Limits to Growth

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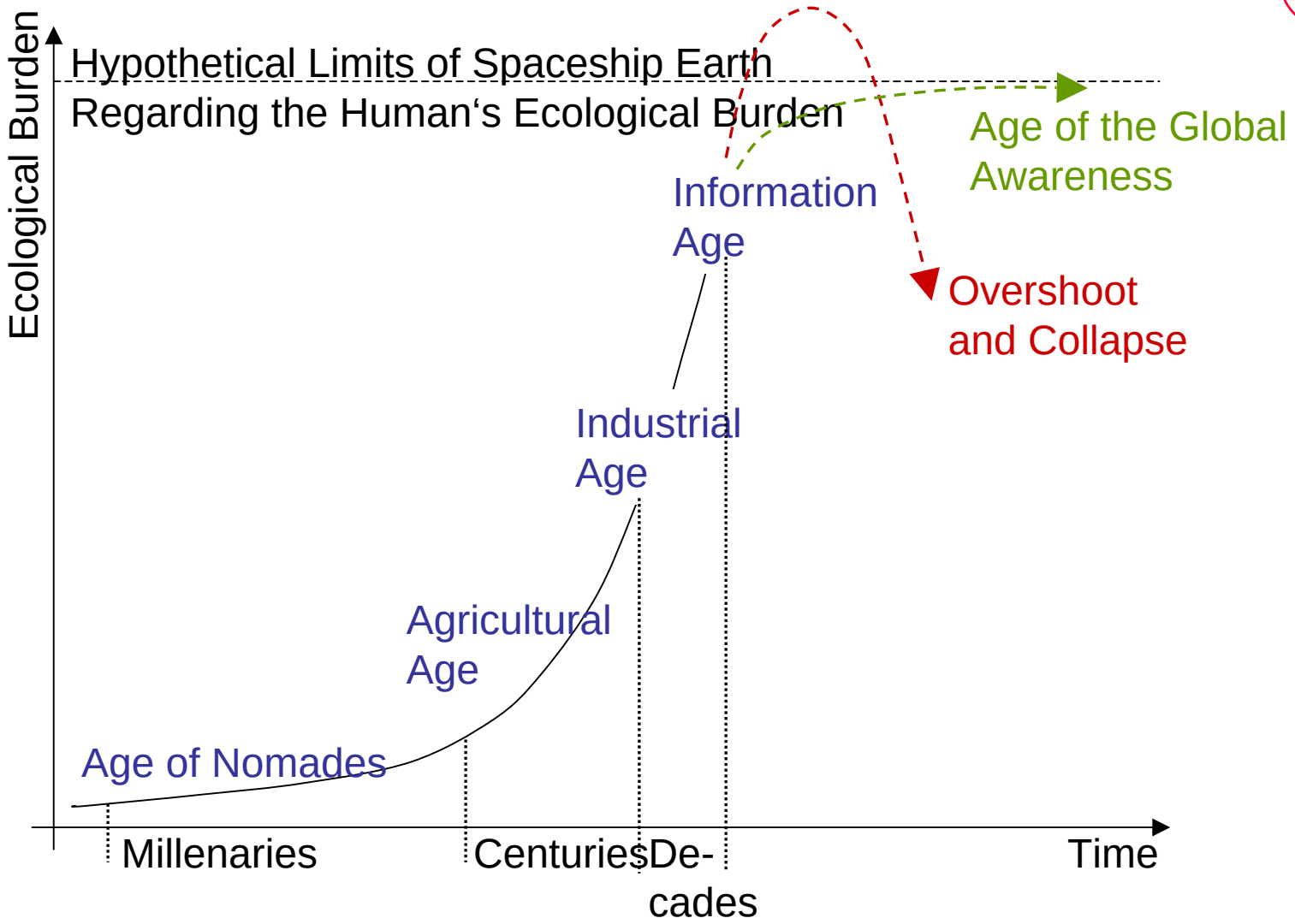
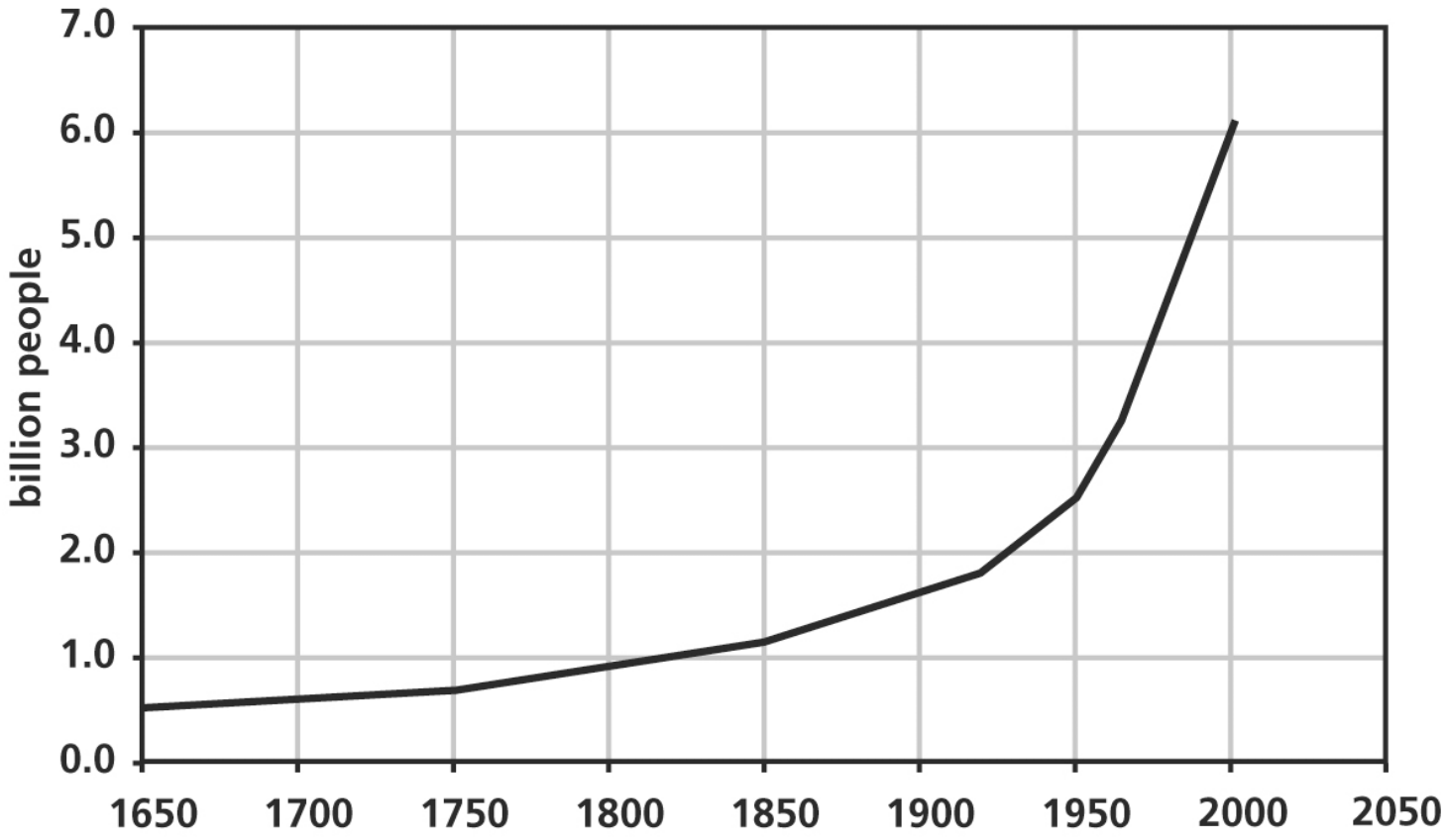
Universität Stuttgart

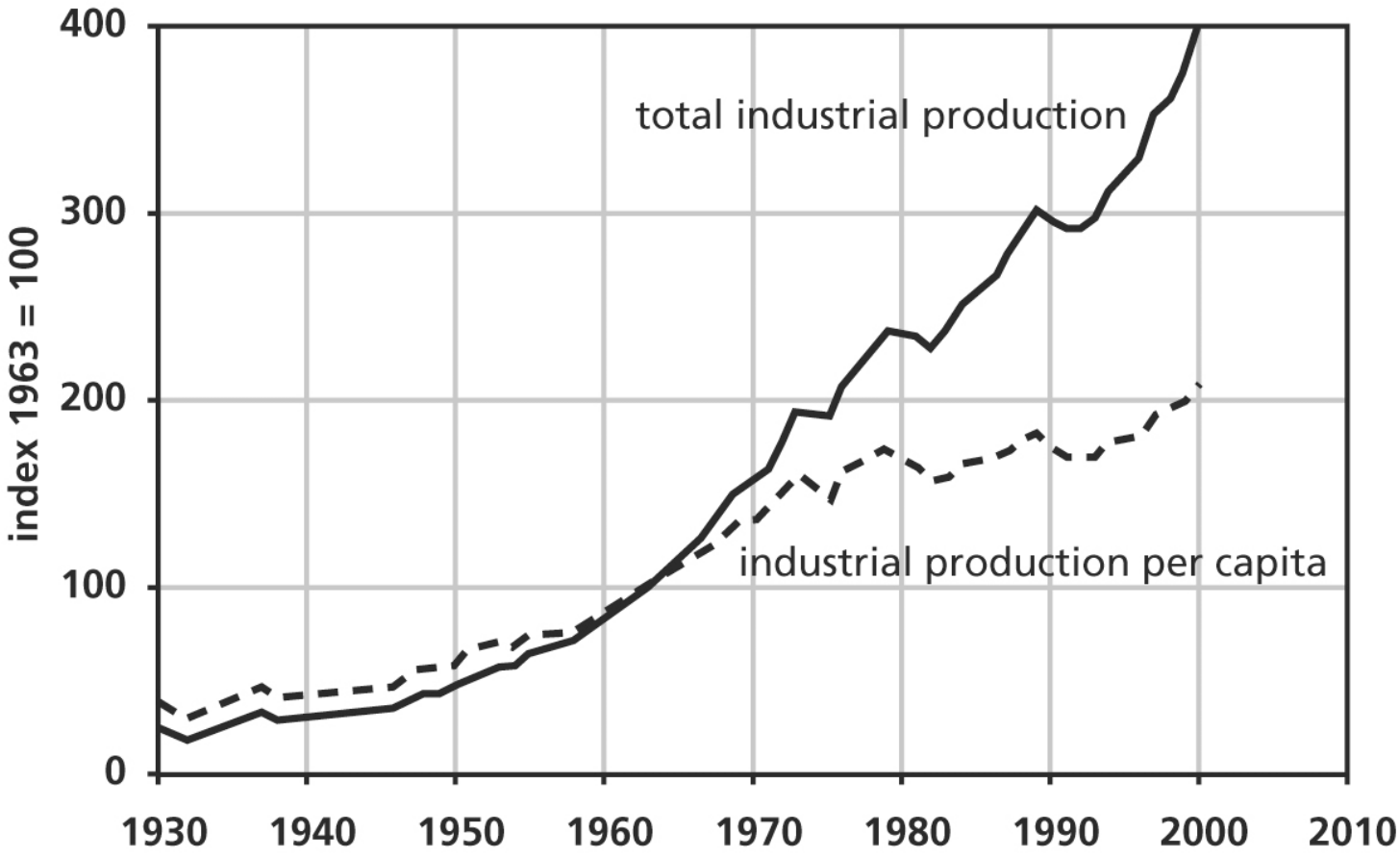
Magdeburg, 22.05.2007



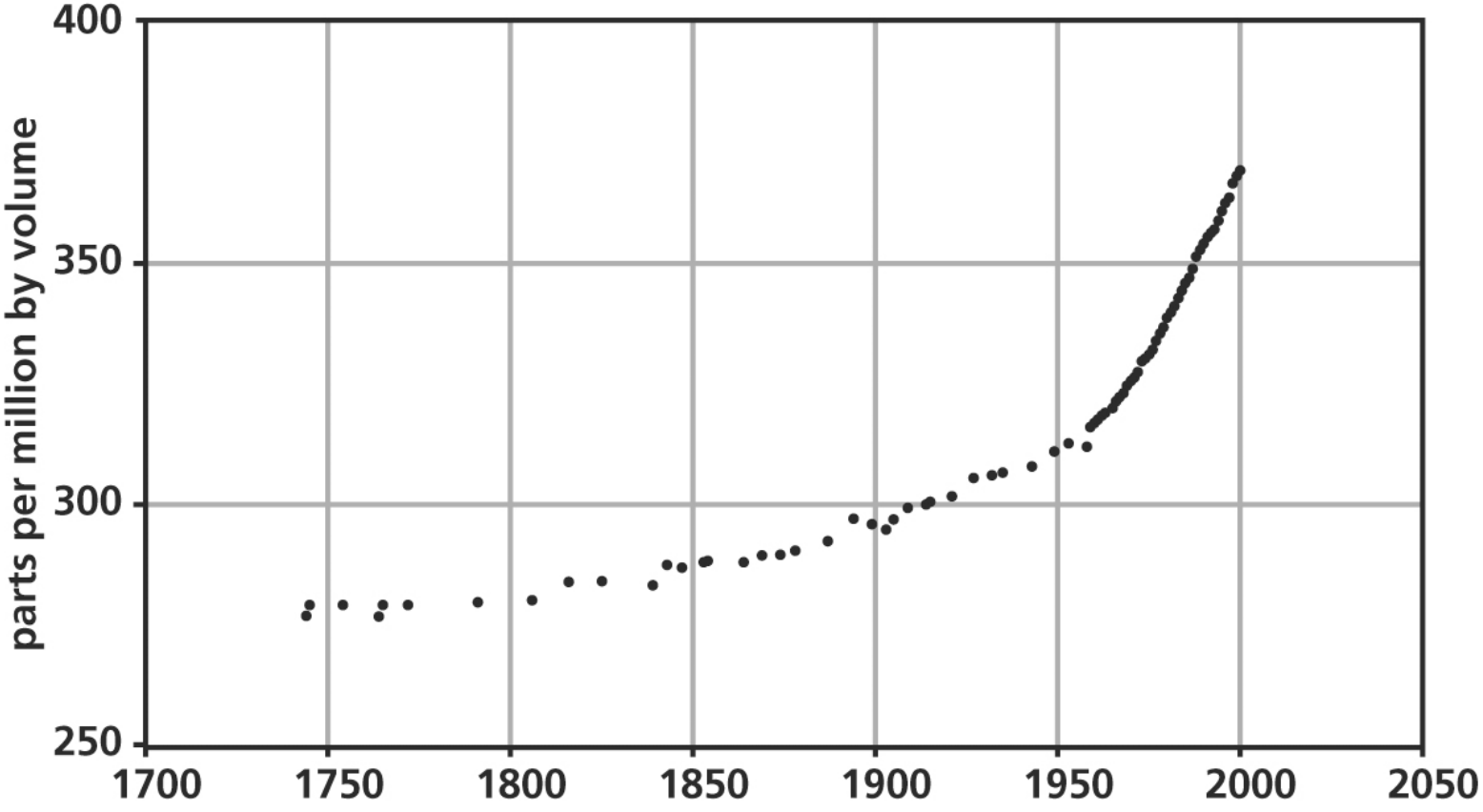
Development of the Ecological Burden During the Existence of the Human Being



World Population

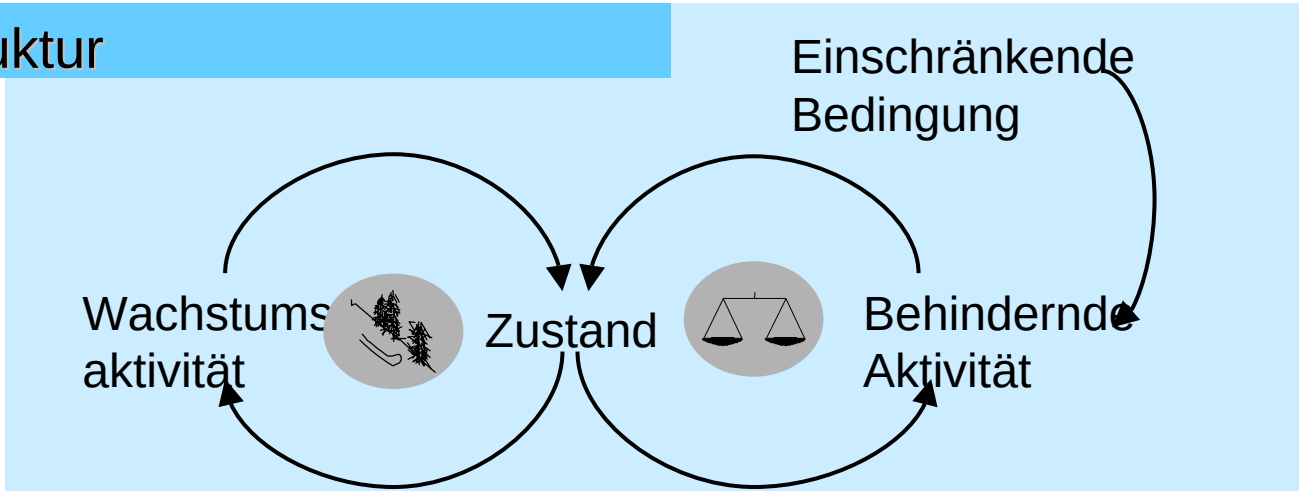


World Industrial Production

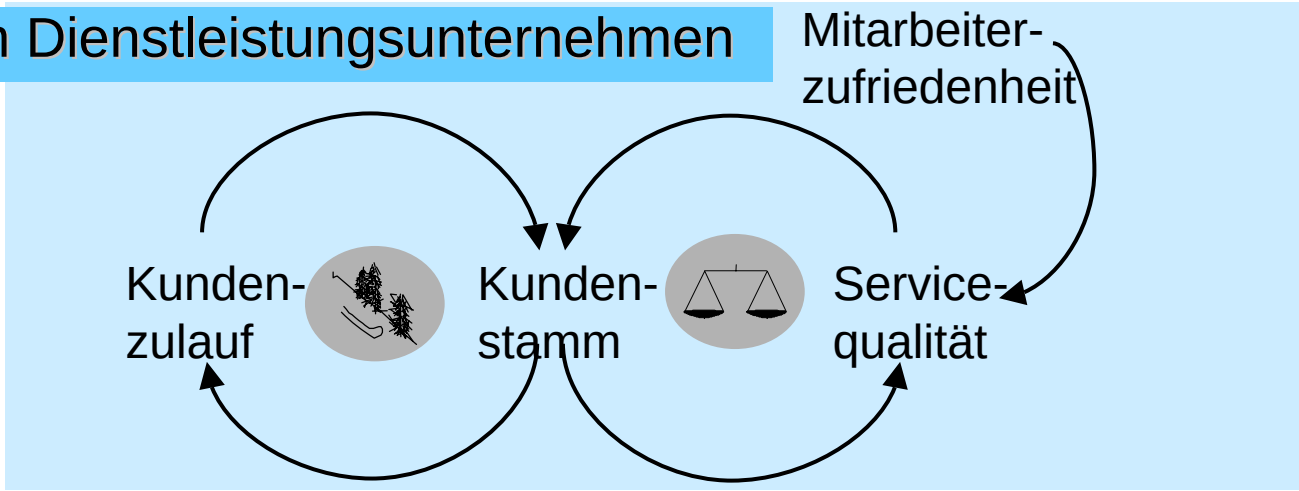


Carbon Dioxide Concentration in the Atmosphere

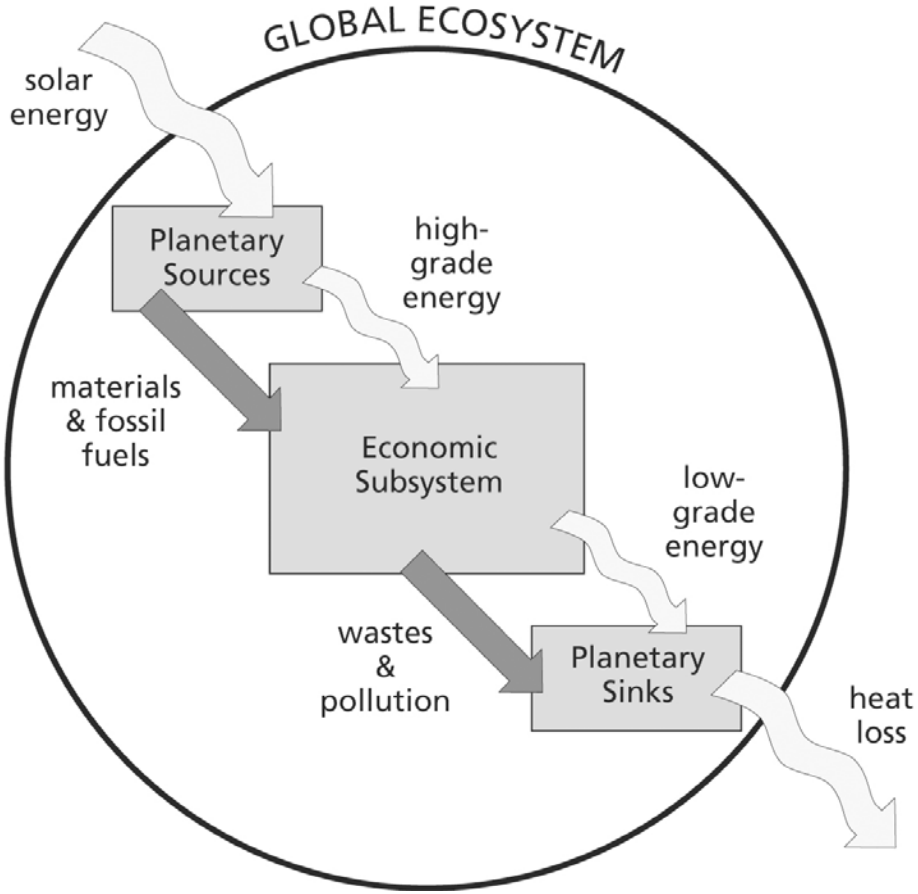
Allgemeine Struktur



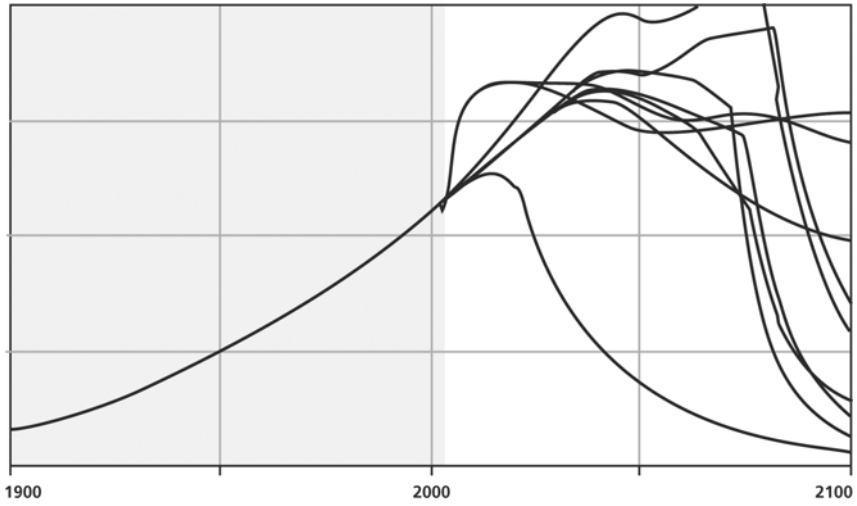
Struktur für ein Dienstleistungsunternehmen

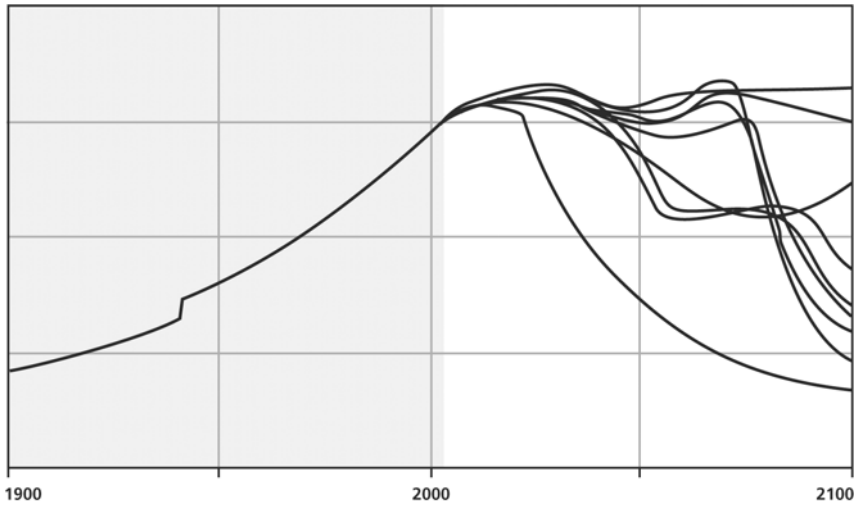


System-Archetyp „Grenzen des Wachstums“

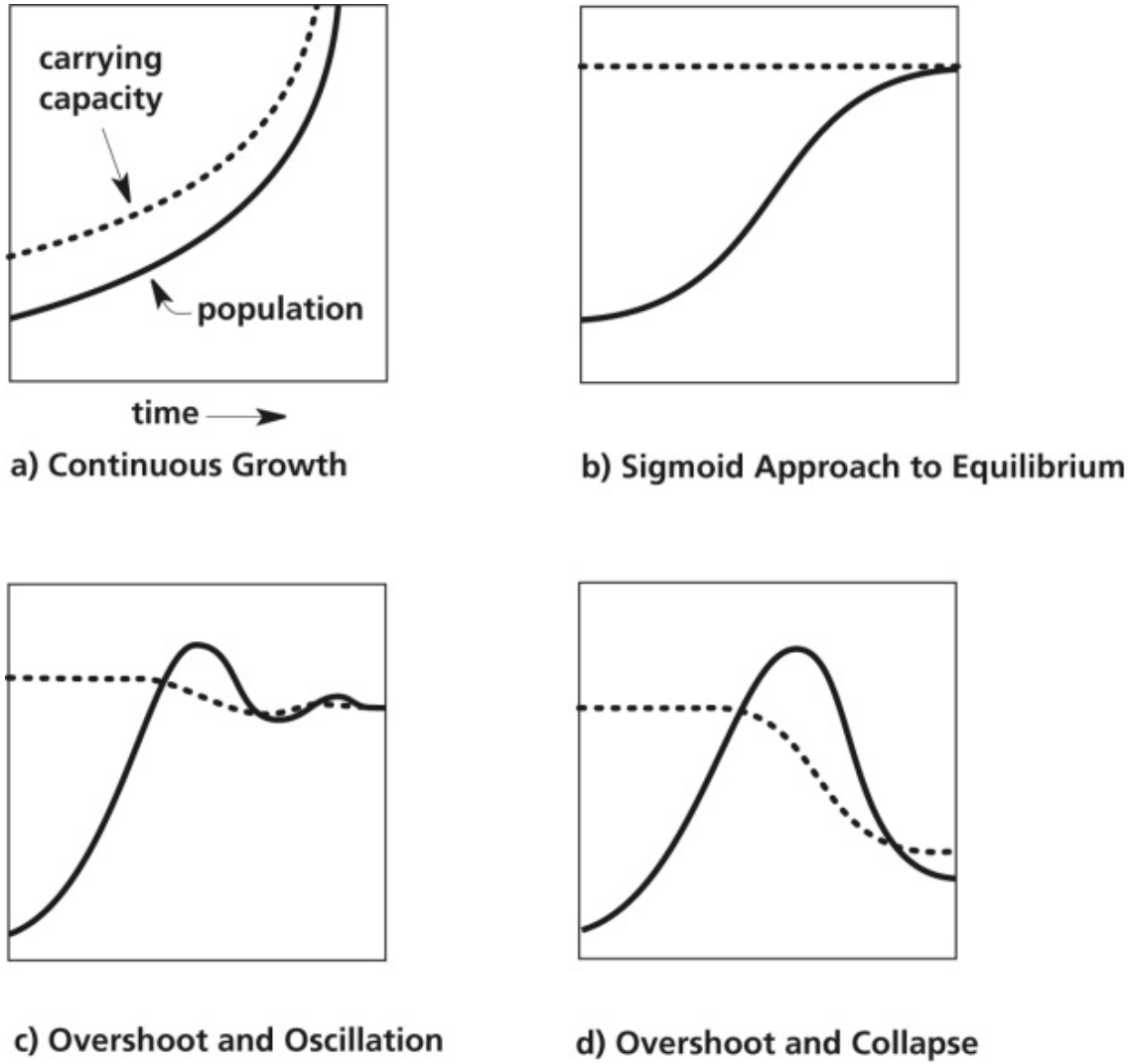


Population and Capital in the Global Ecosystem

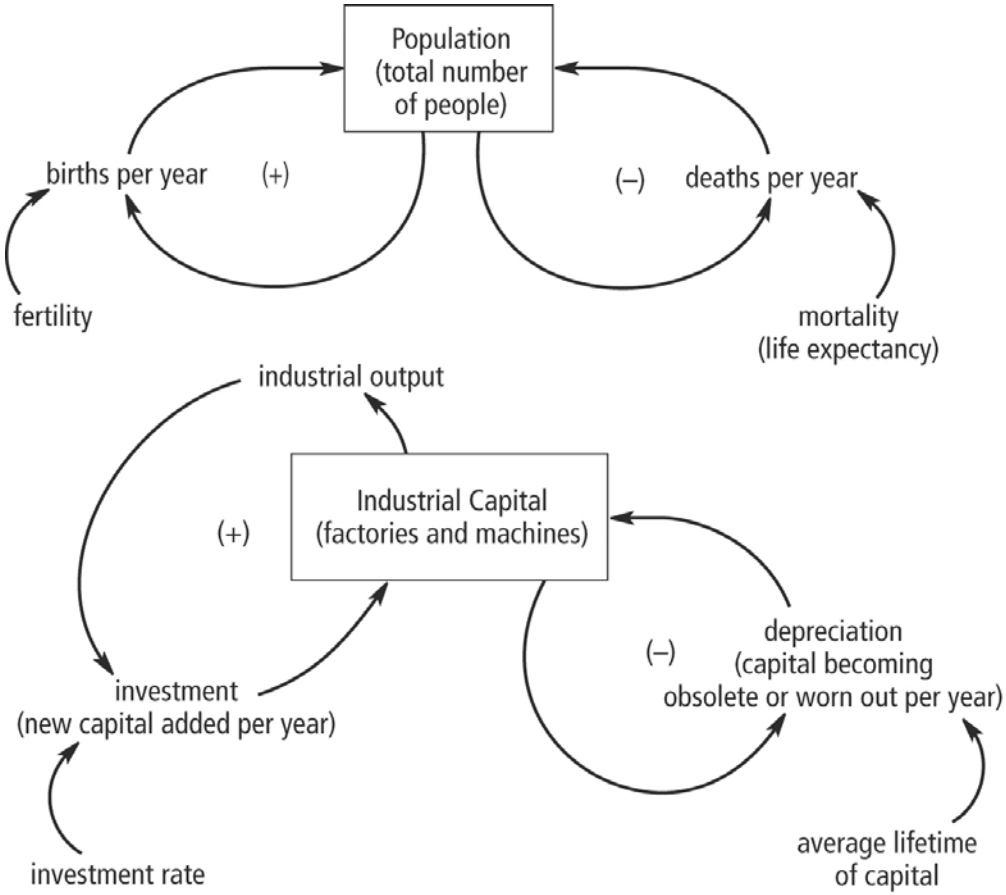




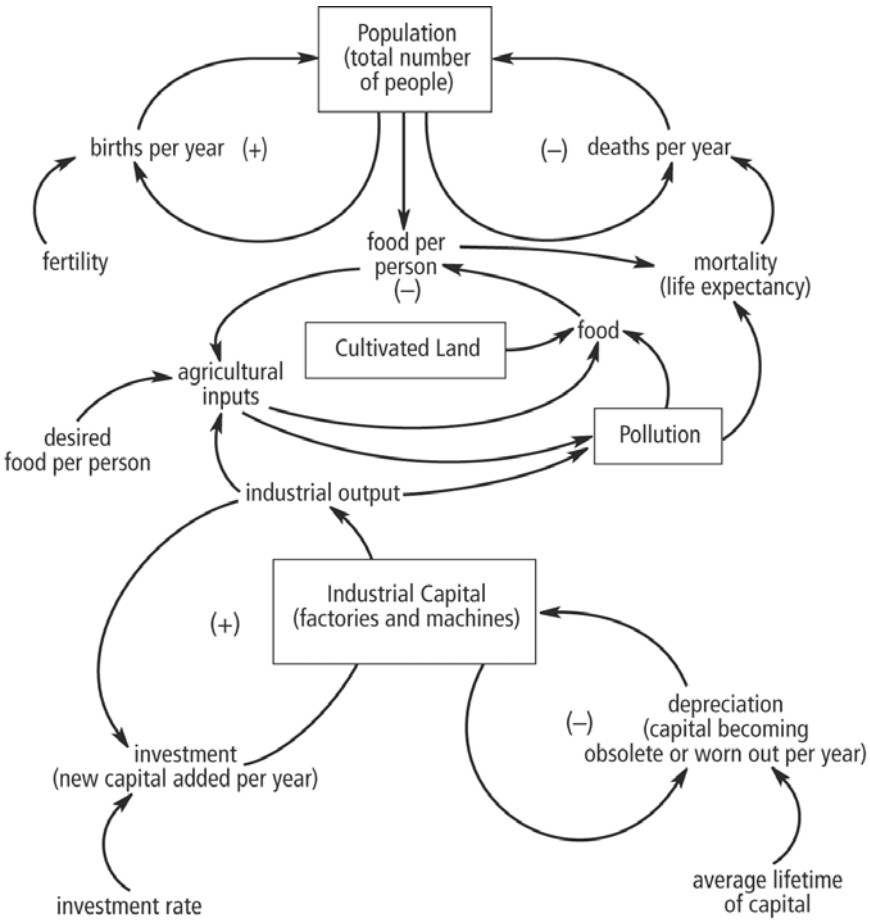
Alternative Scenarios for Global Population and Human Welfare



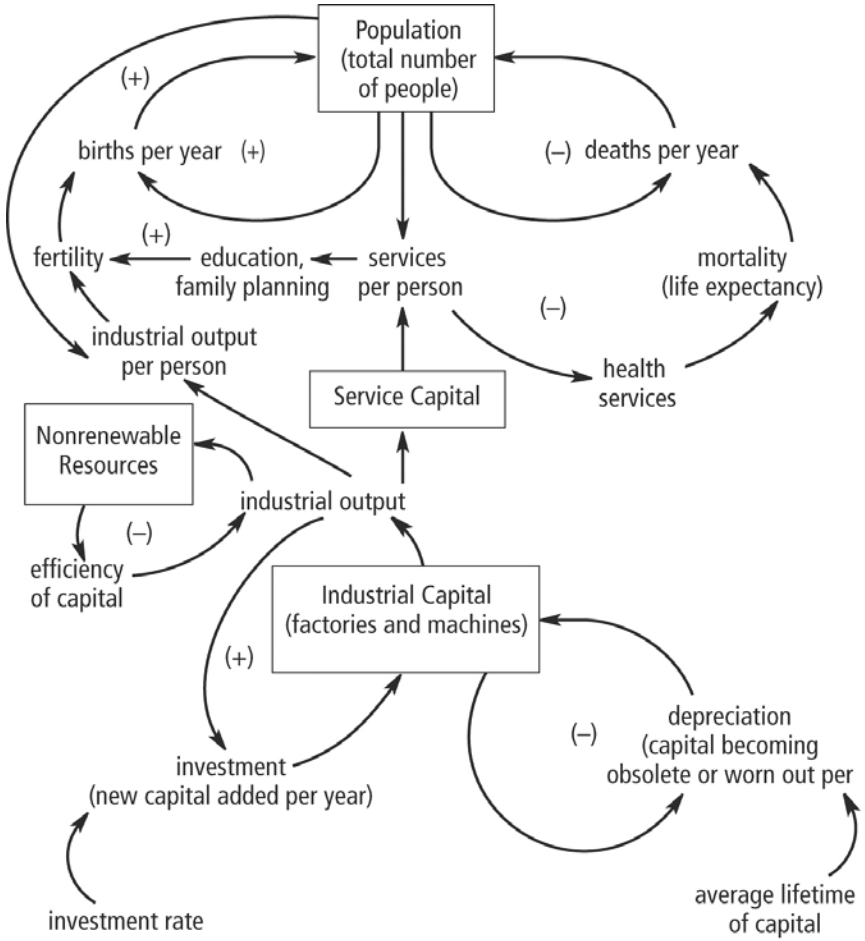
Structural Causes of the Four Possible Behavior Modes of the World3 Model



Feedback Loops Governing Population and Capital Growth



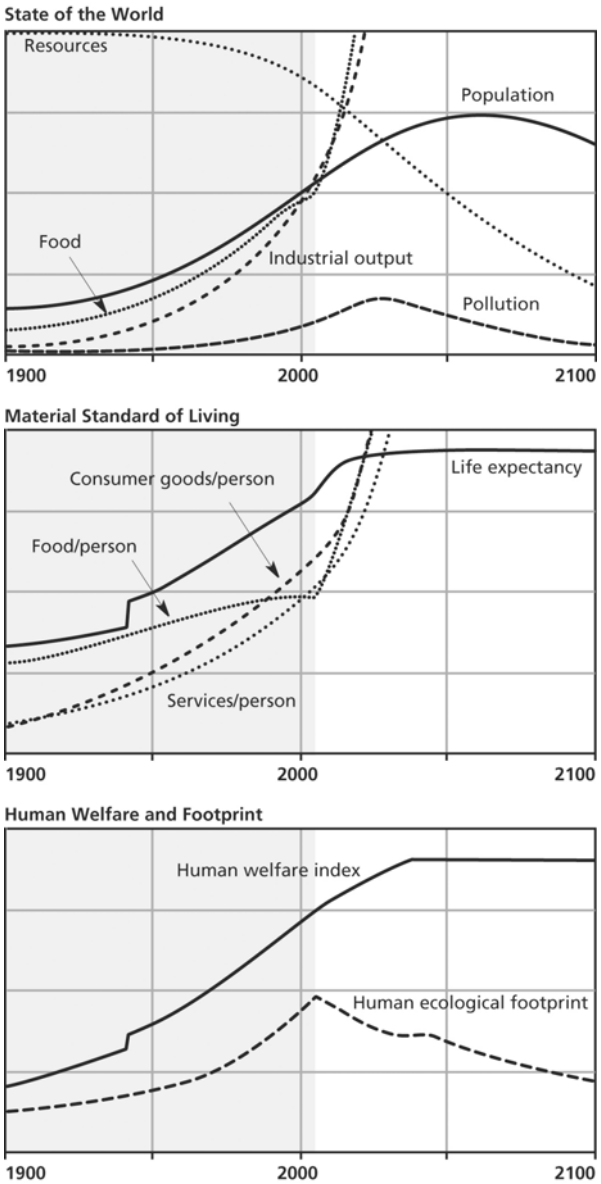
Feedback Loops of Population, Capital, Agriculture and Pollution

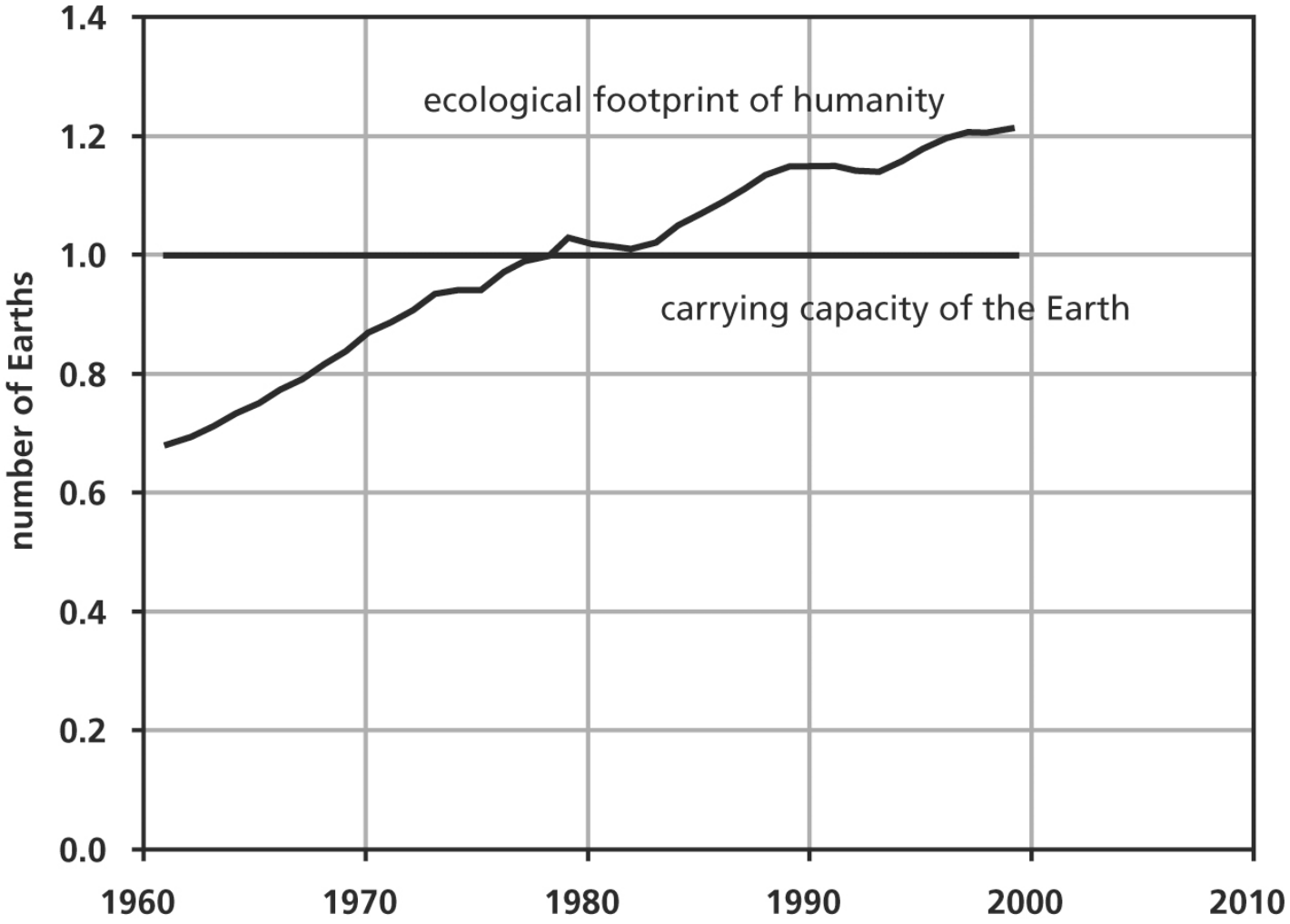


Feedback Loops of Population, Capital, Services, and Resources

Scenario 0: Infinity In, Infinity Out

If all physical limits to the World3 system are removed, population peaks near 9 billion and starts a slow decline in a demographic transition. The economy grows until by the year 2080 it is producing 30 times the year-2000 level of industrial output, while using the same annual amount of nonrenewable resources and producing only one-eighth as much pollution per year.

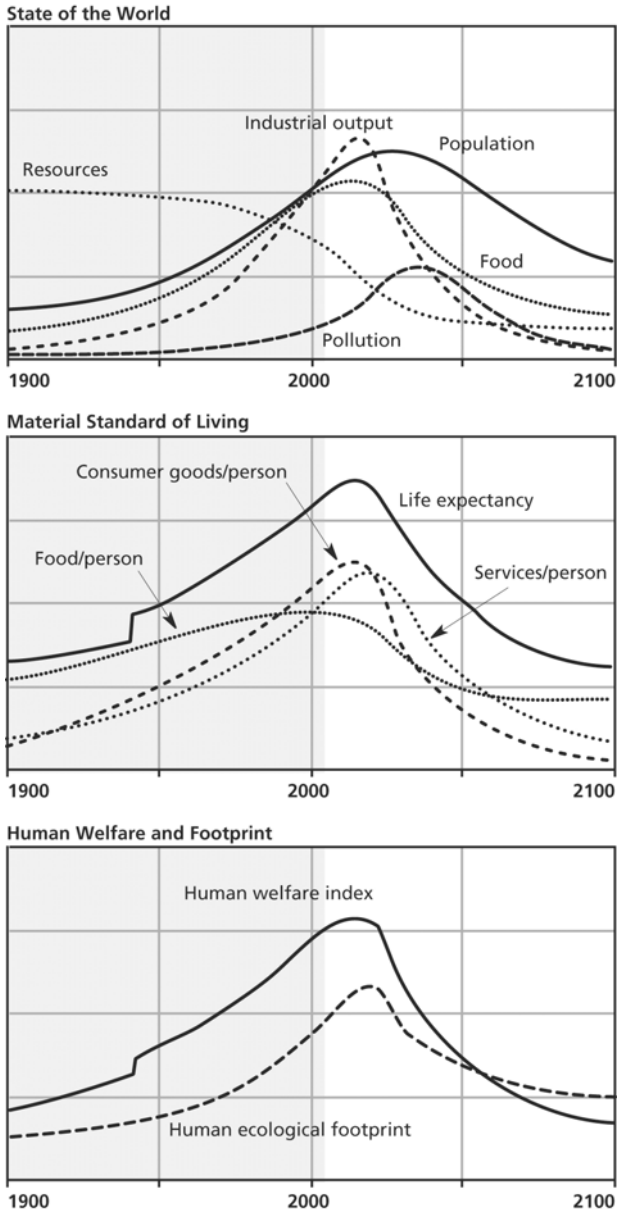




Ecological Footprint versus Carrying Capacity

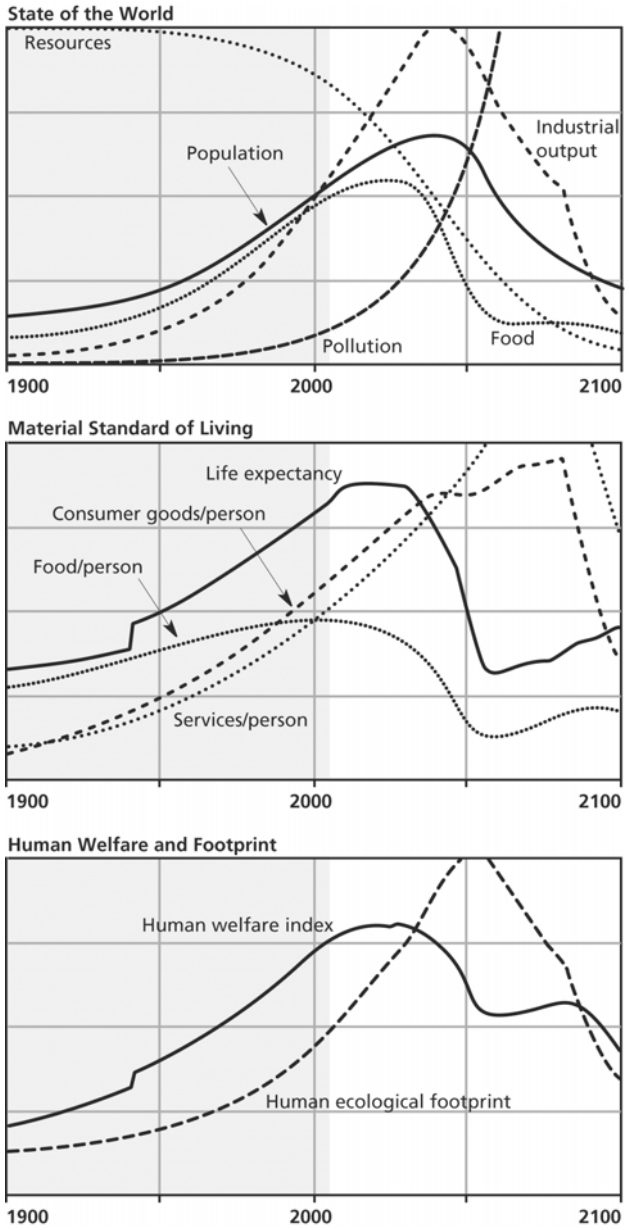
Scenario 1: A Reference Point

The world society proceeds in a traditional manner without any major deviation from the policies pursued during most of the twentieth century. Population and production increase until growth is halted by increasingly nonrenewable resources. Ever more investment is required to maintain resource flows. Finally, lack of investment funds in the other sectors of the economy leads to declining output of both industrial goods and services. As they fall, food and health services are reduced, decreasing life expectancy and raising average death rates.



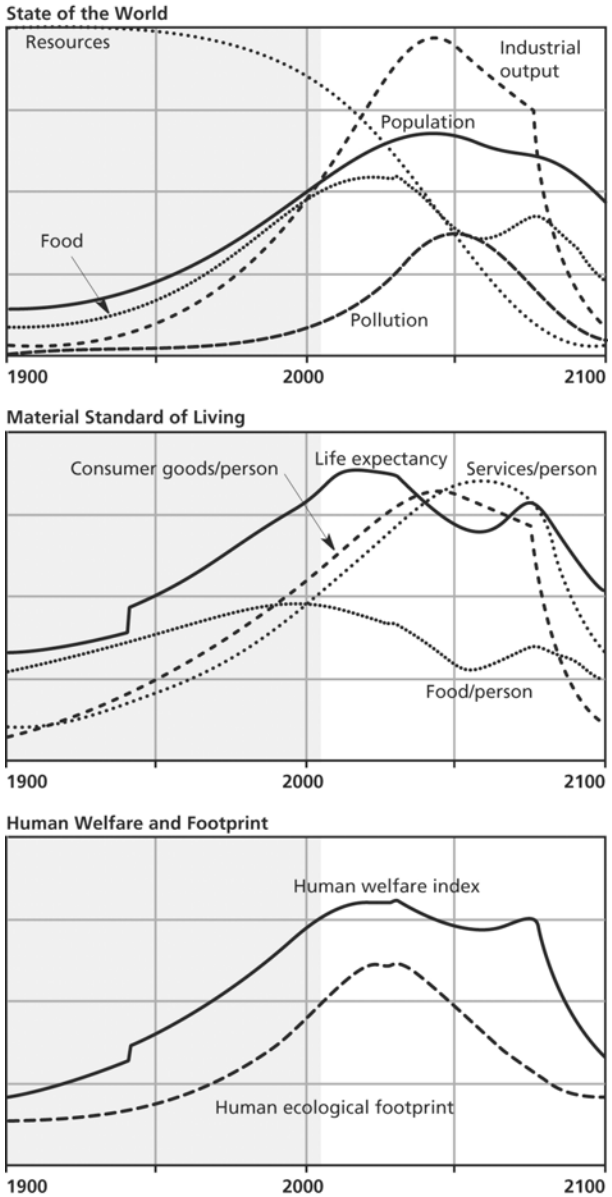
Scenario 2: More Abundant Nonrenewable Resources

If we double the nonrenewable resource endowment assumed in Scenario 1, and furthermore postulate that advances in resource extraction technologies are capable of postponing the onset of increasing extraction costs, industry can grow 20 years longer. Population peaks at 8 billion in 2040, at much higher consuption levels. But pollution levels soar (outside the graph!), depressing land yields and requiring huge investments in agricultural recovery. The population finally declines because of food shortages and negative health effects from pollution



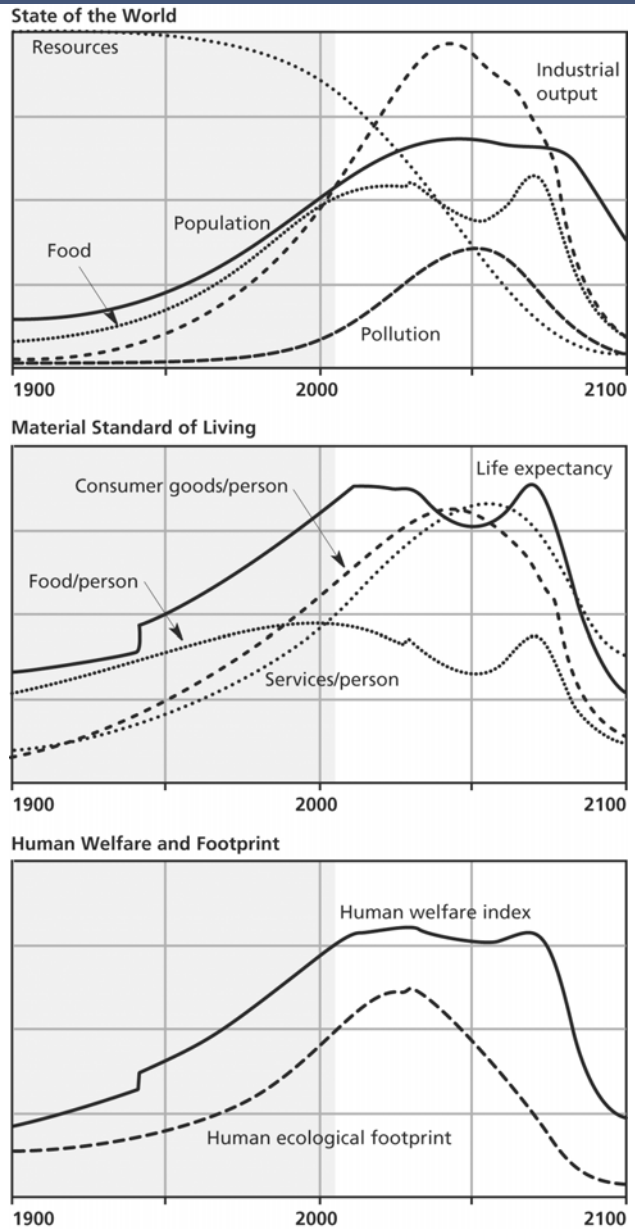
Scenario 3: More Accessible Nonrenewable Resources and Pollution Control Technology

In this scenario we assume the same ample resource supply as in Scenario 3 as well as increasingly effective pollution control technology, which can reduce the amount of pollution generated per unit of output by up to 4 percent per year, starting in 2002. This allows much higher welfare for more people after 2040 because of fewer negative effects from pollution. But food production does ultimately decline, drawing capital form the industrial sector and triggering a collapse.



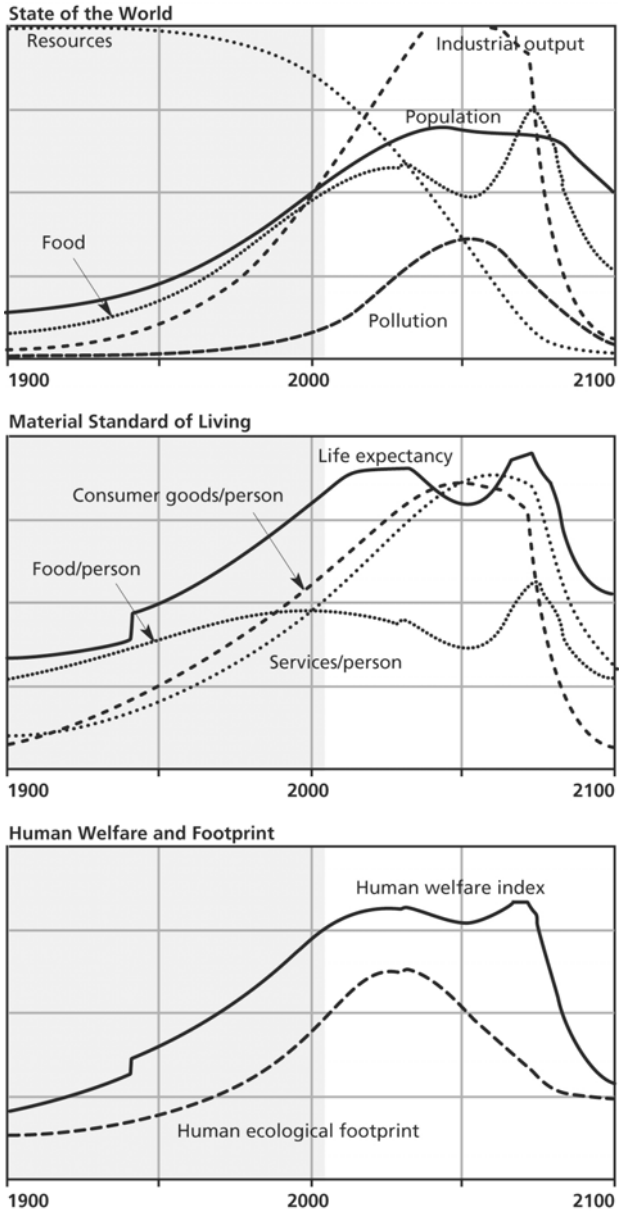
Scenario 4: More Accessible Nonrenewable Resources, Pollution Control Technology, and Land Yield Enhancement

If the model world adds to its pollution control technology a set of technologies to increase greatly the food yield per unit of land, the high agricultural intensity speeds up land loss. The world´s farmers end up trying to squeeze more food output form less and less land. This proves unsustainable.



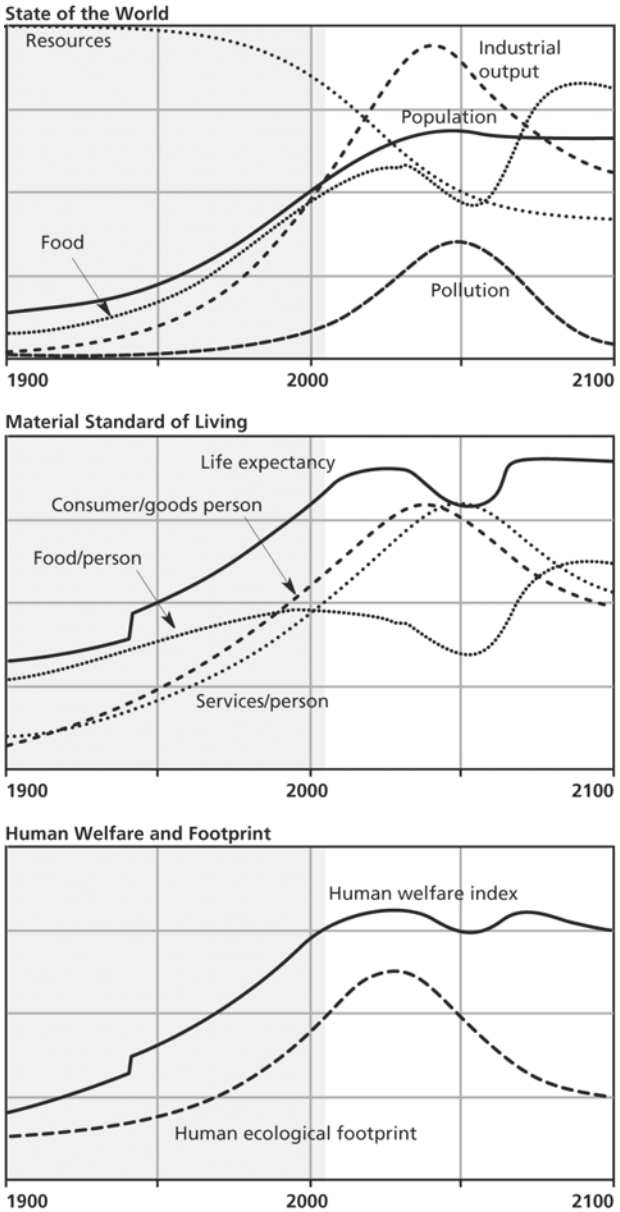
Scenario 5: More Accessible Nonrenewable Resources, Pollution Control Technology, Land Yield Enhancement, and Land Erosion Protection

Now a technology of land preservation is added to the agricultural yield-enhancing and pollution-reducing measures already in place. The result is a slight postponement of the collapse at the end of the twenty-first century.



Scenario 6: More Accessible Nonrenewable Resources, Pollution Control Technology, Land Yield Enhancement, Land Erosion Protection, and Resource Efficiency Technology

Now the simulated world is developing powerful technologies for pollution abatement, land yield enhancement, land protection, and conservation of nonrenewable resources all at once. All these technologies are assumed to involve costs and to take 20 years to be fully implemented. In combination they permit a fairly large and prosperous simulated world, until the bliss starts declining in response to the accumulated cost of the technologies.

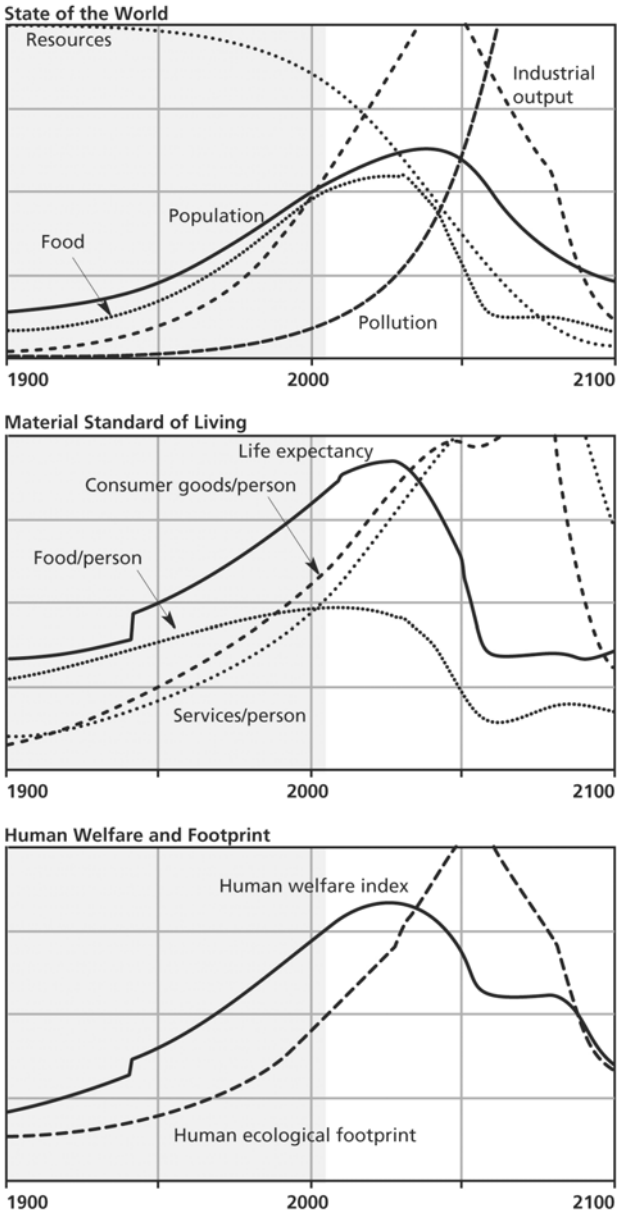


„Ich glaube nicht, dass es sich bei der wirtschaftspolitischen Zielsetzung der Gegenwart gleichsam um ewige Gesetze handelt. Wir werden sogar mit Sicherheit dahin gelangen, dass zu Recht die Frage gestellt wird, ob es noch immer richtig und nützlich ist, mehr Güter, mehr materiellen Wohlstand zu erzeugen, oder ob es sinnvoller ist, unter Verzichtleistung auf diesen „Fortschritt“ mehr Freiheit, mehr Besinnung, mehr Muße und mehr Erholung zu gewinnen“.

Ludwig Erhard in „Wohlstand für alle“, 1957

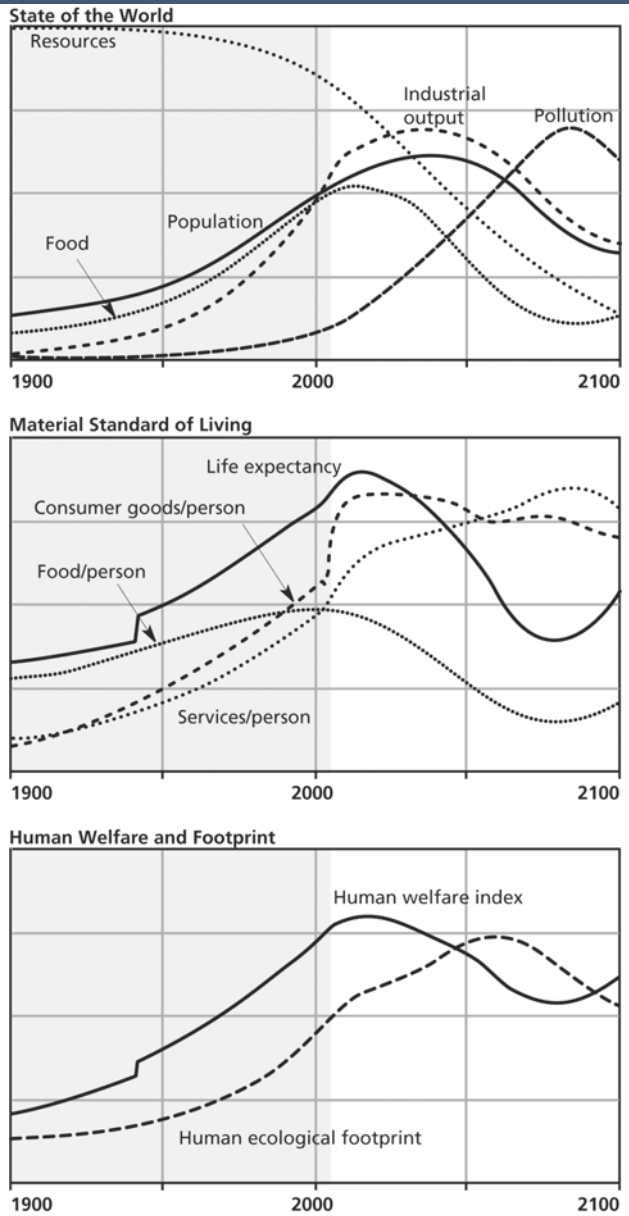
Scenario 7: World Seeks Stable Population From 2002

This scenario supposes that after 2002 all couples decide to limit their family size to 2 children and that they have access to effective birth control technologies. Because of age structure momentum, the population continues to grow for another generation. But the slower population growth permits industrial output to rise faster, until it is stopped by the cost of dealing with rising pollution – as in scenario 2.



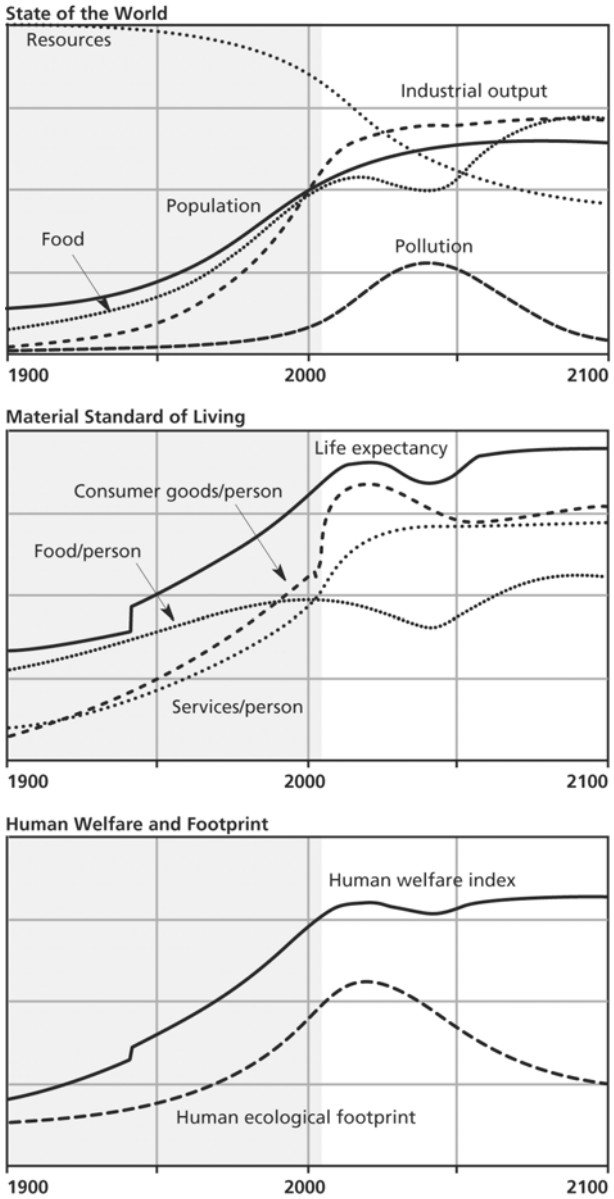
Scenario 8: World Seeks Stable Population and Stable Industrial Output per Person from 2002

If the model society both adopts a desired family size of 2 children and sets a fixed goal for industrial output per capita, it can extend somewhat the „golden period“ of fairly high human welfare between 2020 and 2040 in scenario 7. But pollution increasingly stresses agricultural resources. Per capita food production declines, eventually bringing down life expectancy and population.



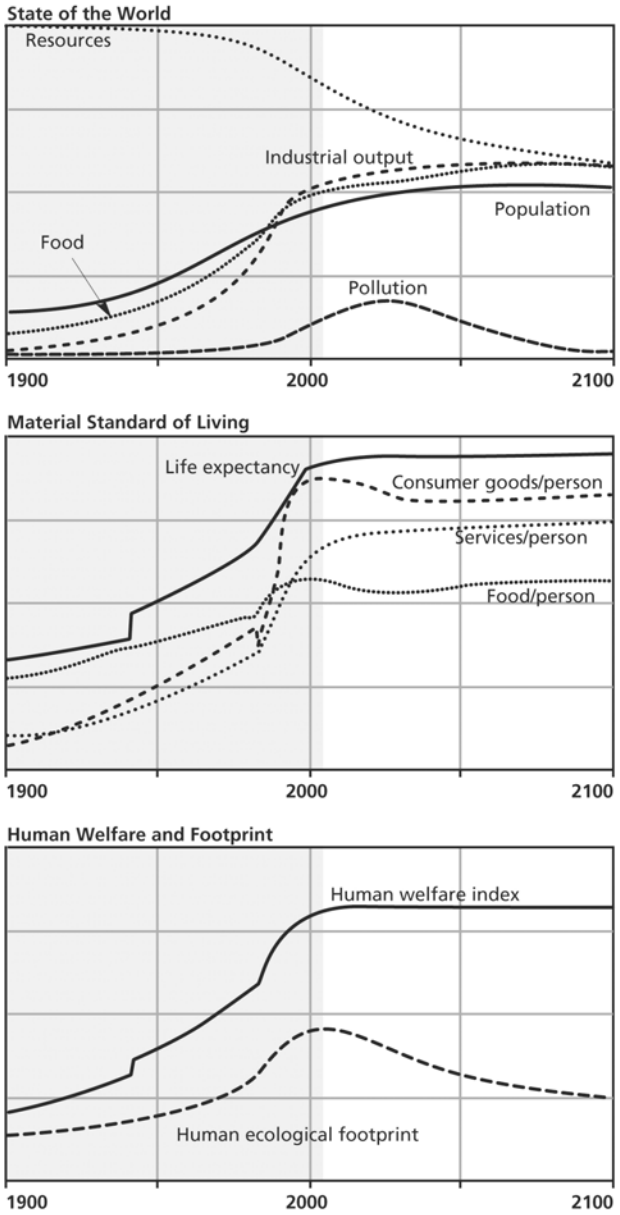
Scenario 9: World Seeks Stable Population and Stable Industrial Output per Person, and Adds Pollution, Resource, and Agricultural Technologies from 2002

In this scenario population and industrial output are limited as in the previous run, and in addition technologies are added to abate pollution, conserve resources, increase land yield, and protect agricultural land. The resulting society is sustainable. Nearly 8 billion people live with high human welfare and a continuously ecological footprint.



Scenario 10: The Sustainability Policies of Scenario 9 Introduced 20 Years Earlier, in 1982

The simulation includes all the changes that were incorporated in Scenario 9, but the policies are implemented in the year 1982 instead of in 2002. Moving toward sustainability 20 years sooner would have meant a lower final population, less pollution, more non-renewable resources, and a slightly higher average welfare for all.



It is scarcely necessary to remark that a stationary condition of capital and population implies no stationary state of human improvement. There would be as much as ever for all kinds of mental culture, and moral social progress, as much room for improving the Art of Living and much more Likelihood of its being improved.

(John Stuart Mill, 1857)

It is hoped that those who believe they already have some different model that is more valid will present it in the same explicit detail, so that its assumptions and consequences can be examined and compared. To reject this model because of its shortcomings without offering concrete and tangible alternatives would be equivalent to asking that time be stopped.

(Jay W. Forrester, 1971)