger all seems plausible and the imperative to reduce the number of unintended pregnancies becomes self evident.

Why then have population and voluntary family planning slipped from the global agenda? Campbell & Bedford (2009) draws attention to what they call a 'perfect storm' that swept consideration of population aside. The focus on HIV/AIDS siphoned money, skills and media attention away from this subject. Both Turner (2009b) and Sinding (2009) mention the 'revisionist arguments' espoused by the 1986 National Research Council review of the economic impact of rapid population growth. The policy of the Reagan administration was that rapid population growth was 'a neutral phenomenon'. Turner is particularly forceful in refuting these arguments. For example, the concept that technology could keep pace with population in such areas as food supply looks less convincing today as food prices rise. The economic benefits of increasing population density, which may have assisted Europe in the nineteenth century, do not help subsistence farmers in Africa today. Perhaps, most importantly, the arguments that revisionist economists made to dismiss the role of savings and capital accumulation as a result of slowing population growth have been refuted by newer analyses of the economic take-off in China and elsewhere (Birdsall *et al.* 2001; Bloom *et al.* 2003; Bongaarts & Sinding 2009).

Another factor pushing global population growth off the international agenda has been the focus on below-replacement fertility in many developed countries (Wattenberg 2004). Hania Zlotnik showed that the number of countries where deaths exceed births is projected to grow from 18 in 2000–2005 to 60 in 2050. At the forum, Nicolas Ebersadt showed that just over three billion (46% of the world's population) now live in societies with below-replacement fertility (i.e. a total fertility rate (TFR) below 2.1). However, this does not mean that all these countries will see big declines in population by 2050. This is because the measure of replacement fertility omits immigration and it ignores demographic momentum. This is because below-replacement fertility is a recent phenomenon in many countries outside Europe. In countries such as Tunisia (TFR 1.70), Brazil (TFR 1.9) or Iran (1.7), there is still a population bulge in the fertile years dating back to a time of higher birth rates. Thus, for example, although the TFR of China is now estimated to be about 1.8, the population will continue to grow until 2033, when it will reach 1.5 billion.

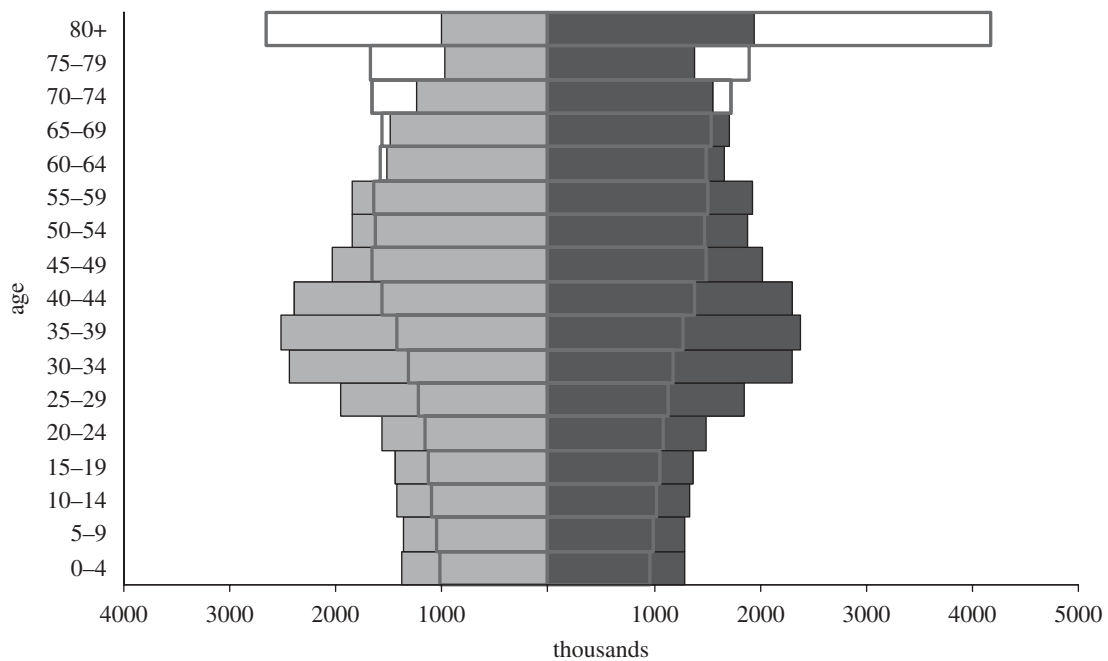


Figure 2. Italy Population Pyramid 2005 (solid bars) versus 2050 (outline). Grey, males; black, females. Adapted from US Census Bureau, International Database.

Russia and Japan are the two large countries which will see the greatest greying of their populations. Since the end of communism in 1991, the Russian population has declined by seven million, partly driven by lower fertility but more markedly by a rise in mortality, especially among men (Wilmoth & Shkolnikov 2009). By 2050, the Russian population could fall by 36 million (25%) and that of Japan by 25 million (21%). Italy will see a population decline of about four million by 2050. To set this in perspective, this fall is equivalent to taking the country back from the population it has today to that which it had in 1975. Of course, the population structure will change (figure 2), but outside Russia and Japan, as Turner (2009b), who chaired the UK Pensions Commission, shows, the economic consequences of an ageing population can be accommodated more easily than is sometimes assumed. Perhaps his most straightforward but most telling point is that efforts to raise fertility (assuming such efforts could be made to work) or immigration policies aimed at maintaining a broad-based population pyramid, if implemented, would simply pass today's problems onto tomorrow's generation—but on an even bigger scale.

In addition to the perfect storm of massive attention to HIV/AIDS, revisionist economic theory and concern over falling birth rates in the west, the media was critical of China's one-child policy and there was genuine anguish over episodes of coercive family planning, with a special focus on India in the 1970s.

4. THE DEMOGRAPHIC TRANSITION

The term demographic transition is used in two ways: (i) as a description of an historical process of fertility decline and (ii) as an explanation of why birth rates fall. Darwin's own family illustrates the transition in the west. He had 10 children and if each generation

that followed him had reproduced at the same rate, then Darwin would have 10 000 descendents today. In fact, he has about 100 great, great grandchildren. The Darwin family, like nearly everyone else in the west, went through the demographic transition from high birth rates and high death rates (three of Darwin's children died prematurely) to low death rates and low birth rates.

Darwin's wife Emma kept a record of her menstrual periods in her diary and she did not welcome every pregnancy (Keynes 2001), but the technologies of birth control available to the Darwin family were little different from those used by the Romans. During Darwin's lifetime, death control made considerable progress. When he died in 1882, the infective role of bacteria was understood, aseptic surgical techniques had been developed, and anaesthetics had been introduced, but it was to be another 80 years before scientific research and insights were focused on developing modern contraceptives as we know them today. Birth rates did decline in the nineteenth century, but slowly and probably with great pain, especially for women. Contraception was 'under-the-counter' in Britain and illegal in the US and in much of the rest of Europe. Millions of women, like Emma Darwin, lived in fear each month they would not see their menstrual period. Abortion was illegal in Europe and North America and restrictive abortion laws were imposed on European colonies. Unsafe abortions, however, were common (Potts *et al.* 1979).

Different disciplines see the demographic transition in different ways, and once again a cross-disciplinary approach is helpful. Until recently, economists have regarded childbearing as a rational behaviour, where parents review their resources and weigh the costs of having a child (Becker 1991). Sociologists emphasize cultural factors in decision-making around

childbearing. Biologists see human reproduction from yet another angle. They see human reproduction as differing from many other species where sex is limited to the time of ovulation and focused exclusively on fertilization. They recognize that human sexual activity occurs throughout the ovarian cycle, during pregnancy and after the menopause. Religious perspectives on family planning vary from broadly supportive in the Holy Koran to extremely hostile in Catholicism, which since St Augustine has taught that non-procreative sex is a sin showing disobedience to God's purpose (Ranke-Heinemann 1990). Clearly, preventing births is manifestly different from preventing deaths and it is encased in layers of religious dogma and social traditions.

Notestein (1953) was among the first to use demographic transition as an explanation of why family size fell, positing that couples made a rational decision to have fewer children as urbanization increases. Among many demographers who followed, the converse that birth rates would not fall in the absence of exogenous change, such as education or increased wealth, has been widely accepted. There are many exceptions and criticisms of the standard theory (Coale & Watkins 1986), yet it has proved remarkably persistent. Sachs (2005) argues in *The end of poverty*, 'one reason for a poverty trap is a demographic trap, when impoverished families choose to have lots of children'. But human beings, as noted above, have sex hundreds or even thousands of times more frequently than is necessary to conceive a child, whether they want to have children or not. Sachs' and others' assumption that having a child is a rational decision can be true only when women have access to contraception and safe abortion. Otherwise, irrational sex drives win out, and family size remains large, whether wanted or not.

Sinding quotes Daulaire *et al.* (2002) who calculated that 'roughly one quarter of the 1.2 billion pregnancies that occurred in the developing world between 1990 and 2000—some 300 million—were unintended'. It is estimated that 40 million of these unintended pregnancies end in abortion because the pregnant woman feels she does not have the physical or economic resources to support the child if born. Even in the USA, half of all pregnancies are unintended (Speidel *et al.* 2009).

In contrast to the nineteenth and the early twentieth century in the west, when questions about desired family size were not asked and little was known about how people sought to limit family size, remarkably rich datasets now exist in the contemporary developing world based on the numerous demographic and health surveys (DHS). These surveys show that in practically every community, there are some women who either want to delay the next pregnancy or want no more children. Moreover, when these surveys are repeated over time, then the number of children women say they want, on average, proves a moving target. Where most women have seven children, few will say they want two. But when they have five, they will say they want three or four. A great many countries with easy access to family planning, such as South Korea, Thailand, Sri Lanka, Iran or Colombia, have seen average family size move from six to two

children or fewer in a generation or less—something the standard explanation of the demographic transition did not predict. Using the DHS, Prata (2009) finds that there are more women who might like to use contraception in sub-Saharan Africa (25 million), but are not using a method, than women who are actually using modern methods (18 million).

When women are offered modern contraception in respectful ways and supported with correct honest information, and backed up by safe abortion, then the birth rate always falls. The need is to make the maximum range of contraceptive methods available through as wide a range of channels of distribution as possible—government clinics, private providers, pharmacies and chemical sellers, kiosks and corner shops, community-based distributors and even door-to-door delivery of methods. Contraception and safe abortion together have lowered family size even in poor, illiterate communities. Making family planning available in resource-poor settings, as Prata (2009) writes, 'is both a feasible and achievable intervention that can be implemented immediately'.

In discussions at the forum, Bongaarts commented that while 'experts may continue to argue about how big the impact of organized family planning is on contraceptive prevalence, we have plenty of evidence that family planning works'. As an economist, Canning suggested that economic models of individual rationality have limited explanatory power and that, in particular, fertility patterns in societies tend to move as a whole and to display much less variation than a model based on individual rationality would predict. He went on to suggest that Africa is at a point where 'quite small investments in family planning could have quite big effects in getting fertility down'. Several participants remarked on the limitations of what Sinding called 'the somewhat discredited theory of the demographic transition'. Other examples, given in the forum discussion, of the power of family planning to lower birth rates in the absence of significant exogenous change come from Italy, where in the 1960s when contraception and abortion were illegal, the Milanese had a low TFR and the Sicilians a high TFR, but when contraception and safe abortion were legalized, these differentials largely disappeared. In Iran, the rural/urban differentials in family size almost evaporated as family planning became widely available. A plausible explanation of the fact that Addis Ababa is the only capital city in Africa with below-replacement fertility is that for over a decade Marie Stopes International has been offering safe comprehensive abortion services, including excellent contraceptive advice, and once women learnt that they could control their fertility, family size fell.

As Campbell & Bedford (2009) points out, no one has found a society that has achieved replacement level fertility without access to safe abortion.³ Laws making abortion illegal do not stop abortions, although traditional abortion techniques can be over 1000 times more dangerous than modern methods based on manual vacuum aspiration and medical abortion. Illegal providers are sometimes financially and sexually exploitive. In Ethiopia, before the abortion law was

liberalized, some illegal operators demanded sex from their clients as part of the price of terminating an unwanted pregnancy. In discussion, Canning noted in several settings that the transition from illegal abortion to abortion on request was associated with a 0.5 reduction in TFR, and this change had a demonstrable and positive economic impact.

In addition to laws restricting access to safe abortion for the poor (in all countries, rich women can purchase a safe abortion regardless of the law), both Prata and Campbell highlighted the many tangible and intangible barriers that all too often prevent access to family planning. These may be invisible, even to the woman seeking advice, as when providers let their own personal biases deny a client a valid method, or they may be obvious, such as cost-prohibitive contraceptive pricing. Building on the evidence of unmet need and the many barriers to family planning, Campbell & Bedford (2009) writes, 'simply stated, it appears that the timing of fertility decline is dependent on the degree to which women have freedom from barriers to fertility regulation and are able to obtain the technologies and the supporting information they need to manage whether and when to bear a child'. Sinding pointed out that the 'natural experiments and the actual experiments', whether you take Matlab or Navrongo,⁴ or take Kenya or Bangladesh national programmes, provide 'a great deal of evidence to support (Campbell's) statements', and he captured the whole discussion of this key topic in the statement that, 'the theory of the demographic transition, as opposed to a description of historical change, overestimated the rational decision-making of couples with respect to the value of children, and vastly underestimated the desire of women to manage their fertility given the opportunity to do so.'

5. HUMAN CAPITAL

Adam Smith wrote of 'the acquired and useful abilities of all the inhabitants or members of the society', (Smith 1776). Today, human capital refers not only to the stock of human skills arising from education and training, but also includes investments in health, or as Lutz (2009) labelled this combination, *schola et sanitate*. There was a consensus among the various disciplines participating in the forum that national governments and international agencies invest too little in human capital, particularly in education. For example in 2008, USAID allotted \$2.4 billion to HIV/AIDS but only \$0.7 billion to education. Educated girls and women have smaller families than those who have not had the opportunity to learn. This is partly because educated women are better able to get around the many barriers that all too often separate them from the contraception they need. However, where population growth is rapid, the availability of education suffers in the rush to keep up with numbers. Conversely, when family size falls, the investment both the family and the government can make in education for each individual increases.

More than most meetings, the forum overcame the ever-present human tendency to dichotomize

issues. It is not a question of investing in education or family planning, but of understanding the synergy between the two. It is not a choice between economic development or slowing population growth, but seeing how the two interact. The forum summary contains four coherent and linked statements about human capital.

- (i) The coming decade should be dedicated to the needs of the one billion young people aged 15–24 in the world, the majority in low-income settings with limited educational and employment opportunities.
- (ii) Education... particularly of women makes an important contribution to fertility decline and a critical contribution to development.
- (iii) Rapidly growing countries cannot always expand education fast enough to keep pace with the growing number of children each year.
- (iv) It is essential that national leaders and international donors, especially the World Bank and the International Monetary Fund (IMF), understand the imperative to invest in education and improved access to family planning.

Both education and family planning are imperative for development to take place in the high-fertility regions of the world. Today, there are one billion young people aged 15–24 as there were people of all ages in the world when Darwin was born. This youthful generation presents the greatest challenge and the greatest opportunity in the history of human capital development. Young people, interacting with their peers, along with as much assistance as possible from formal and informal educational systems, need both the knowledge and the means to decide whether and when to have a child. Slowing population growth is critical to achieving the millennium development goals. (All Party Parliamentary Group on Population, Development and Reproductive Health 2007). International donors, especially in the World Bank and the IMF, national leaders and a wide range of scholarly disciplines need to follow the evidence on the impact of investing in human capital and access to family planning and on the future welfare of the human and the natural world in the twenty-first century (Lutz 2009).

6. CONSILIENCE

The application of scientific discoveries drove much of the industrial revolution. It was not rises in fertility,⁵ but falls in mortality driven by medical discoveries such as vaccines, which gave rise to rapid population growth. Today science must provide the insights to forecast adverse future events and provide the technical and scientific options needed to confront the current crisis.

Wilson (1998) has called for a consilient approach based upon evolutionary insights to unite disparate disciplines, from economics to reproductive physiology. It is a useful perspective. For instance, we were not evolved to live in a world where thousands

of people interact socially and where we are all influenced by decisions on resources made by hundreds of millions of people we will never know. For most of human existence, we lived in small bands of hunter-gatherers where the human population, if it grew at all, grew slowly and where warfare or starvation was a perpetual threat. In such a world, we might never see more than a few hundred people. Given that Darwinian evolution can drive altruism towards kin but not to the whole of our species, not surprisingly today many people find it difficult to see population as a problem.

In the case of family planning, there are added hurdles to be overcome. The concept of a billion people is literally incomprehensible to the human brain designed to interact with a few hundred people. Moreover, our Stone Age brains, in Slovic's (2007) vivid phrase, are 'numbed by numbers'. Psychology experiments show that people will donate to relieve the plight of an individual starving girl in Africa, but they will give less money if they are also told that there are millions more like her. To further complicate matters, public policies related to population or the provision of fertility regulation excite powerful emotional and religious responses, often challenging deep-seated competition between the two sexes (Potts 2005; Potts & Campbell 2008). Even today, those in the international community who are scientifically informed and sympathetic to the suffering of women are prone to shy away from a discussion of abortion.

Also, we find it difficult to make sacrifices today for benefits that will emerge decades ahead, however great those benefits may be. For example, economically feasible and technically achievable options exist to slow GHG accumulation, but we are not evolved to act in our progeny's long-term interest. It will take great political leadership, enhanced scientific education and an informed media to begin a real transition to a biologically sustainable way of life. That transition needs to be well on its way before 2050. In some ways, slowing rapid population growth is the easiest of the many changes that need to occur by 2050. As the *Bixby Forum* noted, 'meeting the unmet need for family planning has been highly successful in slowing rapid population growth. Ready access to contraception and safe abortion has decreased family size, even in illiterate communities living on less than a dollar a day'.

7. CONCLUSIONS

Coming at the end of a meeting where participants from a number of disciplines had thought about, and worried about, the impact of rapid population growth on economics, health, conservation, global warming and national security, a simple, uncontested policy consensus arose: 'meet the unmet need for family planning'.

The cross-disciplinary approach adopted at the forum painted a more sombre picture of the future than many experts started out with when thinking within their own disciplines. One welcome outcome of this volume, with its emphasis on the large unmet need for family planning and the opportunity to slow

population growth in a human rights framework, is the hope that it will assist in initiating new lines of investigation in a number of scientific disciplines such as ecology, climate change and peace and conflict studies—disciplines that have largely stayed outside the debates on population and family planning.

Some estimates suggest that the world exceeded its 'ecological footprint'—the capacity of the biosphere to sustain human activities and to absorb and recycle human waste—in the 1980s (May 2007). Other analyses suggest that the point of no return is still some way into the future, but certainly before 2050. The forum demonstrated unequivocally that rapid population growth in poor countries and unintended pregnancies in rich countries will be important variables in the hoped-for and necessary transition to a biologically sustainable global economy, which needs to be well advanced by 2050.

In some regions, especially in sub-Saharan Africa and parts of the Middle East, the loss of attention to family planning, both domestically and internationally, and the consequent collapse of family-planning budgets, has had two tragic consequences: one related to equity and justice for individuals, and the other to demographic changes of tectonic proportions. As family-planning efforts weakened, the poorest economic quintiles were increasingly cut off from the information and supplies they needed: the use of contraception remained low while the unmet demand for family planning rose (Ezeh *et al.* 2009). The richer quintiles, with more knowledge and resources, in most countries continued to find the means to separate sex from childbearing. The increased disparity in family size between rich and poor will translate into further inequities in education, health, employment opportunities and income. The ecological and geopolitical consequences of what has been called the 'lost decade' in family planning are alarming, and the increase in the projected population of some parts of Africa 'may lead to food scarcity and crumbling infrastructure, and, potentially, to violent conflicts over scarce resources' (Potts *et al.* 2009).

In a real, although albeit unintentional way, the classic explanation of the demographic transition being driven by an exogenous socio-economic change opened the door to coercion in family planning because if rapid population growth outstripped economic growth—as it was in India in the 1970s—then policy-makers either looked the other way or devised 'incentives' to slow population growth. It is important to understand that the emphasis the forum gave to removing barriers to family planning, combined with a latent demand among women for fewer children, is a recipe for slowing population growth entirely within a voluntary, human rights framework. Past episodes of coercion have cast a long shadow over international family planning and must never be repeated. The new imperative is to ensure also that women are not subject to coercive pregnancies because they are denied access to the information and technologies they need for the voluntary control of childbearing.

In 1992, the Royal Society, the United States National Academy of Sciences and the Royal Swedish Academy of Sciences concluded that 'if current

predictions of population growth remain unchanged, science and technology may not be able to prevent irreversible degradation of the natural environment and continued poverty in much of the world'. A year later, a Population Summit of the World's Scientific Academies in New Delhi stated,

The academies believe that ultimate success in dealing with global social, economic, and environmental problems cannot be achieved without a stable world population. The goal should be to reach zero population growth within the lifetime of our children ... Humanity is approaching a crisis point with respect to the interlocking issues of population, environment, and development. ... With each year's delay the problems become more acute. (Graham-Smith, 1994)

Fifteen years later, there are one billion more people on the planet and a growing unmet need for family planning. In 1993, a delay was highly reprehensible; today it could prove lethal and possible catastrophic. Can a violent primate, whose brain is largely adapted to the threats and opportunities of a Stone Age world, use its intelligence and scientific insights to give women reproductive choices they need so urgently? Or at some time in the coming decades, the media, political advisors and an anxious public could well wake up and say why we did not see a new population crisis coming? A startled world will realize that they could have done much to avert the disaster which is confronting them.

The Fred H. Bixby Foundation has been a strong and successful supporter of attention to population, and of domestic and international family planning for many decades. In 2009, the trustees wound up the Foundation, and as a capstone event to their work they supported the Bixby Forum on the World in 2050, which took place at the University of California, Berkeley, and also the publication of the papers presented at the Forum in this theme issue of the *Philosophical Transactions of the Royal Society B*. The editors, authors, and all the participants at the Forum are extremely grateful for the foresight and generosity of the Bixby Foundation. The editors also appreciate the tireless and highly professional work of Kathleen Bedford at UC Berkeley, who managed the complex task of assembling and submitting the manuscripts. Finally, it has been a pleasure working with Claire Rawlinson and her colleagues in the Royal Society on the publication of this theme issue.

ENDNOTES

¹Adair Lord Turner contributed two papers to the forum but, as the newly appointed chair of the UK Financial Services Authority, he was unable to attend the meeting in person.

²A participant from the Food and Agriculture Organization cancelled their attendance shortly before the meeting.

³Women from European countries such as Ireland or Malta, where abortion remains illegal, commonly travel to neighbouring countries such as England or Italy, where abortion is legal.

⁴Matlab in Bangladesh and Navrongo in Ghana are sites where high-quality demographic and health research is conducted.

⁵A fall in the age of puberty and shorter birth intervals as a result of changing breastfeeding practices can increase family size in agricultural communities compared with pre-literate, hunter-gatherer societies, but these changes are small compared with falls in infant mortality.

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