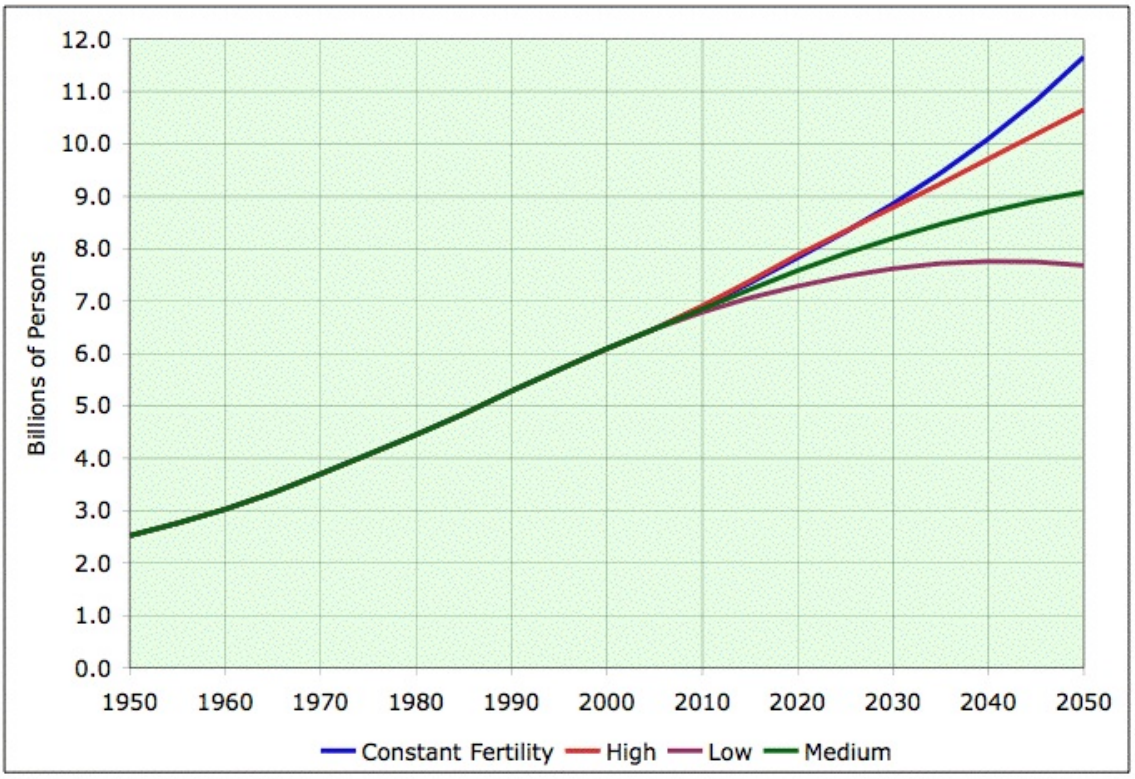
The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

So let's talk about population

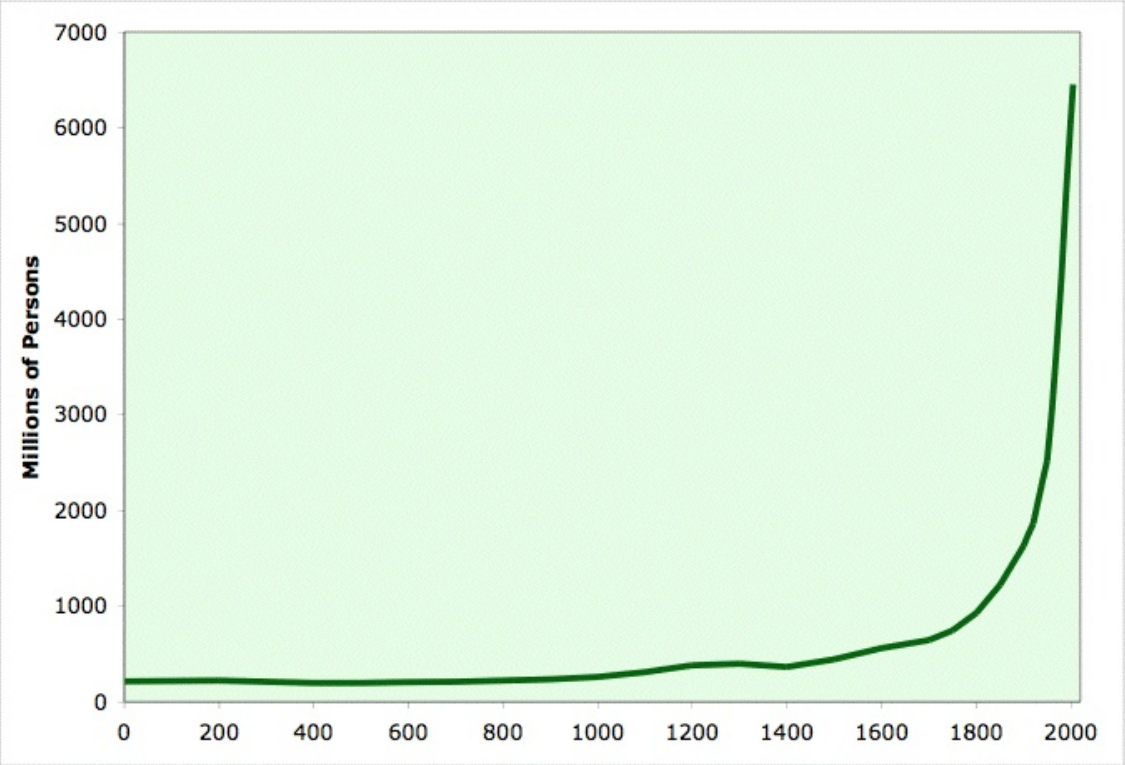
Posted by Stuart Staniford on December 20, 2005 - 2:57am
Topic: Sociology/Psychology
Tags: hubbert peak, oil prices, peak oil, population [list all tags]

Back in the thread on my radio interview with Jason Bradford, there were requests for a thread on population issues (which came up at the end of the interview as we ran out of time). So let's dig into the United Nations' World Population Prospects: The 2004 Revision.



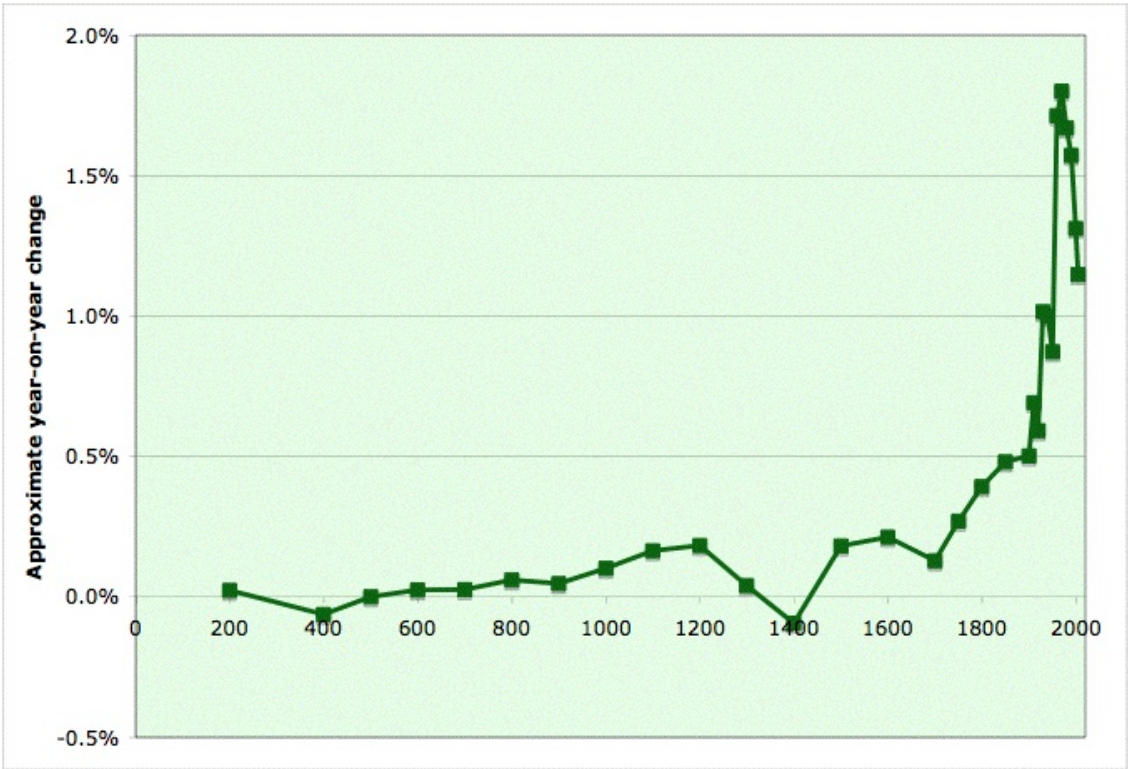
UN population projections through 2050. Click to enlarge. The medium scenario (dark green) is the UN's best guess as to what will happen. High and Low represent their best estimates of the range of reasonably likely outcomes. The Constant Fertility line is their estimate of what would happen if world average fertility did not decline any further. Source: World Population Prospects: The 2004 Revision.

Let's start by panning the camera back to take a look at the big picture. Every person planning to live through much of the twenty-first century should spend at least a little while staring at this graph, and thinking about the implications. If the world feels at all crowded to you, this is why. This is what the scientific and industrial revolutions have wrought.



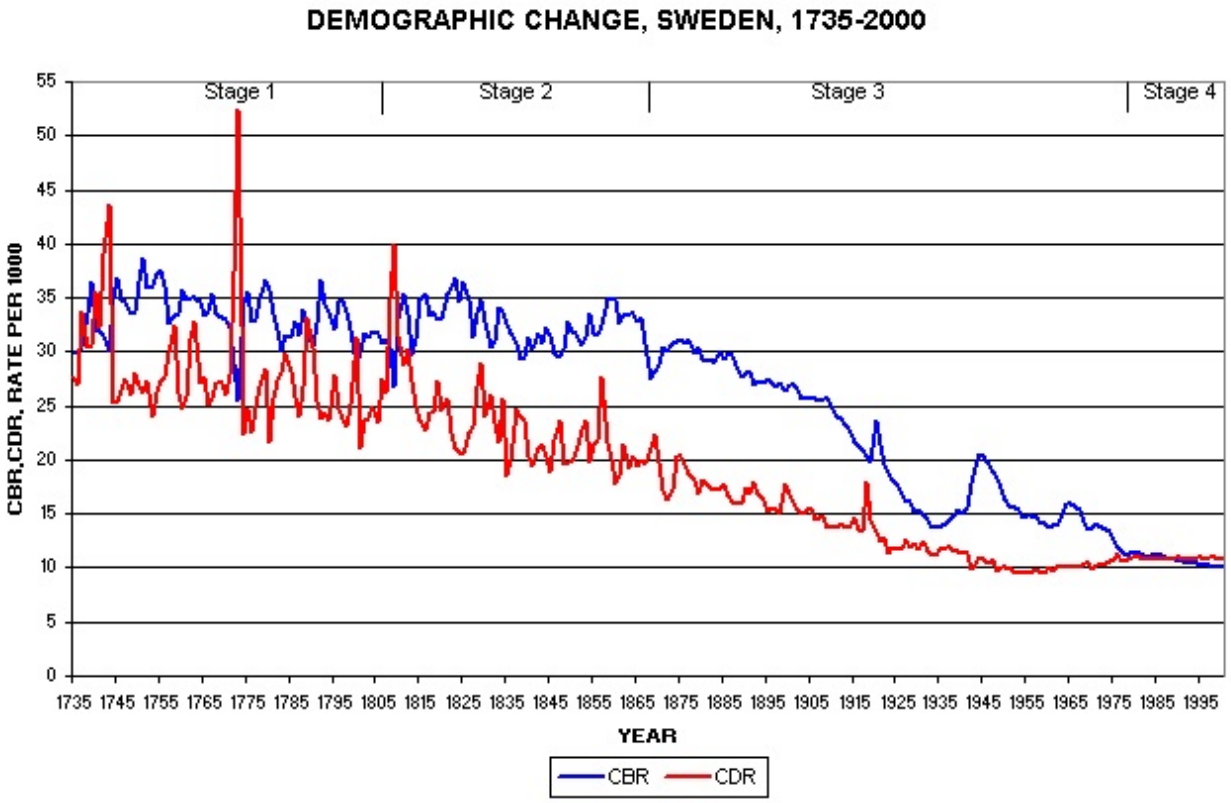
Growth of human population since AD 0. Click to enlarge. Source: US Census Bureau. Also here -- my graph before 1900 is an average of the McEvedy/Jones and the Biraben estimates. After 1900 I use the UN numbers.

To understand population growth, you need to know a little bit about how the demographers think about the world. Human population growth is sort-of-exponential, but not really. It's sort-of exponential in that the rate of change of the population is sort-of proportional to the number of people now. The more people, the more kids they can have, other things being equal. However, other things are not equal, and so the rate of population growth varies over time, and thus the graph doesn't follow an exponential curve with much precision. In fact, the growth above is mostly super-exponential - the growth rate increased over time until quite recently:



Population growth rate since AD 0. Click to enlarge. Source: Interpolated approximately from population figures in prior graph.

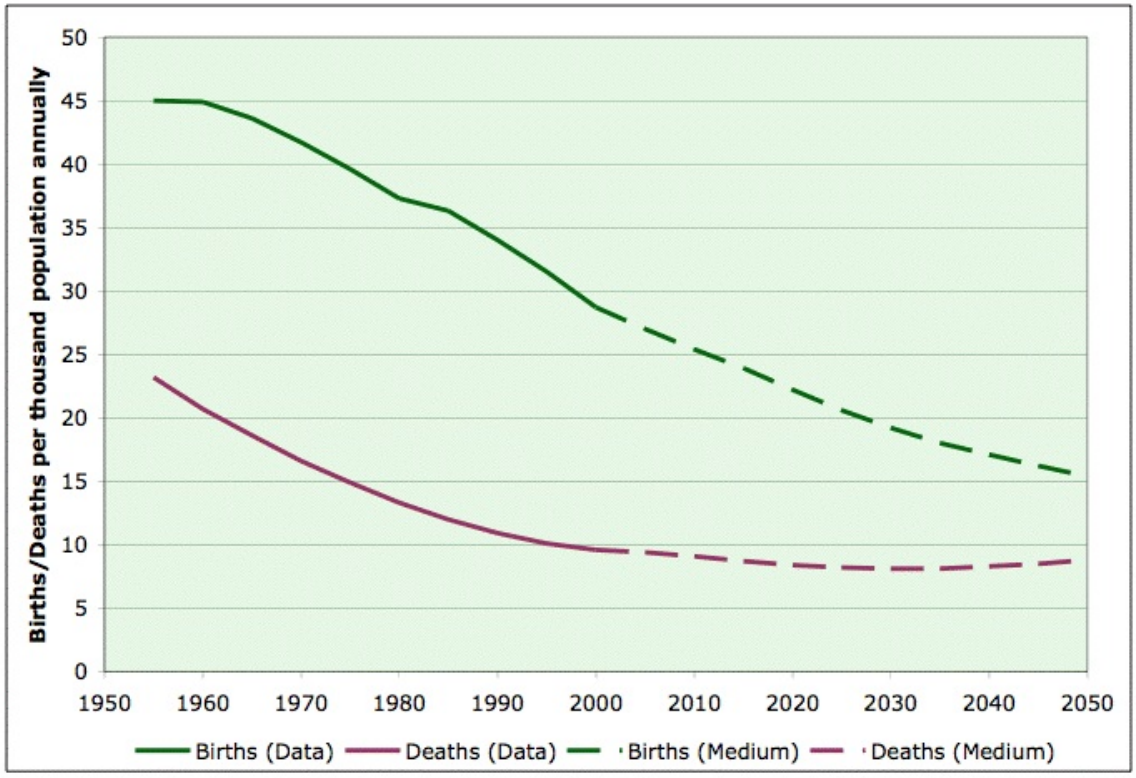
The population growth rate is controlled by two things: the number of babies born each year as a proportion of the people currently alive (known as the crude birth rate), and the number of people who die each year (known as the crude death rate). These can be illustrated as we look at the most important concept in demography: the demographic transition. Here's data for Sweden, for illustration.



CBR = Crude Birth Rate (blue), and CDR = Crude Death Rate (red) rates in Sweden. Click to enlarge. Source: The Demographic Transition, Keith Montgomery.

The general idea is that in undeveloped countries, both birth rates and death rates are high. Development first causes a decline in the death rates, due to improved public health and sanitation, antibiotics, etc, etc. At first, birth rates don't come down and the population thus grows. Later, birth rates begin to come down also, and the population stabilizes with both fertility and mortality at low levels. Like pretty much all developed countries, Sweden completed it's demographic transition gradually and has largely finished. Most developed countries are now at population stability, and some, like Italy and Germany, even have fertility substantially below replacement level and are likely to have shrinking populations in the future.

The UN divides countries into three groups, which are politely named "more developed" (places like the US, Western Europe, and Japan), "less developed" (India, China, Mexico, Brazil, etc), and "least developed" (Afghanistan, Niger, Botswana, etc). The following graph looks at mortality and fertility data for the the less developed countries (excluding the least developed).

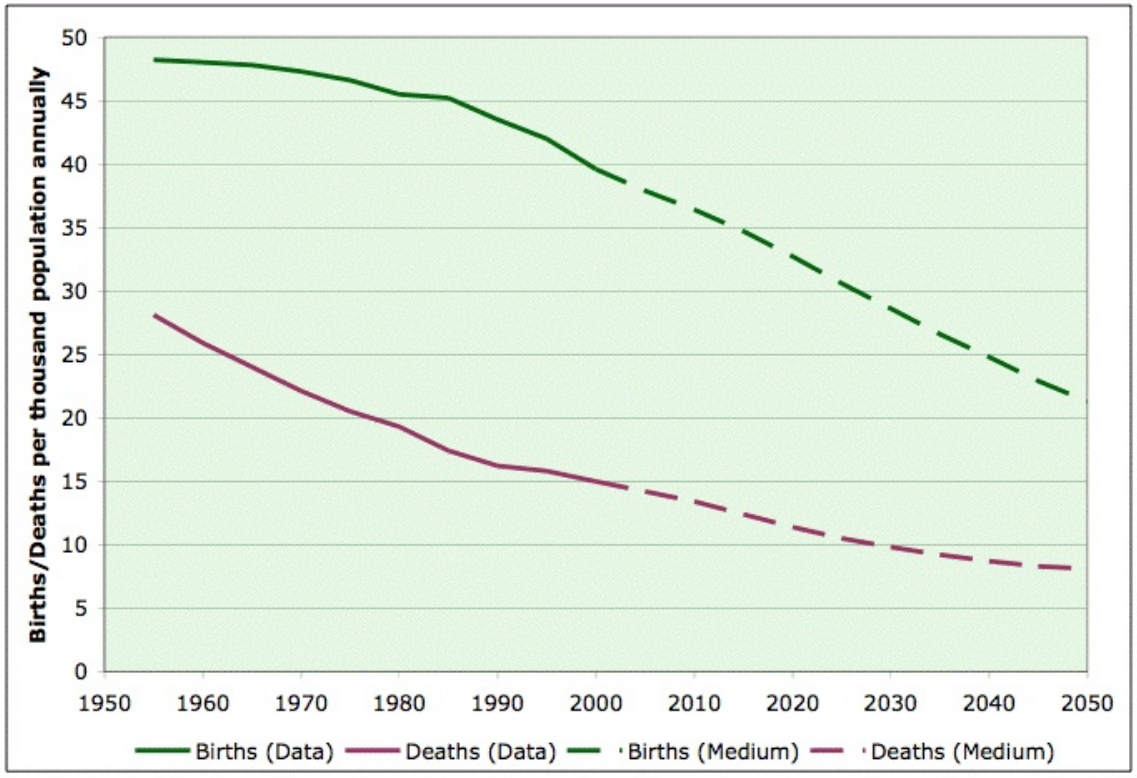


*Birth and Death rates for UN **less** developed countries (excluding least developed). The lines through 2000 are data, and after that the lines are the UN's medium projection. Source: World Population Prospects: The 2004 Revision.*

Now, this group of countries - generally the better-off developing countries - comprised 59% of world population as of 2000. Several things stand out from the graph:

- The demographic transition is well under way in these countries. Death rates fell early in the twentieth century, are continuing to fall, but are stabilizing. All of that "Save the Children" activity has worked to a considerable degree. Birth rates have also fallen significantly, but there is a big gap between births and deaths still, which accounts for the enormous population growth in these countries.
- The demographic transition is happening much faster in this group of countries than the centuries-long process in the developed countries.
- The UN's medium projection assumes a business-as-usual continuation of the same trends in these countries that have enabled the demographic transition to date.

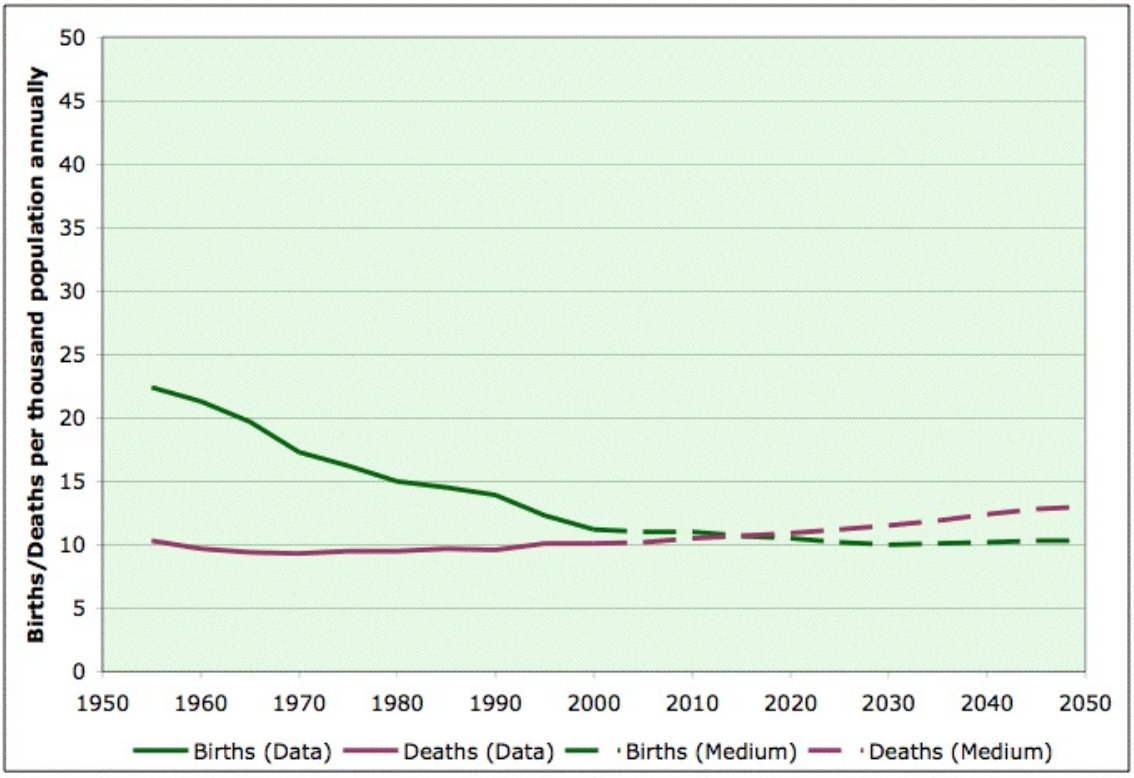
The next graph shows the exact same thing, on the same scale, for the UN "least developed" countries (mostly poor African and a few exceptionally poor Asian countries).



*Birth and Death rates for UN **least** developed countries. The lines through 2000 are data, and after that the lines are the UN's medium projection. Source: World Population Prospects: The 2004 Revision.*

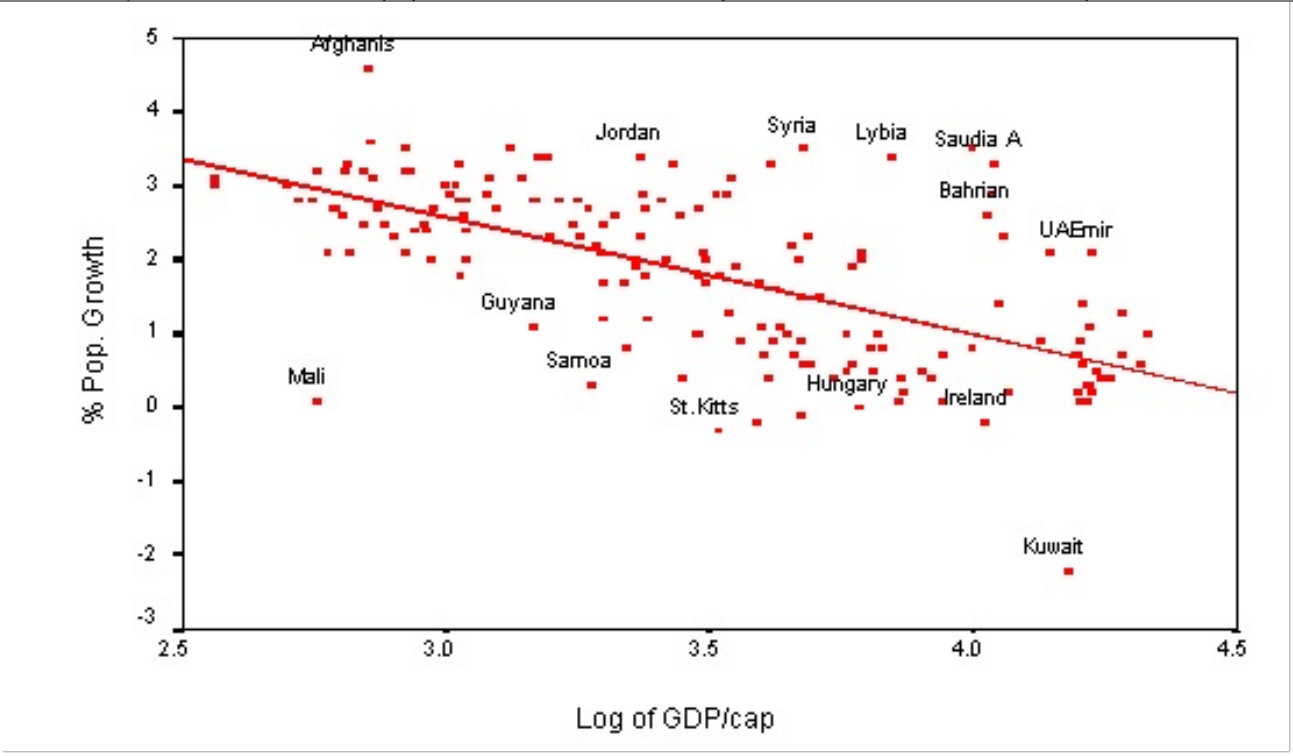
These countries comprised 11% of the world's population as of 2000, but are obviously increasing their share at a good clip. They are much less far along in their demographic transition, and have huge gaps between births and deaths, hence the large population growth rates. The UN is projecting that they will, nonetheless, go through the transition. What the modelers basically do is take a composite average profile of countries that have gone through the transition in the not-too-distant past, and assume these countries will follow the same path.

Just to complete the story, here's the final 20% of the world's year 2000 population in the UN's **more** developed countries. These are the countries that have more-or-less completed their demographic transition.



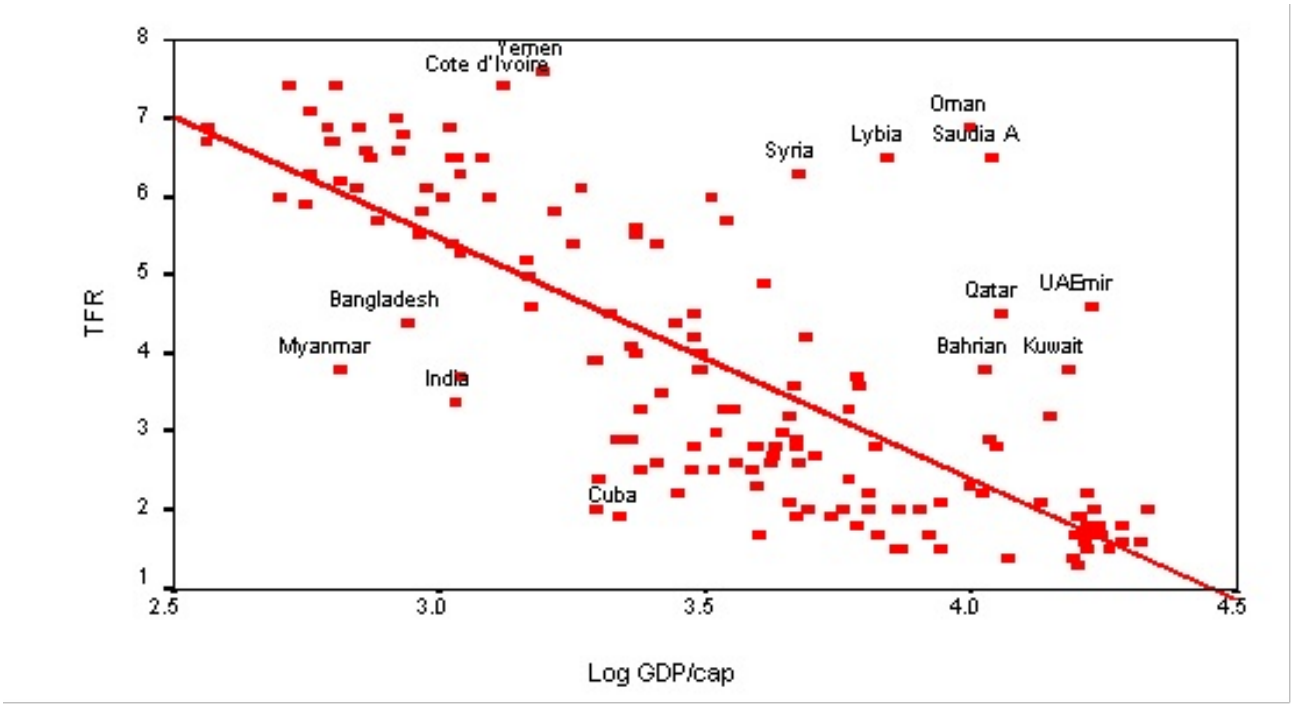
*Birth and Death rates for UN **more** developed countries. The lines through 2000 are data, and after that the lines are the UN's medium projection. Source: [World Population Prospects: The 2004 Revision](#).*

All in all, the UN medium projection strikes me as generally plausible if one assumes that demographic change plays out while holding geology and economics on a steady business-as-usual course. Alas, with peak oil, most of us don't believe in that assumption set. Thus we are left to wonder how those dotted lines for the developing countries might really evolve in a post peak world. Certainly there is not enough oil for them to end up looking like the developed countries that have just completed their demographic transitions in recent decades. As we can see further in this next graph, population growth rate has a good deal to do with affluence. Wealthy countries (high GDP/capita) tend to have low population growth rates, and poor ones tend to have high rates. The most obvious exceptions are oil exporters which presumably tend to function like a poor country with a small super-rich elite grafted on.



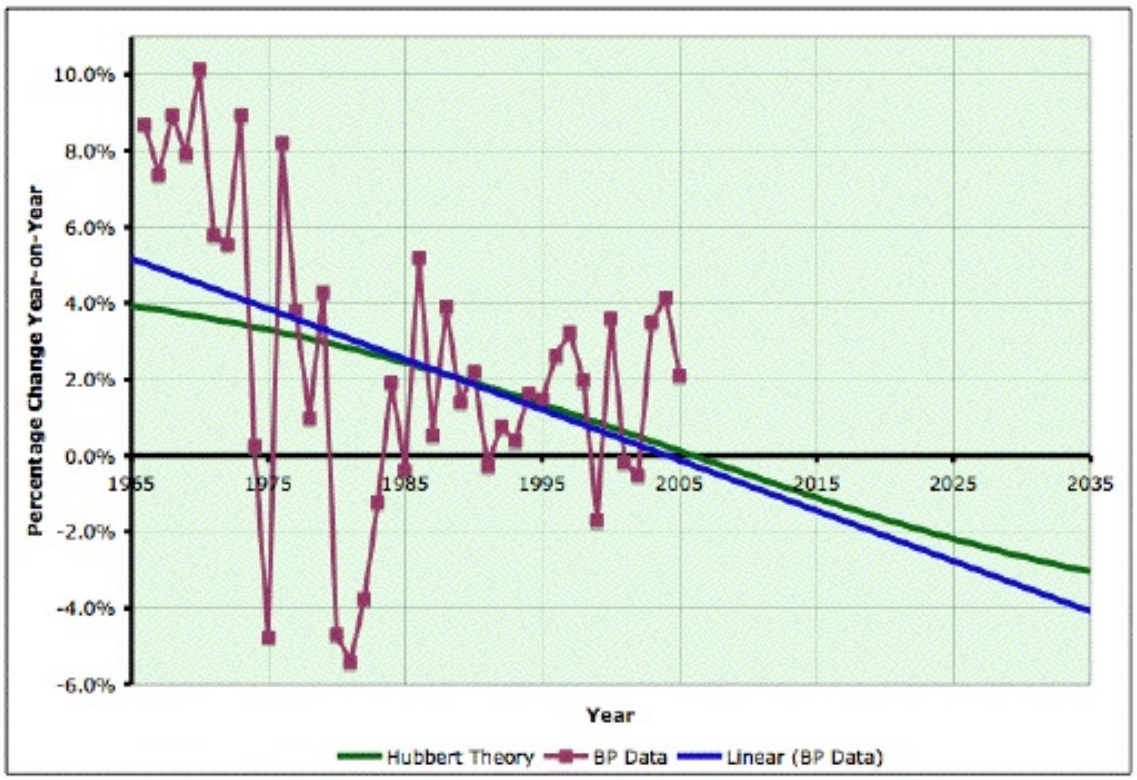
Population growth rate against log GDP/capita. Source: Demographic Transition: An Historical Sociological Perspective, David Allan.

The situation is even clearer if we look at fertility alone - total fertility is the expected number of children a woman will have over her lifetime.



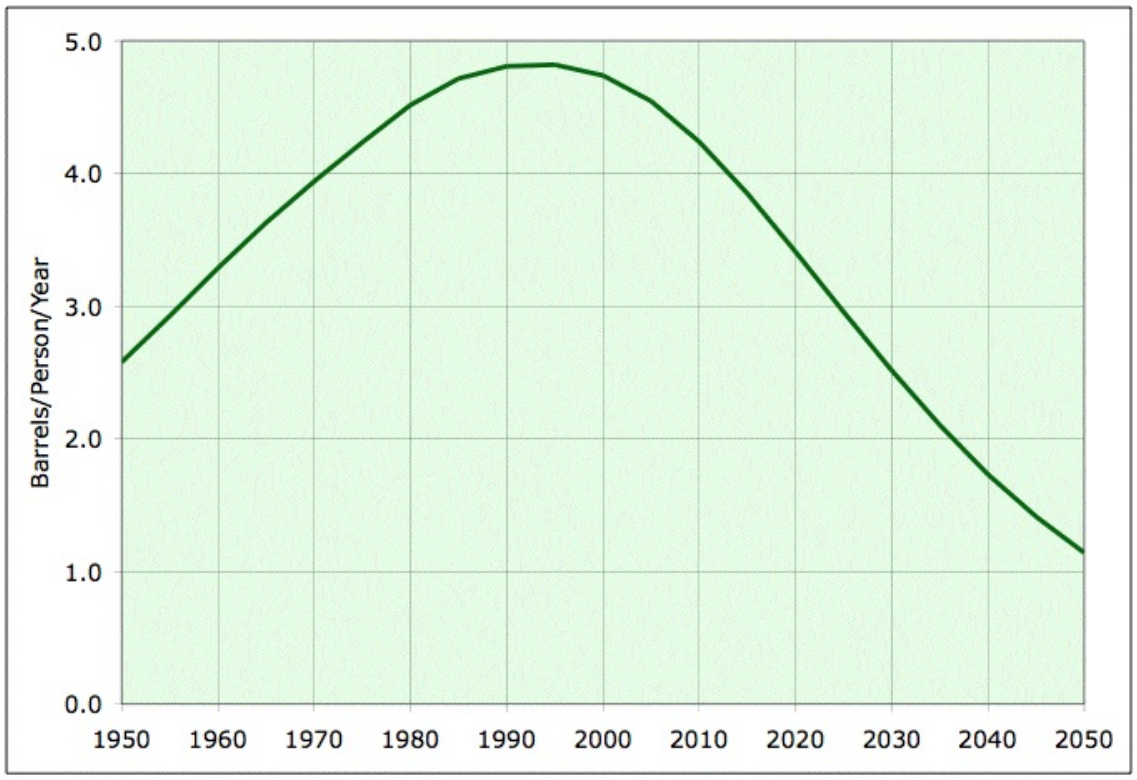
Total fertility (children/woman) against log GDP/capita. Source: Demographic Transition: An Historical Sociological Perspective, David Allan.

Now, if we think there's a near term peak, even if it's soft as I argued from this graph the other day:



Hubbert-style prediction of future global oil production decline rates, together with recent year-on-year change in BP production data (inc NGLs), and a linear fit to the BP data.

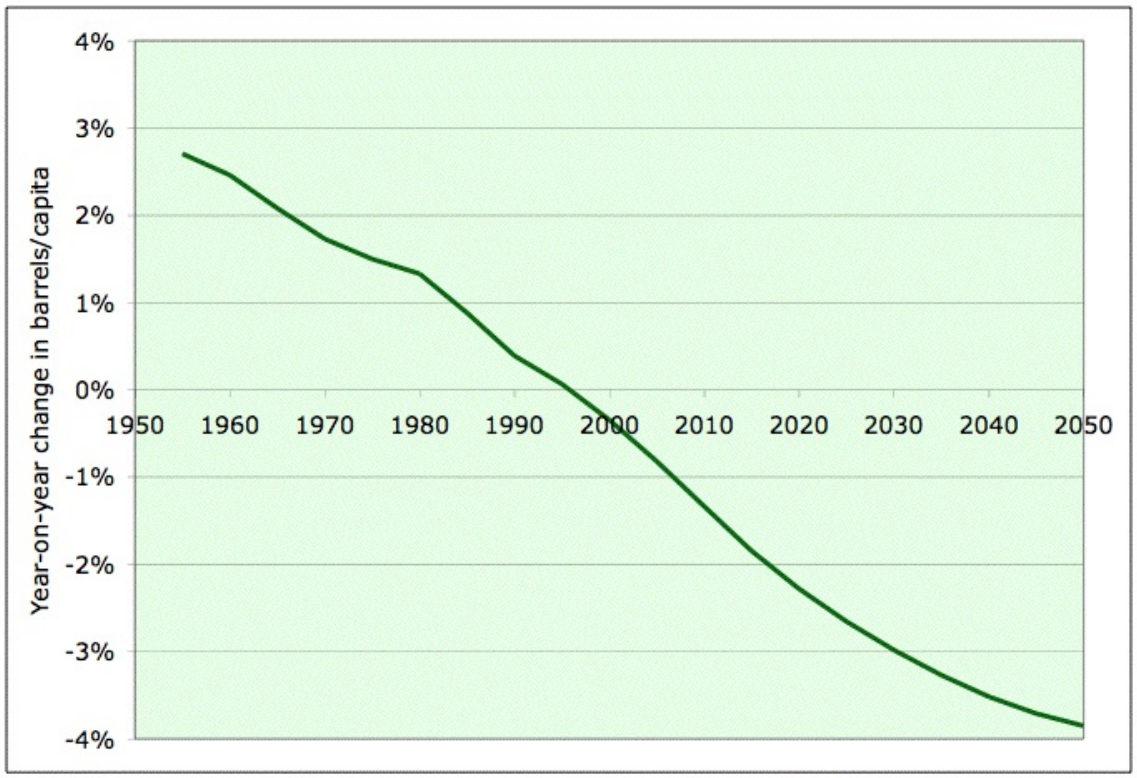
Then the barrels/capita goes like this (in the medium case):



Barrels/capita of world population assuming a Hubbert curve with URR=2350gb, peak =

2005, and K=5%, together with the UN medium population growth curve.

The all important decline rate in barrels/capita is:



Annual growth/decline in barrels/capita assuming a Hubbert curve with URR=2350gb, peak = 2005, and K=5%, together with the UN medium population growth curve.

Can those less developed countries continue enough development to achieve their demographic transition while we all collectively save that much oil/person? This post is already long, so fuller consideration will have to wait for another time, when I'll try to look at the potential role models.

Finally, I'd like to mention some resources on population issues besides the UN report. There's a superb set of lectures from the Global Change Program at the University of Michigan. Another nice online discussion is by Keith Montgomery. There's a book How Many People Can The Earth Support, by Joel Cohen. This book is an incredible piece of scholarship, and while I don't agree with all of it, it's must reading for anyone wanting to understand the issues. Finally, I'll mention The Rapid Growth of Human Populations 1750-2000 by William Stanton. Despite his deplorable politics, it's the most peak-oil aware population book I know of, and does have a lot of interesting data and discussion on individual countries. Then there's the classic Limits to Growth series, and Catton's Overshoot. The case for why no-one should worry about population growth has been made by the late Julian Simon, an economist, in The Ultimate Resource 2. I can't say I found this book very well argued, but I'm not aware of a better argued version of the same thesis elsewhere - certainly this is the famous one.