

Population and climate change: a proposal

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University of Maryland

with deep gratitude to all the people and organizations that
helped me throughout my scientific life:

I dedicate the 54th WMO/IMO Prize to

Rolando V. García

who made everything possible for thousands of brilliant
argentine scientists

Thank you!

- To my parents, **Jorge Kalnay** and **Susana Zwicky**
- To **Argentina**, who gave me a free, superb education
- To **Rolando García**, who led the School of Sciences to an amazing level, and then, as Secretary General of the WMO/GARP, led it to its FGGE success. At 90 years he continues to be a leader in world policy
- To **Jule Charney** who admitted me at MIT after the “night of the long sticks” and became my advisor
- To the **US**, who allowed me to work at **dream places**: MIT, NASA/GSFC, NWS/NCEP, OU, and UMD
- To **Jack Hayes** and **Hector Ciappesoni**, Directors of the US and Arg. NWS for their nomination and support

Thank you to my mentors and bosses!

- **Milt Halem**, my first boss and mentor who invited me to join him at Goddard in 1979. **Shukla**, who got this Prize two years ago, is younger but has always been my mentor. **To all my colleagues at Goddard!**
- **Bill Bonner** who invited me to join NMC (now NCEP) as Director of EMC in 1987. **Bonner, Ron McPherson** and **Louis Uccellini** made me proud to work for the NWS.
- I put my heart and soul into NCEP, and when I decided to step down in 1997, I left half of my heart there. **To all my colleagues and friends at NCEP!**
- The University of Oklahoma, where **Fred Carr** was my mentor and where I wrote most of my book.

Thank you to the University of Maryland!

- **Jim Carton**, who invited me to apply as chair in 1998.
- **Dan Mote**, the President, and **Steve Halperin**, the Dean of CMPS.
- **Bob Hudson**, who preceded me as chair of AOSC, and **Russ Dickerson**, who succeeded me.
- **Jim Carton** organized this ceremony with **June Sherer** and **Tammy Paolino**, and with the kind guidance of **Bill Bolhofer**, **Anne Shukla**, and **Jim Kinter**.
- **Jim Yorke** who had the vision of the Weather-Chaos group. **Brian Hunt**, **Kayo Ide**, **Takemasa Miyoshi**, **Ed Ott** are my inspiring colleagues. The **LETKF!**
- **All my brilliant students!** I am so grateful to them...

Thank you to the WMO and U. of Bs. As.

- **WMO** supported the Workshop on “**Intercomparisons of 4D-Var and EnKF**” Buenos Aires, November 2008. It showed both methods comparable, hybrid best.
- Preceded by a two-week **Intensive Course on Data Assimilation**, co-directed with **Celeste Saulo**, and with **Juan Ruiz** and **Takemasa Miyoshi**.
- We trained **100 outstanding students**, most from Latin America on a shoe-string budget: half of them then stayed and actively participated in the WMO Workshop that was designed only for experts!
- This was only possible with the huge volunteer support of the **UBA**, the **SMN** (NWS) and **CIMA**.

My research at the U. of Maryland

- 1) Data assimilation, Ensemble Kalman Filter and the LETKF, CO2, AIRS data and Mars data assimilation
 - 2) Impact of land use and land-use change on climate (Observations minus Reanalysis): over the last 30 years, changes of land cover have significantly increased surface temperature: “Green is cool”.
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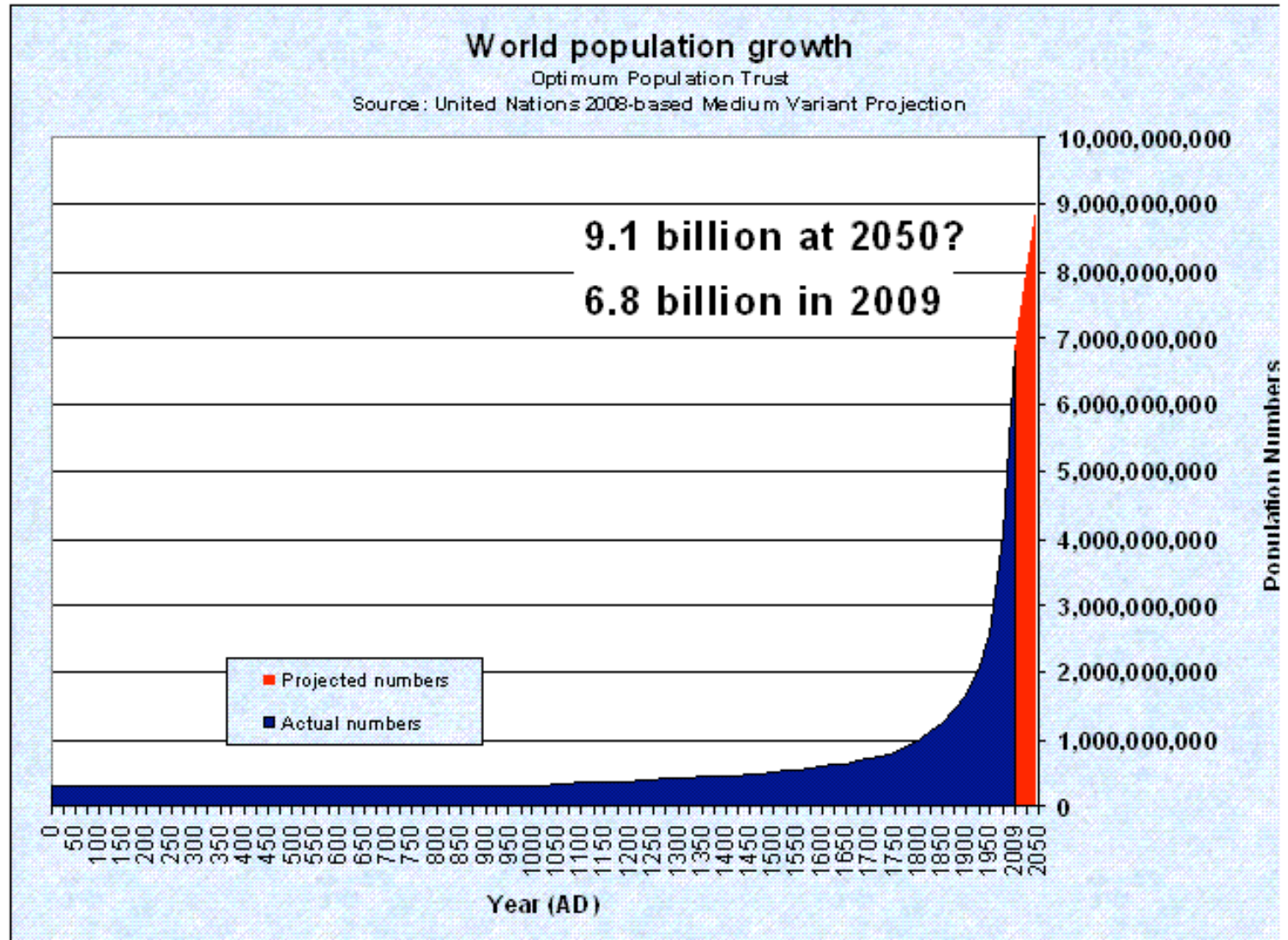
Today I will talk about something different:

“Population and Climate Change: A Proposal”

With many thanks to Jorge Rivas and Jim Carton

Population growth

1AD	0.3b
1650	0.5b
1800	1.0b
1927	2.0b
1960	3.0b
1975	4.0b
1987	5.0b
1998	6.0b
2011	7.0b



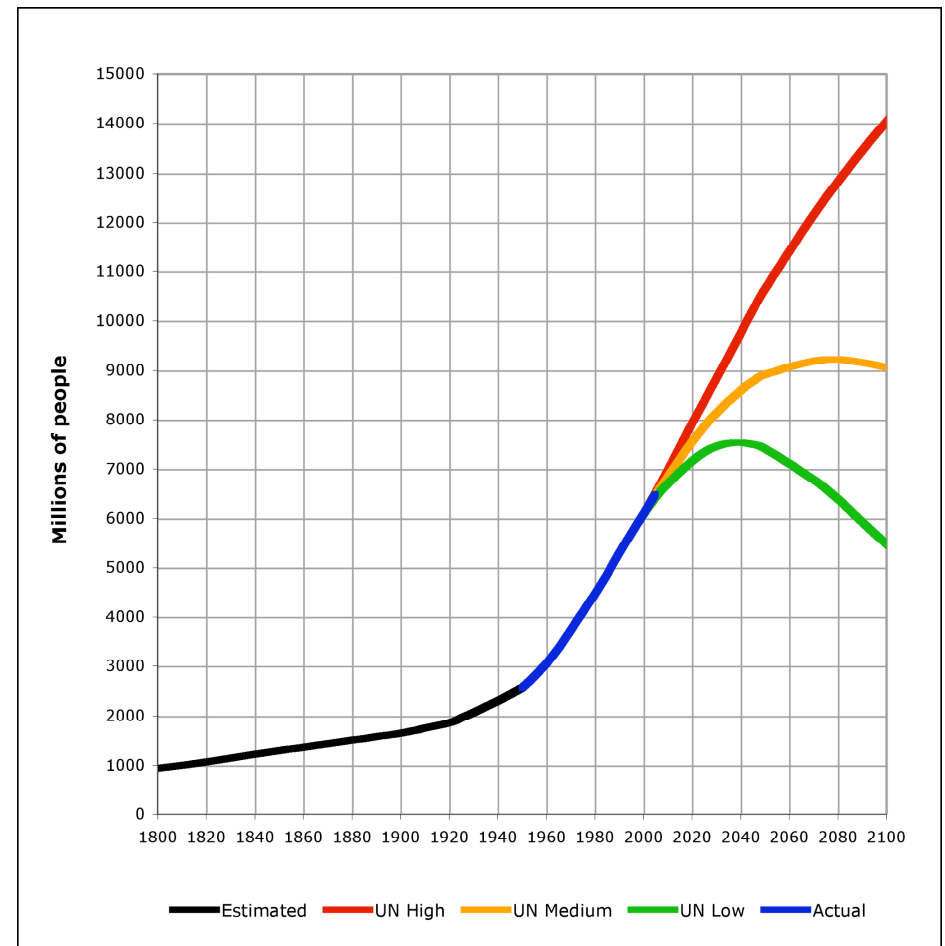
Population and climate: one study at the London School of Economics

Per dollar spent,

family planning reduces four times as much carbon over the next 40 years as adopting **low-carbon technologies**

Concluded: Family planning is cost effective and should be **a primary method to reduce emissions**

Copenhagen: **no discussion** on population or family planning



Population growth affects every environmental challenge we face:

- Generation of GHG, other pollutants and toxic waste
- **Resource depletion**: water, oil, fisheries, topsoil, etc.
- Resource wars and civil conflicts
- Malnutrition and world hunger
- Lack of resources for education and health care, especially in poor countries
- Best farmland converted to urban and suburban sprawl
- Garbage disposal and need to find more landfill space
- Species extinction...

Why was the population able to grow so fast since the 1950's?

Two reasons:

- 1) Sanitation and antibiotics (living longer)
- 2) Use of fossil fuels in agriculture starting in the 1950's:
 - fertilizers, pesticides, irrigation, mechanization

1950 to 1984: production of grains increased by 250%!

Without fossil fuels population would be much smaller!

- Growth in grain production is now flattening out
- Industrial farming is destroying forests, soil
- Urban and suburban sprawl is overrunning best farmland

Is this population sustainable?

Ethanol: we all know that it takes more energy to produce a gallon of ethanol than what we get from burning it (!)

Food: It is not well known that we spend orders of magnitude more calories to grow food than the calories we get from it!!!

This **unsustainable** situation is only possible because **we are using non-renewable resources**

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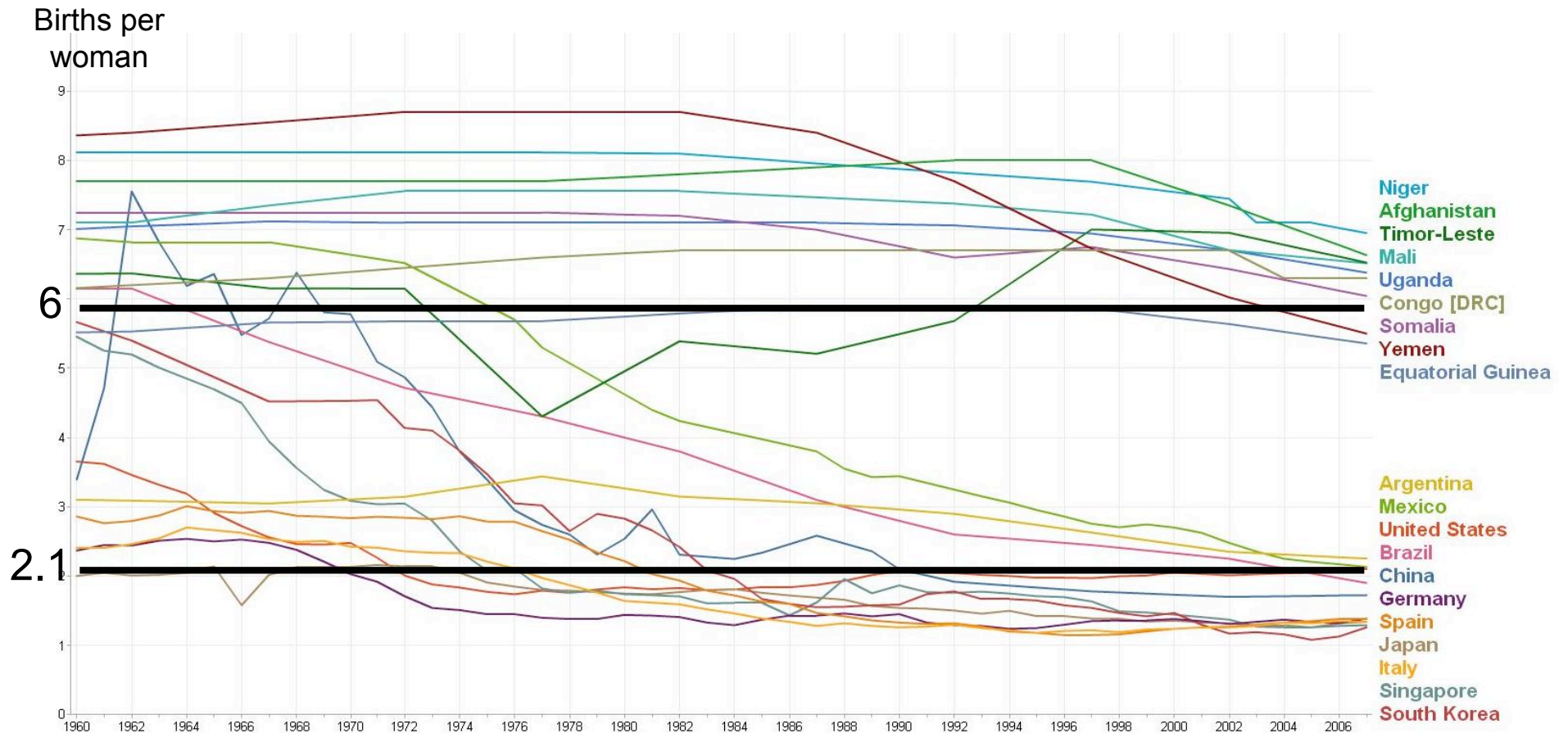
Herman Daly (UMD, founder of Ecological Economics): “We are drawing down the stock of natural capital as if it was infinite”

The real world resources are **finite**, so this is **unsustainable**.

Many researchers think we are well beyond the Earth’s carrying capacity (~1-2 billion?), and every year we add ~75m more. Optimistic estimates: leveling off after adding 2 more billion.

Births per woman

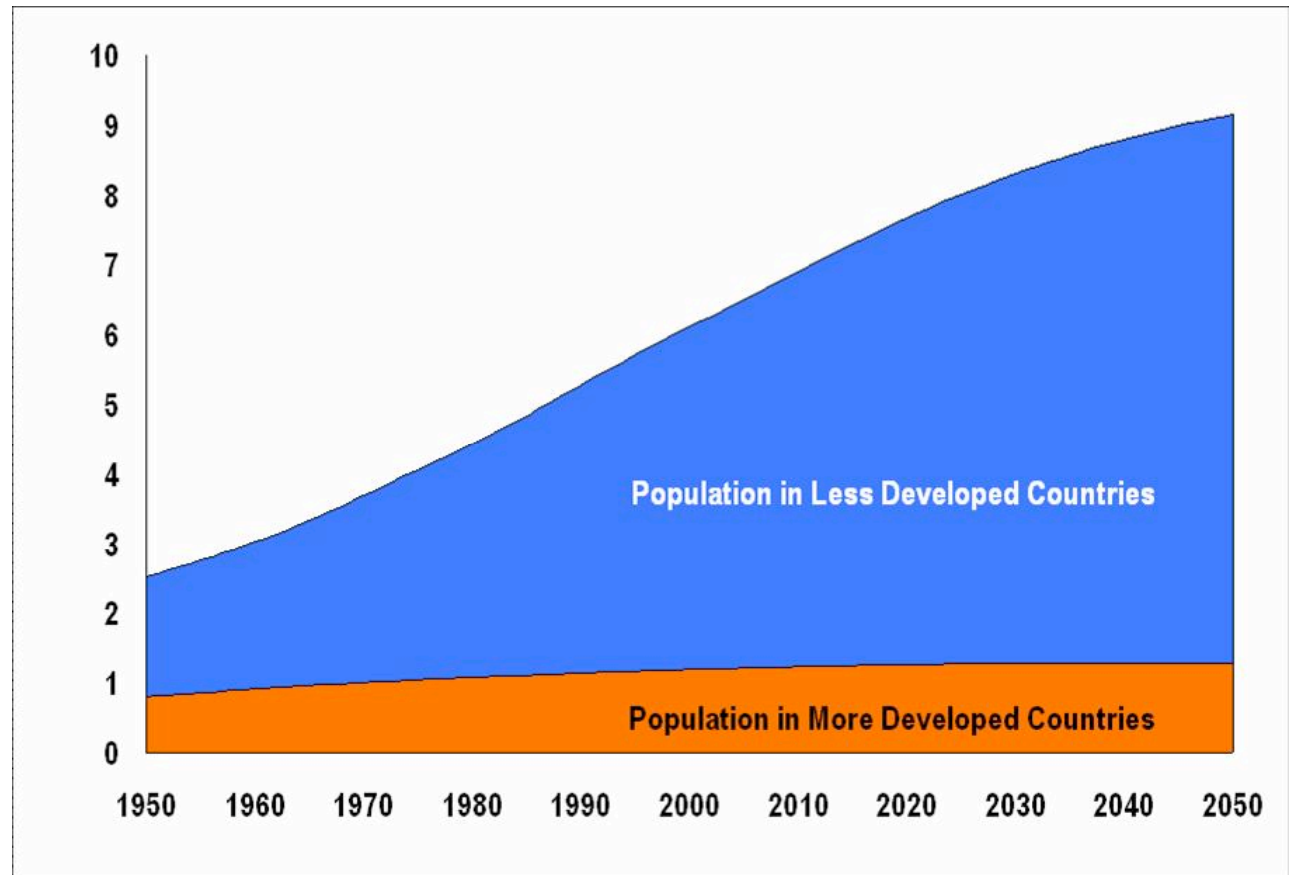
There are many countries that are still at the level of 6 or more births per woman.
Many countries are close to or below replacement level. China is at 1.7 b/w



Data source: [World Bank, World Development Indicators](#) - Last updated November 20, 2009

Still growing...

Most population growth takes place in underdeveloped countries,



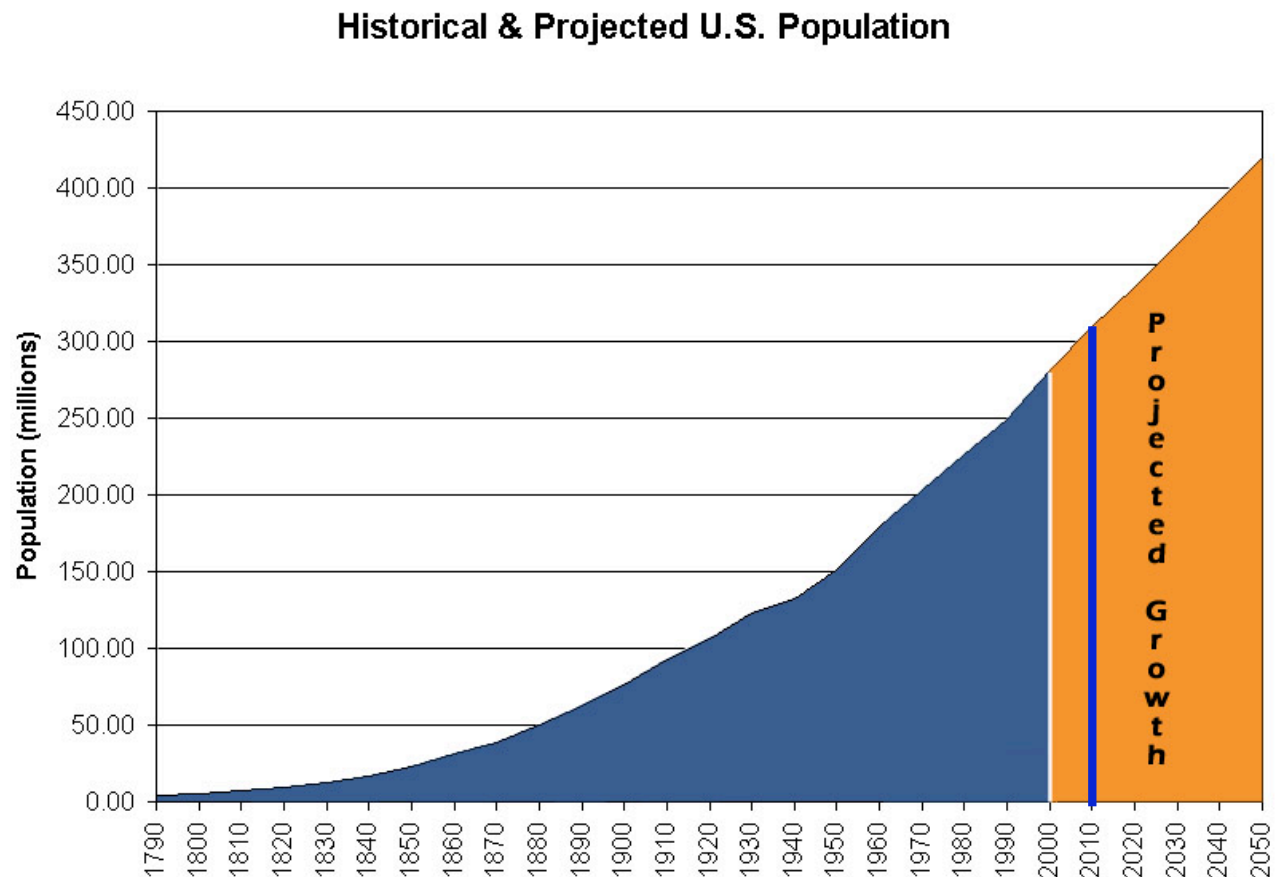
Still growing...

Most population growth takes place in underdeveloped countries, but

Some developed countries are still growing fast:

UK grew more in 2008 than in the previous 50 years despite lower immigration

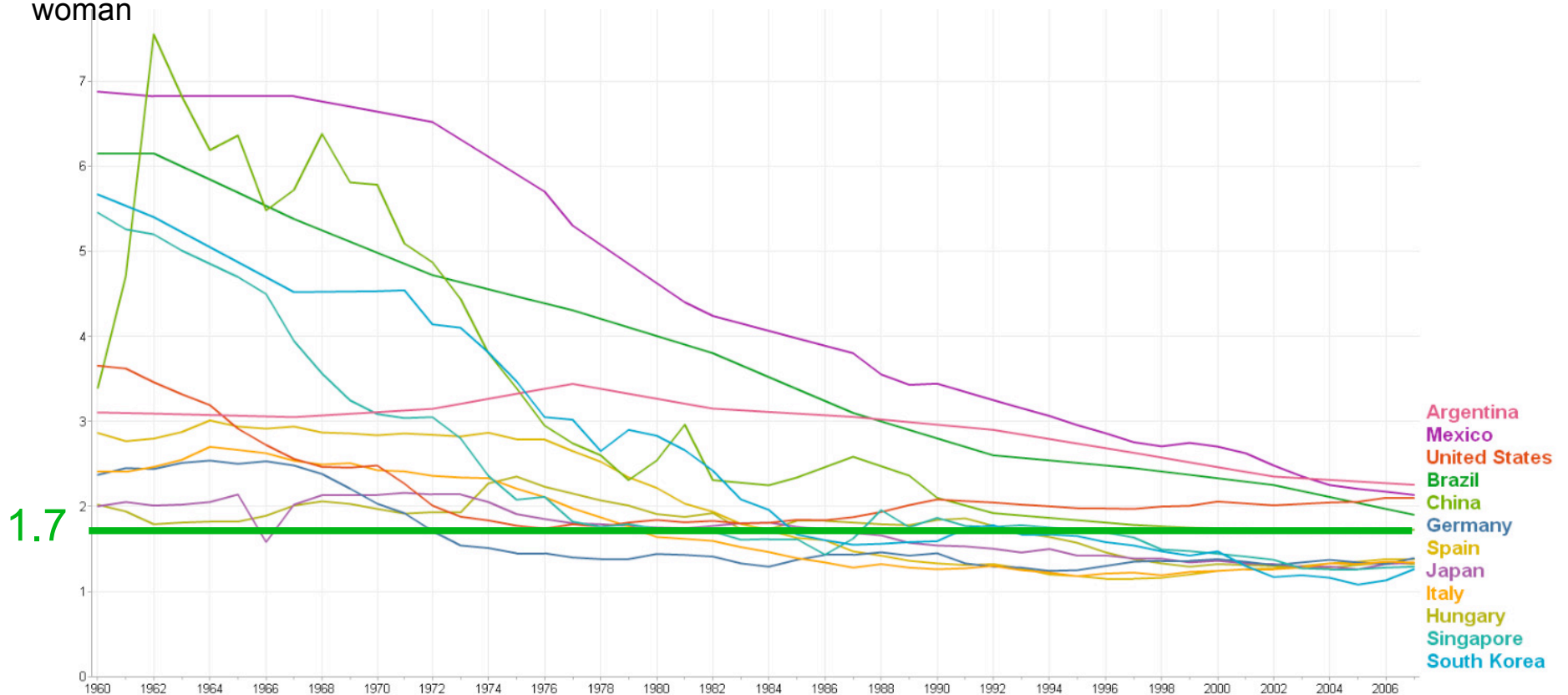
US fertility rate is creeping up: 1.7 in the 1970s, now it is 2.13.



The good news!

~40 countries (Canada, most of Europe, South Korea, Taiwan, Cyprus, etc.) have reached a birth/woman rate

Births per woman **lower than China's 1.7 without coercive measures!**



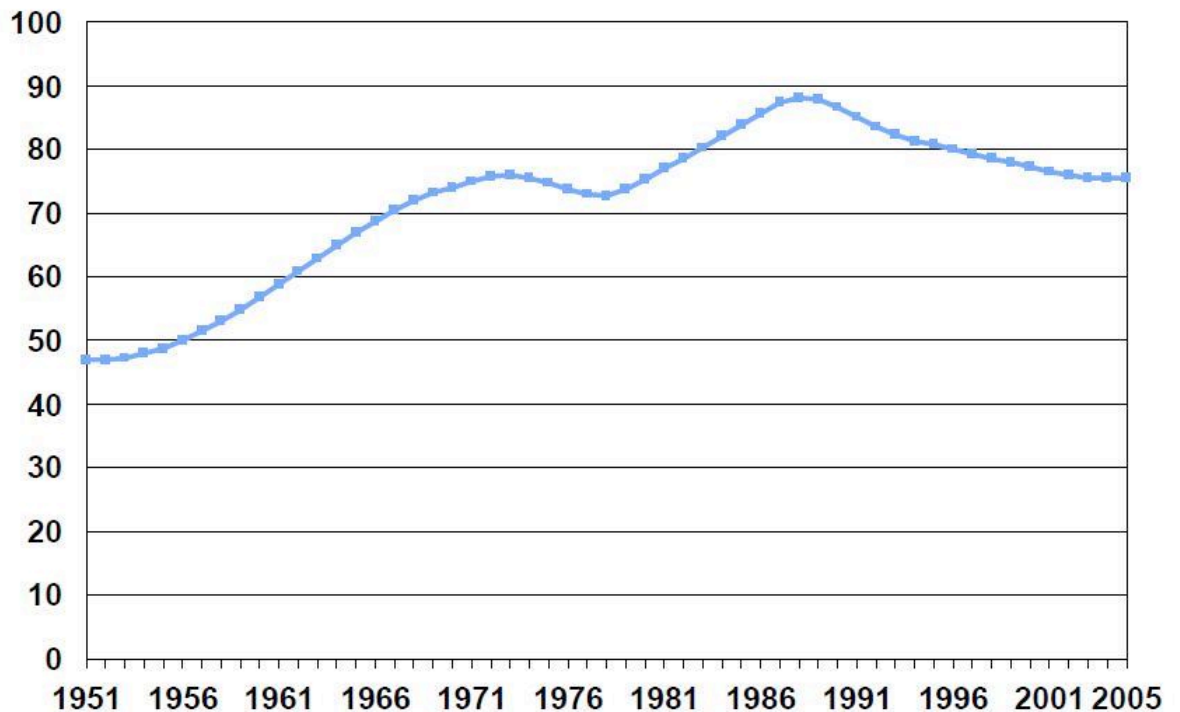
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Are we past the problem of population growth?

Conventional wisdom is that population growth is **no longer a problem** because the rate of growth is going down

Annual Increase in World Population

Millions



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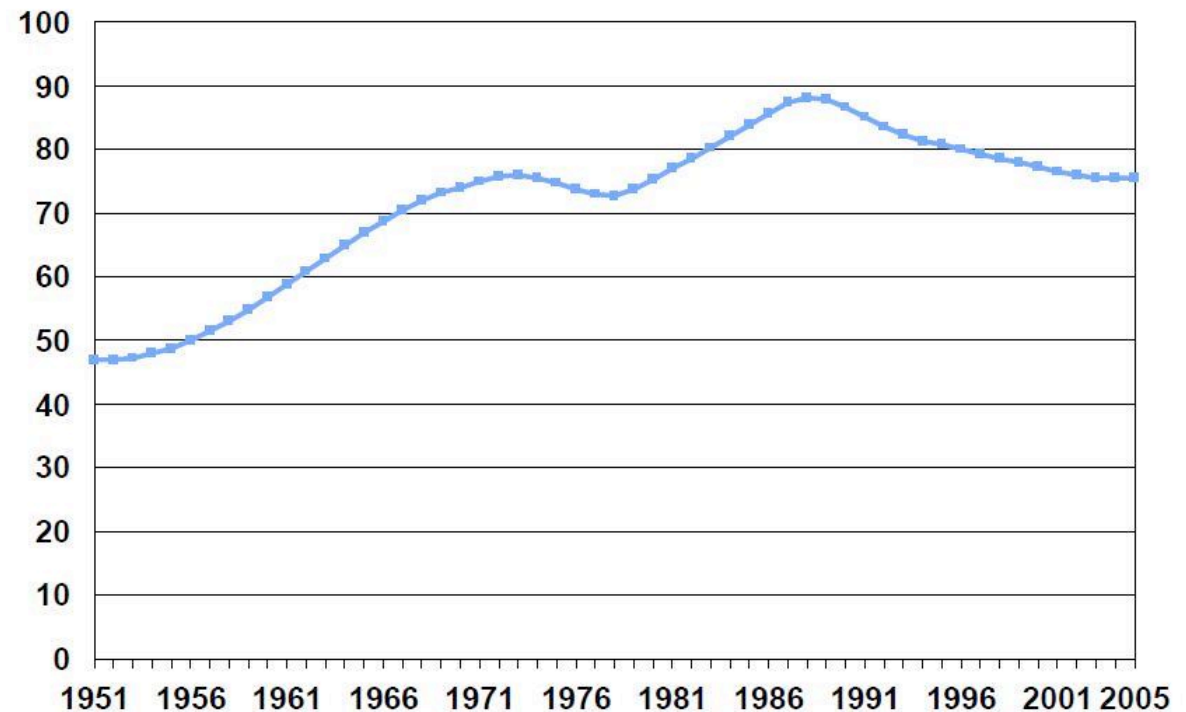
The **population explosion** took place in the second half of the 20th century.

Although **the rate of growth is going down**, in absolute terms we are still adding about **75m every year**.

This is more than during most of the population explosion period!

Annual Increase in World Population

Millions



What about human rights?

When people think of reducing population growth, they think of **coercive** measures: the one-child target in China, forced sterilizations in India.

This misses the fact that ***most women are forced to have more children than they want.***

It is a human rights issue indeed but in the **opposite** direction. International UN polls show in many countries more than 80% of married women of reproductive age with 2 children, do **not** want to have more children.

A nurse I know was asked by a Somali patient why she had no children, and she responded she had not wanted any yet. The response of the Somali woman was: “Wow! You are so lucky to have that choice. I have 6 children already and I have no choice in the matter. I wish I had that choice!”.

Non-coercive methods to reduce growth

The UN estimates that 40% of all pregnancies worldwide are **unintended**. Just helping women to avoid unintended pregnancies would have a huge impact.

Non-coercive ways to drastically reduce fertility:

- **Education,**
- **access to birth-control** and
- **equal economic opportunity for women**

Population control is both feasible and effective.

In stark terms,

if every woman of bearing age had only one child,
the population would be reduced to a level
between 1 and 2 billions in about 150 years.

Supportive government policies (national and
international) to **empower women** are
essential for reducing growth.

What about the economics of reducing population?

We hear a lot about the dire problems that reducing the population will bring... Let's look at the evidence:

China has had the strictest population control policies since the 1970's: b/w went down from more than 6 to 1.7. It is estimated that 300-400 million births have been avoided (more than the population of the US!)

At the same time China has had **the highest rate ever of sustained economic growth in the human history.**

Similarly Japan, South Korea, Taiwan have had extremely high sustained economic growth with lower birth rates.

A counter example is the Philippines, with higher population growth and lower economic growth.

Will we face a shortage of workers?

We are repeatedly told that in Europe, Japan, the US, and China, **lower birth rates** will create a huge **demographic crisis** due to a **shortage of workers**.

However, as Dean Baker, of the Center for Economic and Policy Research, explains:

Prices reflect supply and demand. A shortage of labor means workers' wages will rise and higher wages shift the labor force from low to high productivity work. So, we may have fewer greeters at Wal-Mart, valet parking or all-night convenience stores. And dangerous or unpopular work would be mechanized.

(has this "crisis" scared you yet?)

This alleged "demographic horror story" would actually be great: today these economies suffer from **labor surpluses** and **high unemployment** rates.

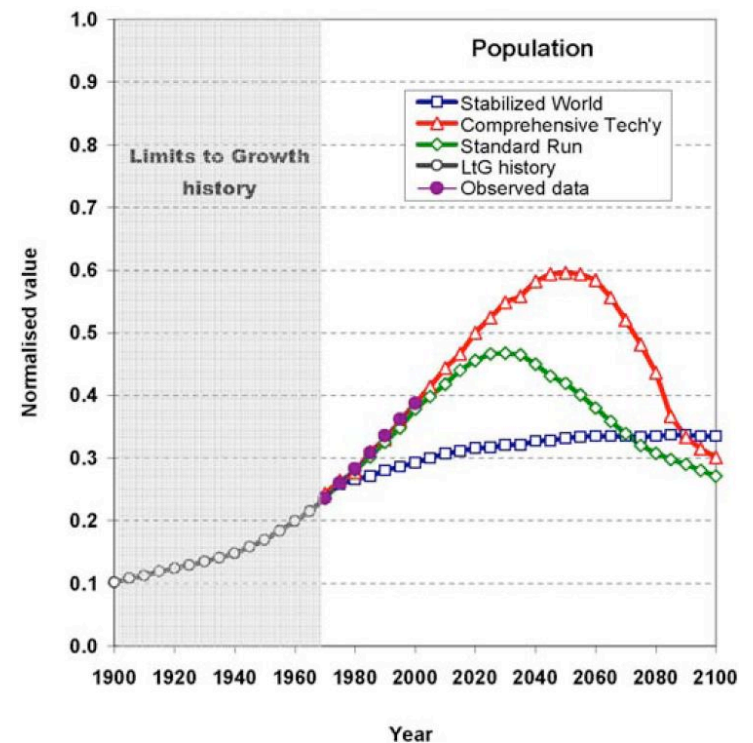
1972: Club of Rome “Limits to Growth”

The Club of Rome commissioned a group at the MIT Sloan School of Management to study:

“Are current policies leading to a **sustainable** future or to **collapse**?”

When the results appeared in 1972, the conclusion that **with finite natural resources growth would overshoot and collapse** was dismissed as **absurd** by many economists.

35 years later the “standard run” model compares well with reality.
(Gareth Turner, CSIRO, 2009)



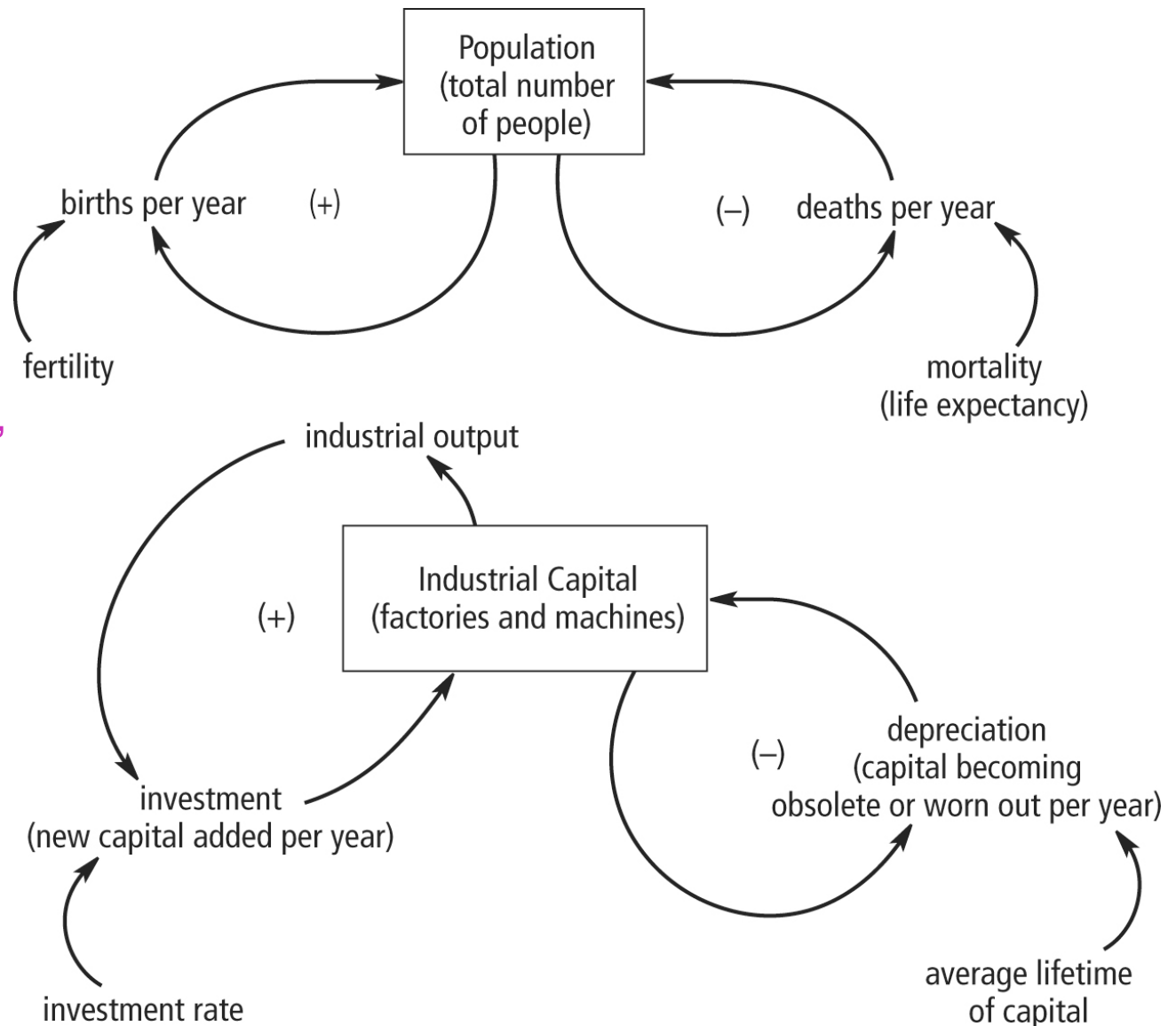
The “World3” model they used:

The model is relatively simple:

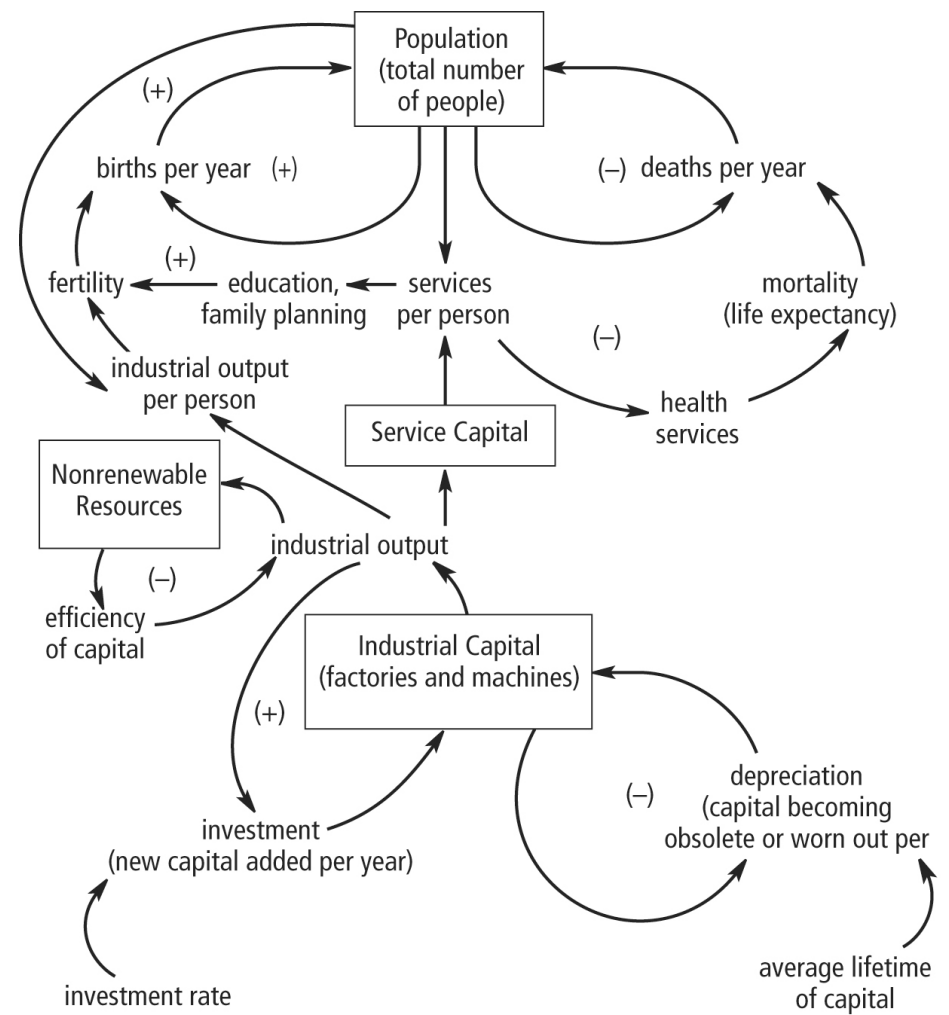
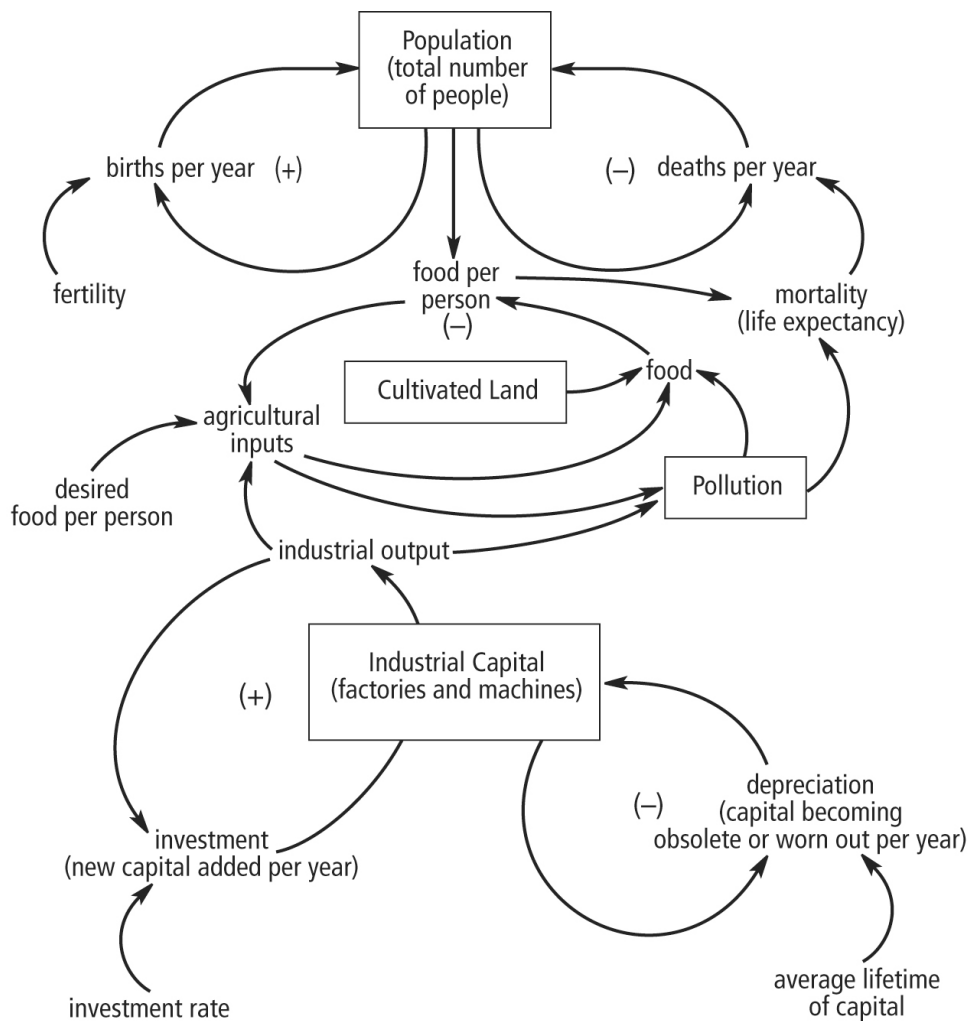
There are “stock” variables [boxes]:
population, cultivated land, industrial capital, non-renewable resources, pollution, etc.

There are interactions (arrows) with positive or negative feedbacks.

The model is then integrated from 1900 to 2100.

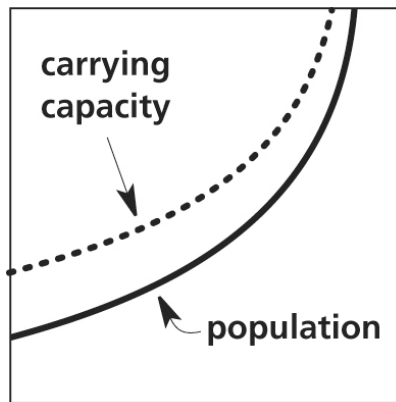


Feedbacks of Population, Capital, Agriculture and Pollution (left) and Population, Capital, Services and Resources (right)

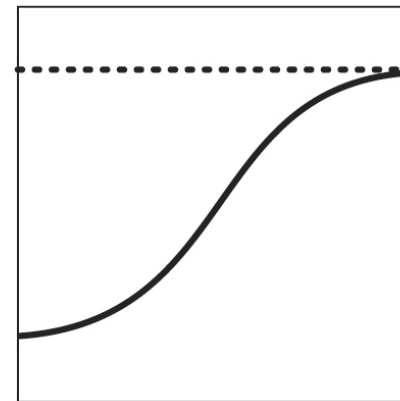


The model could have four possible types of outcomes

Infinite World



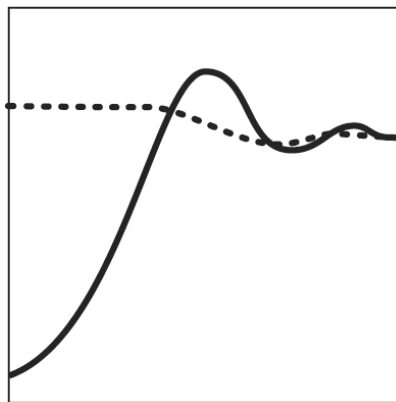
a) Continuous Growth



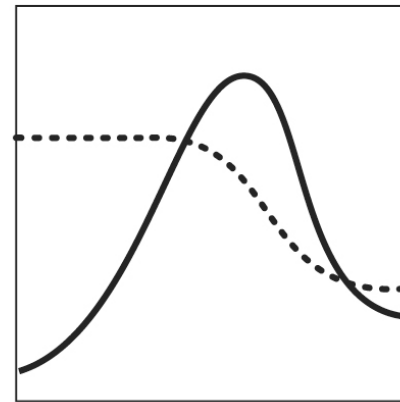
b) Sigmoid Approach to Equilibrium

Ideal
(no overshoot)

Hopefully...



c) Overshoot and Oscillation

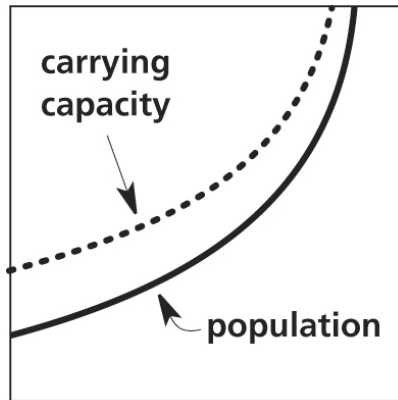


d) Overshoot and Collapse

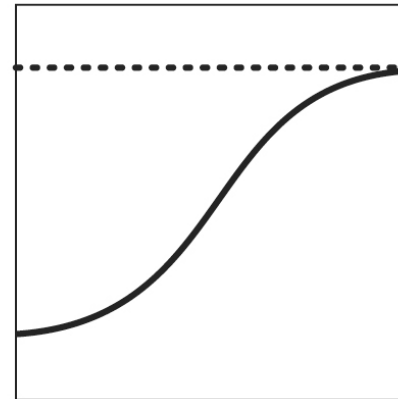
Disaster

The model could have four possible types of outcomes

Infinite World



a) Continuous Growth



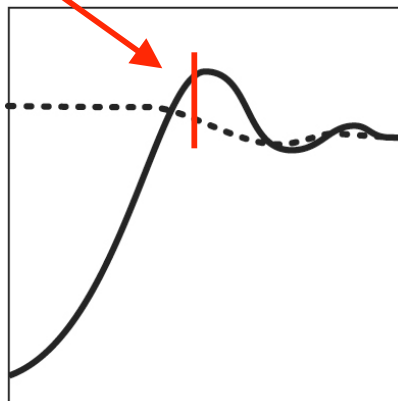
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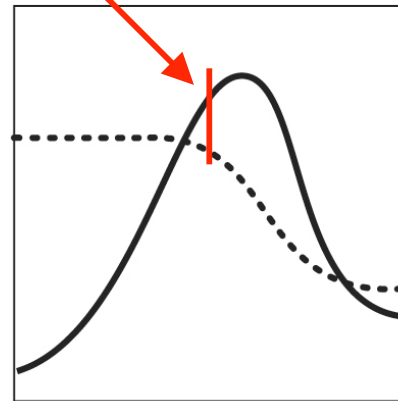
You are here...

Or here...

Hopefully...



c) Overshoot and Oscillation



d) Overshoot and Collapse

Disaster

The results are sobering: most scenarios collapse

Even if **resources are doubled**,
collapse is only postponed ~20 years

In order to **avoid collapse**
policies are needed to:

- Stabilize population and
- Stabilize industrial production per person
- Adopt technologies to
 - abate pollution
 - conserve resources
 - increase land yield
 - protect agricultural land

Need to develop regional models.

The model aggregates the **whole world** into a **single model**.

Therefore it cannot include:

- Rich vs. poor (differential consumption rates)
- Resource wars
- International migration
- Government policies
- ...

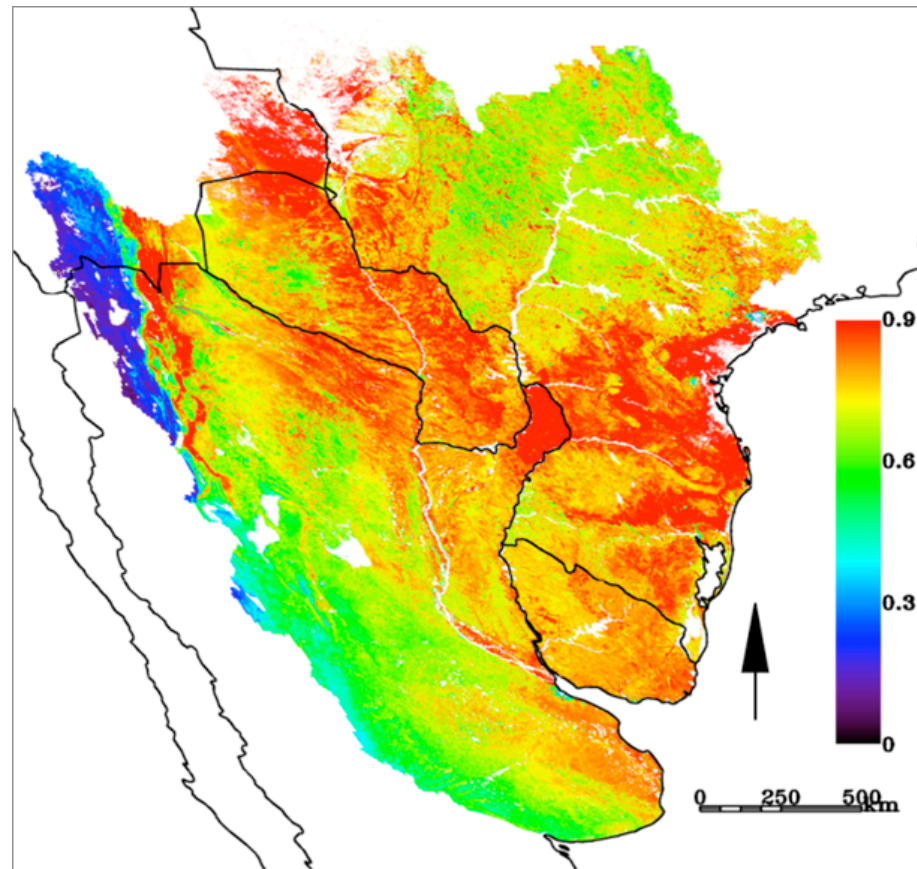
To include these important factors we need to develop regional population models.

We could start with 20-30 regions like

- Brazil
- Argentina, Uruguay and Chile
- ...

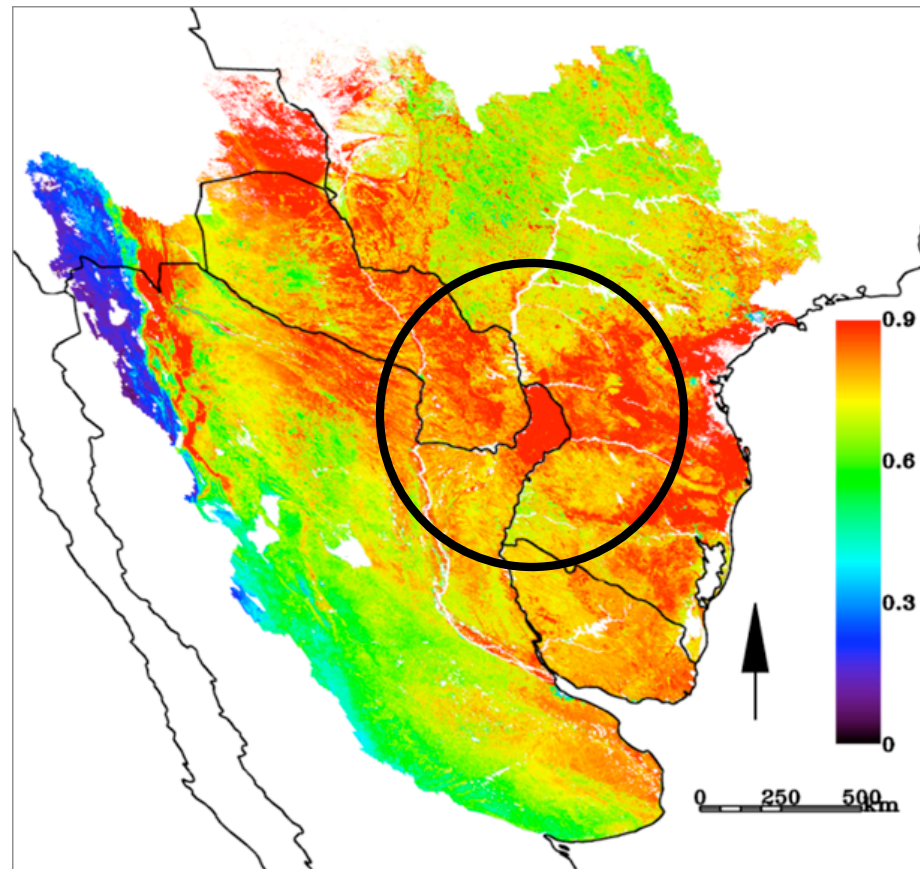
This is **computationally very feasible** (about 10 stocks and 1000 parameters per region)

Can government policies be effective?



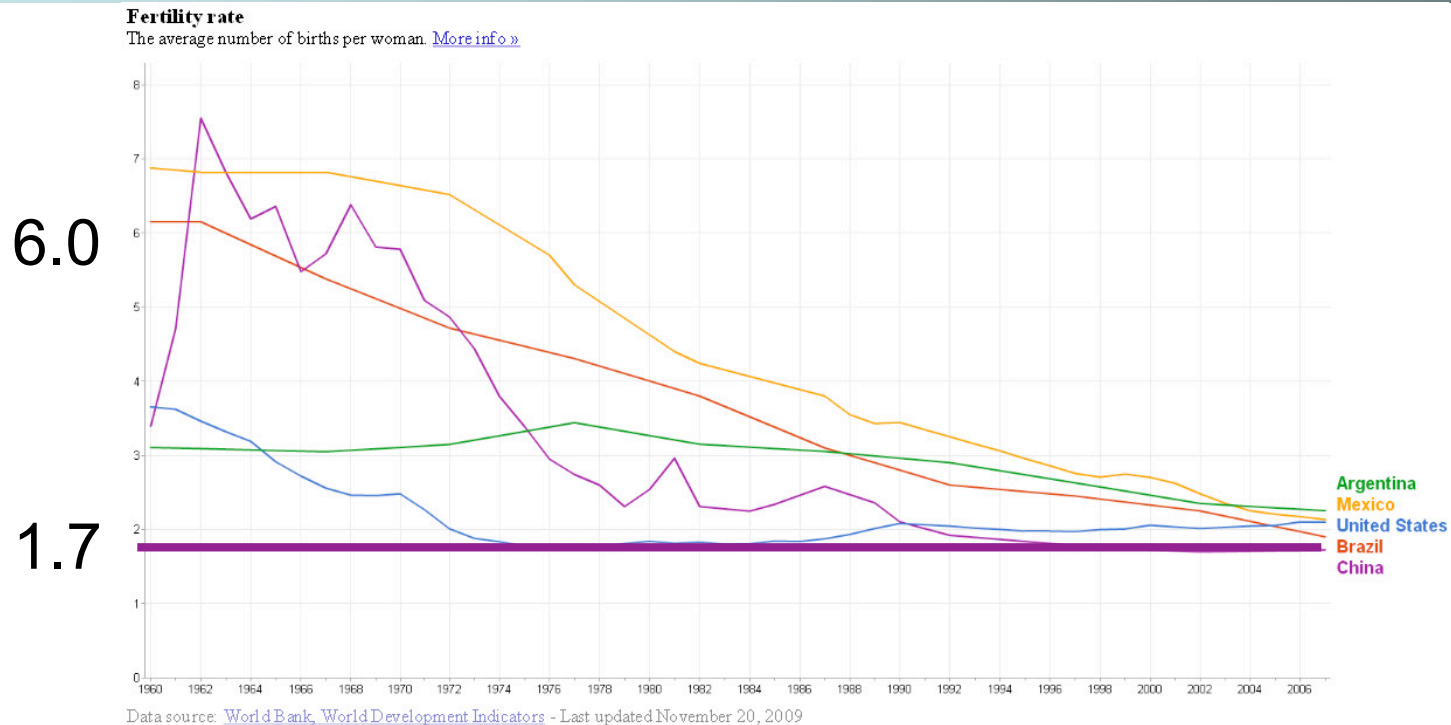
Vegetation productivity (NDVI) in South America:
red is maximum primary (vegetation) productivity

Government policies are important!



The red (highest NDVI) is in the **province of Misiones**, Argentina, that **protects the forest**. Compare Misiones with Brazil, Paraguay and the rest of Argentina!

Government policies are important!



In the 1960's **Argentina's** fertility rate was **less than half** of **Brazil** and **Mexico**.

With government support for family planning, **Brazil and Mexico** have now much lower fertility rates than Argentina.

Government policies matter!

A proposal to DOE, NASA, NOAA, NSF, State Dept., and others

We already include in Earth System models coupled modules for land-ocean-atmosphere-vegetation, carbon emissions and chemistry.

Push for Earth System modelers and economists to develop coupled scenarios for climate change with regional modules for population:

An interactive human population module to the Earth System Models could start with regional World3-type models, or other economic models and add

- human interaction with land,
- separate resources: oil, water, fisheries,...
- government policies,
- international policies and treaties,
- investment policies,
- international migration...

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Push for Earth System modelers and economists to develop coupled scenarios for climate change with regional modules for population:

This would achieve two major goals:

- 1) Study different scenarios for world development and population policies.
- 2) Force us to look at the population problem from a scientific point of view.

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Call for Earth System modelers and economists to develop coupled scenarios for climate change with regional modules for population:

This would achieve two major goals:

- 1) Study different scenarios for world development and population policies.
- 2) Force us to look at the population problem from a scientific point of view.

It would eliminate “the elephant in the room”

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