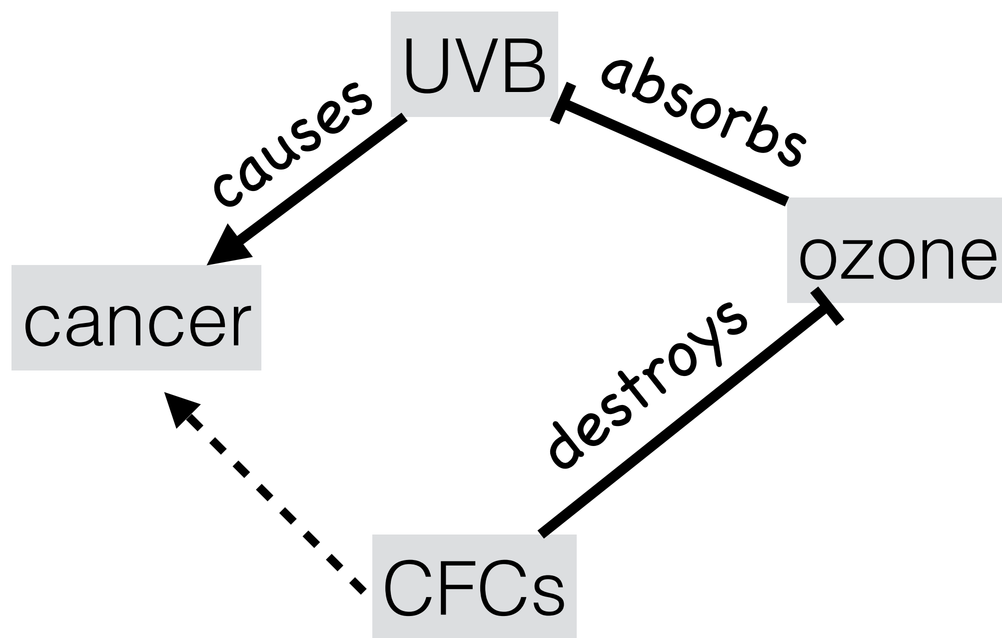
Human Population 2017

Lecture 18

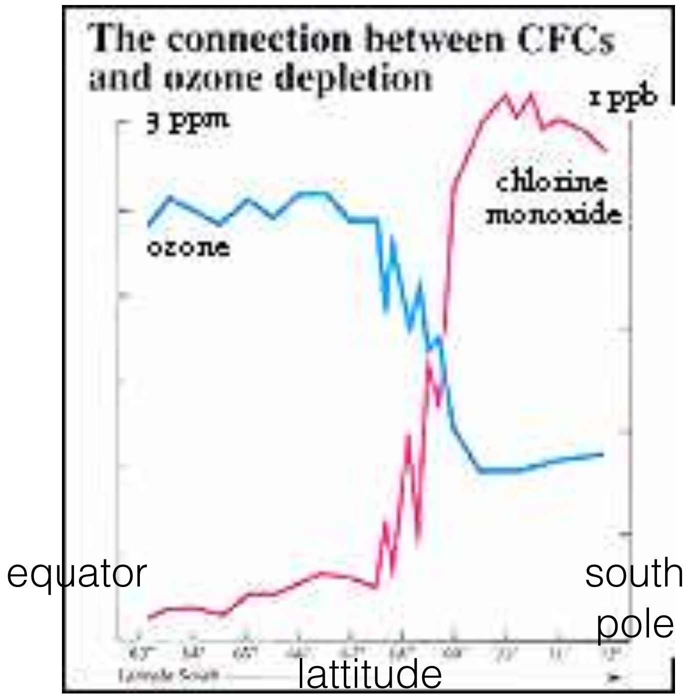
Cycles, Circles, and Holes

Questions?

A cause and effect graph

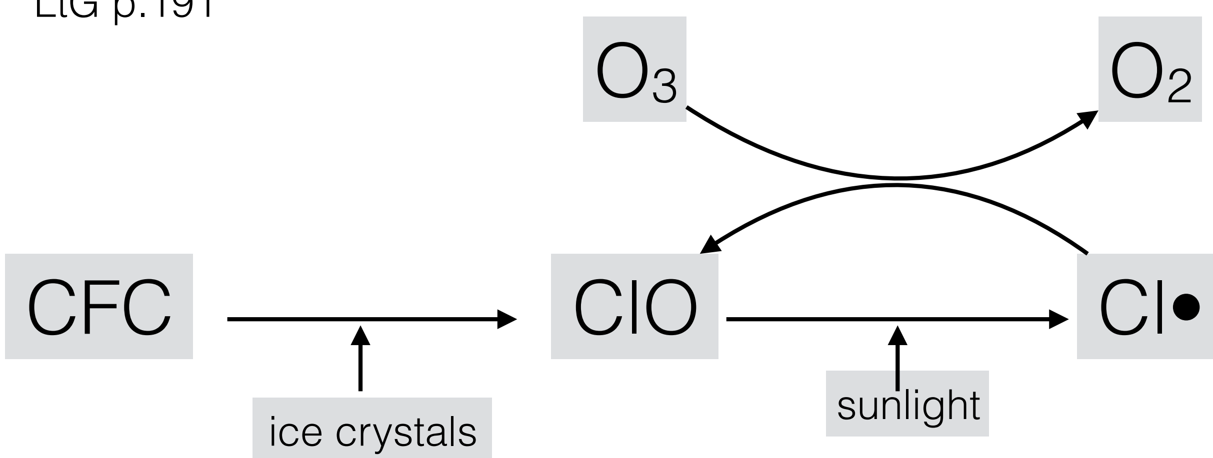


"smoking gun" against CFCs

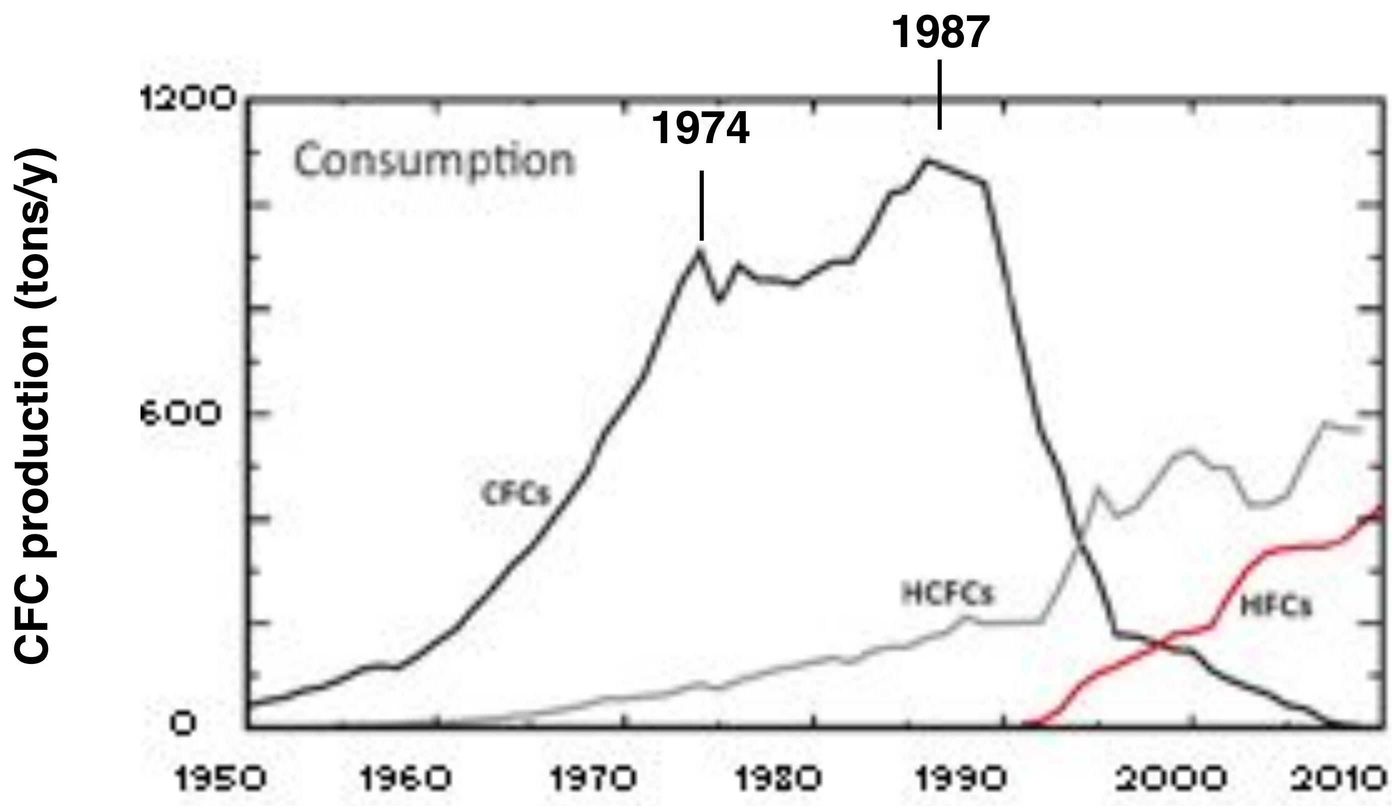


LtG p.191

Inverse correlation between ozone and CFC biproduct ClO.



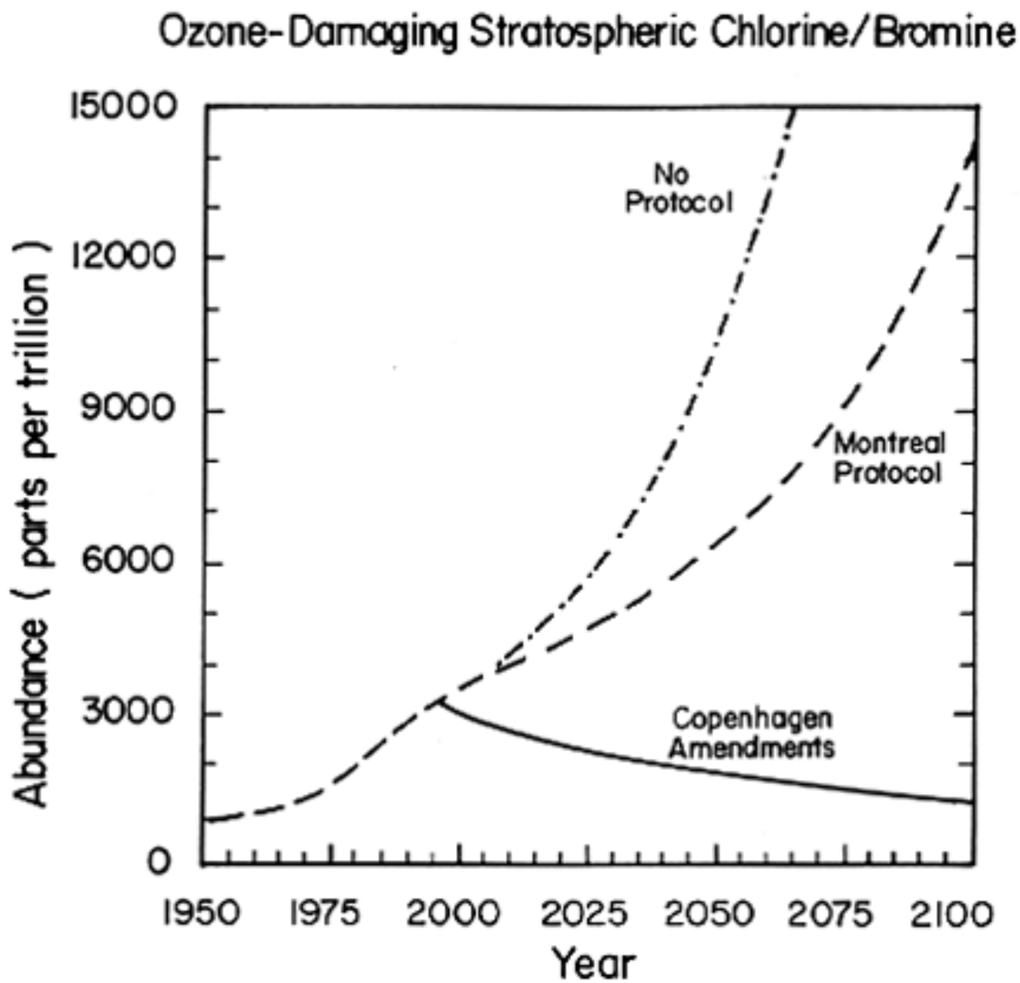
rise and fall of CFCs



LtG p.183

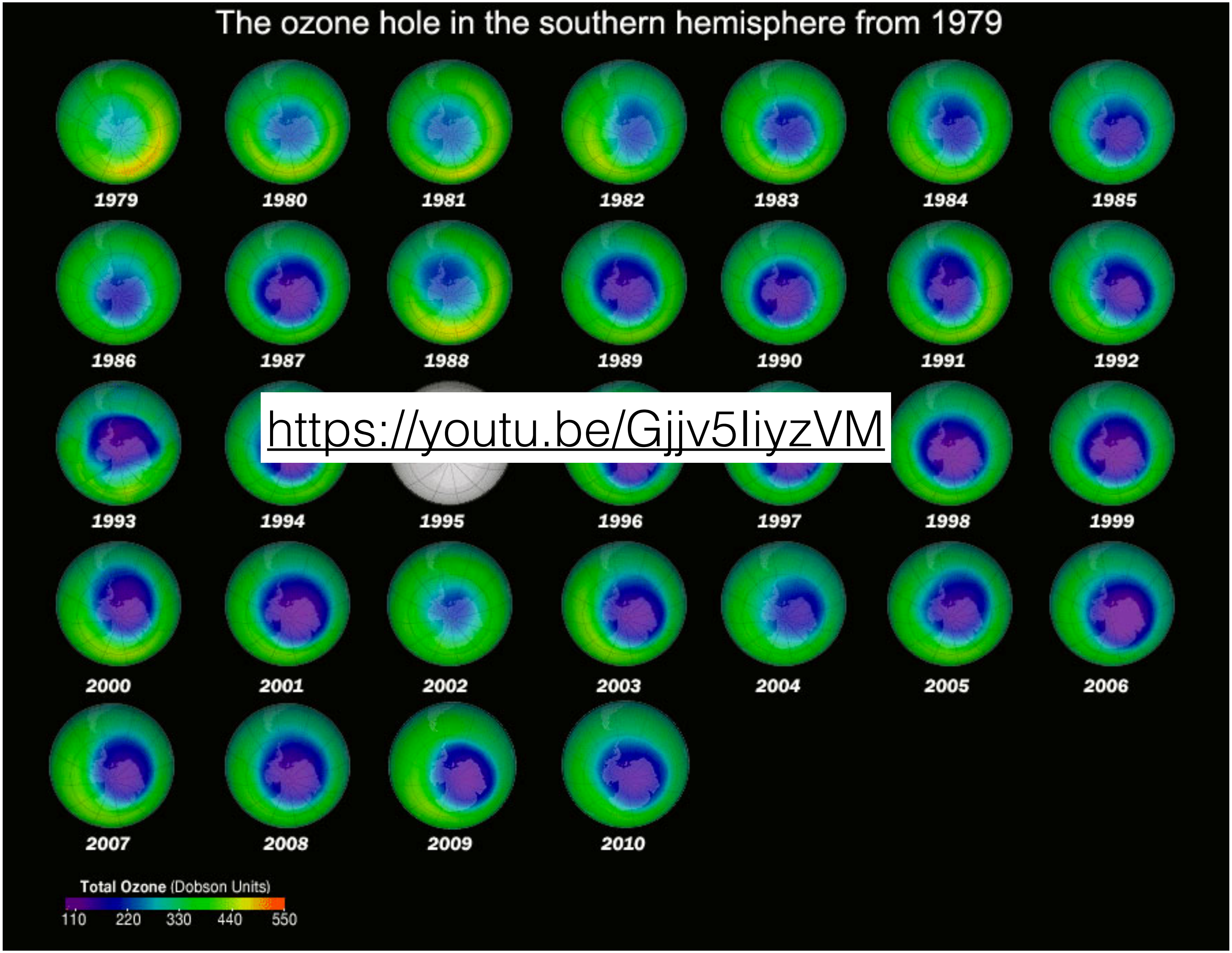
What would have happened?

Forward projections given policy scenarios.



1974 First public awareness.
1987 Montreal Protocol.
1992 Copenhagen Amendments

South pole



https://youtu.be/Gjjv5IiyzVM

http://www.theguardian.com/

How did they do it?

- Long-term thinking.
- Good data, good model.
- International cooperation.
- Frequent monitoring.
- Revision, maintenance.

Can we do it again?

- **Climate change**
  - Global agreement reached 2015!
  - Tech solutions reaching mass market!
  - Recent set-backs.
- **Overpopulation**
  - Still in early stages. Many books. Some activist groups. No global discussion. No funding for research!
  - Beginnings of recognition that family planning and ecological conservation are directly linked.

    www.devex.com/news/family-planning-takes-a-360-degree-approach-87892

Purpose of the World models

- "broad sweep of the future"
- "to avoid creating an impenetrable thicket of assumptions, modelers must discipline themselves. They cannot put into the model all that they know, only what is relevant for the purposes of the model." (LtG)

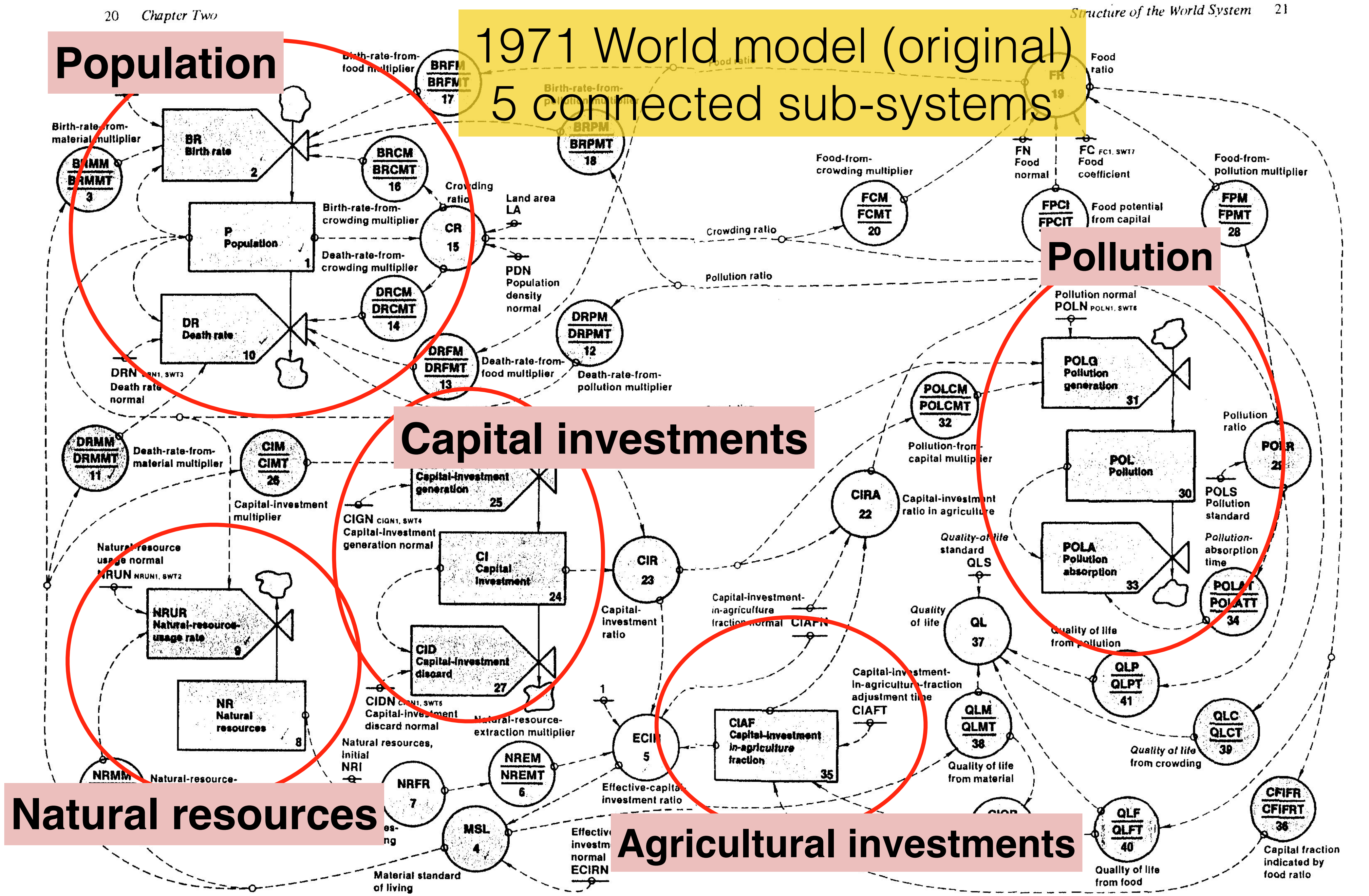
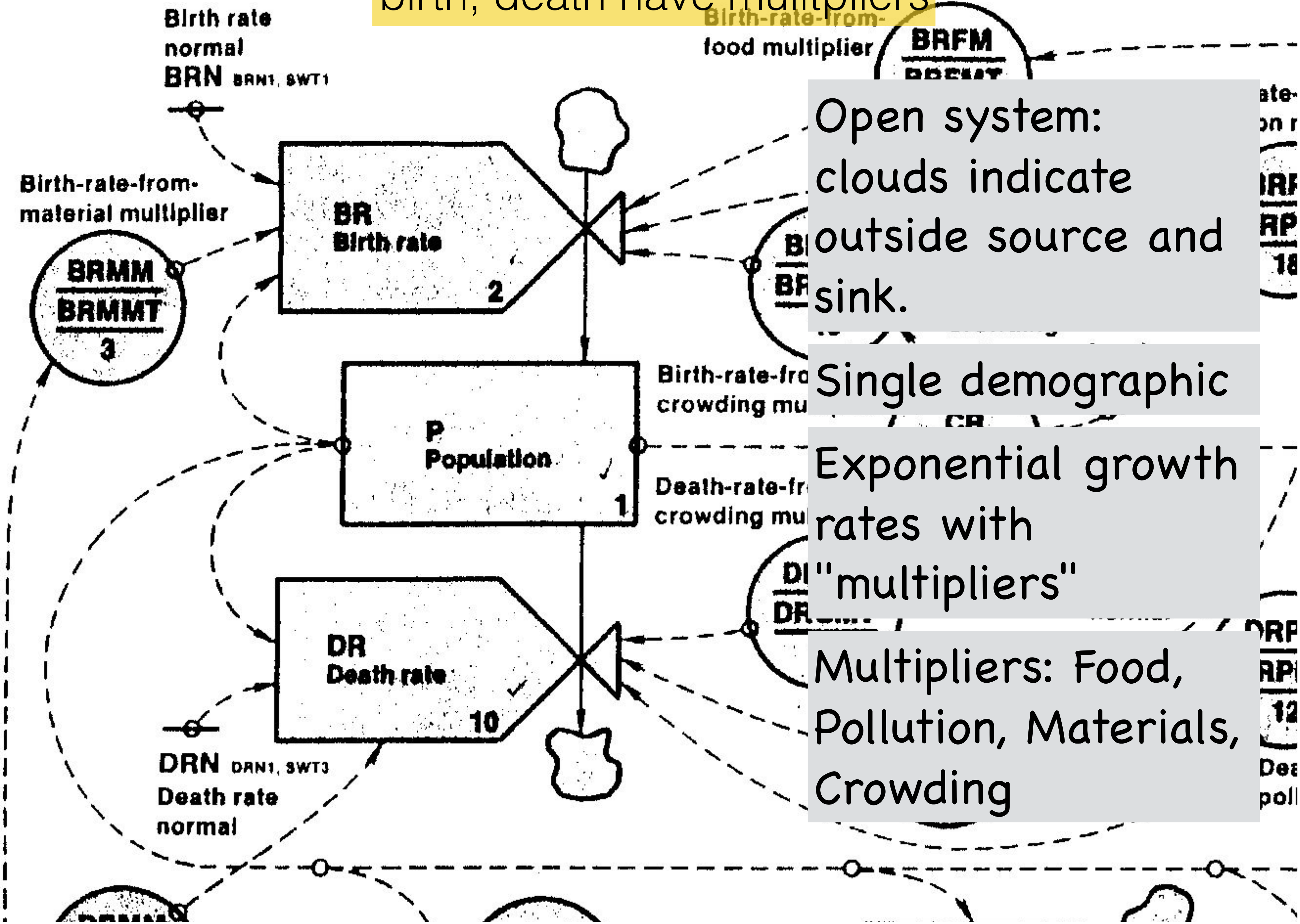


Figure 2-1 Complete diagram of the world model interrelating the five level variables — population, natural resources, capital investment, capital-investment-in-agriculture fraction, and pollution.

population is one stock
birth, death have mulitpliers



Open system: clouds indicate outside source and sink.

Single demographic

Exponential growth rates with "multipliers"

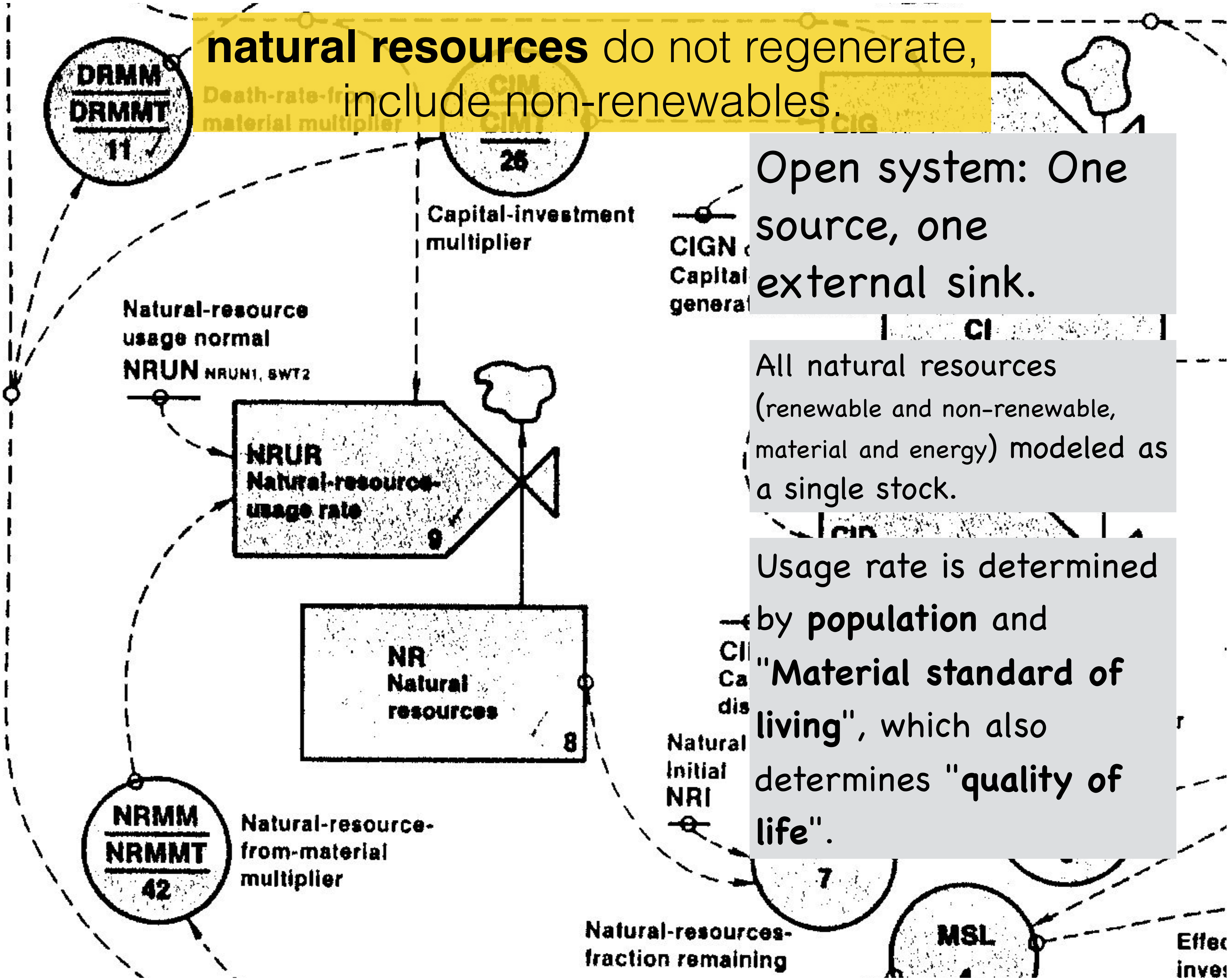
Multipliers: Food, Pollution, Materials, Crowding

natural resources do not regenerate, include non-renewables.

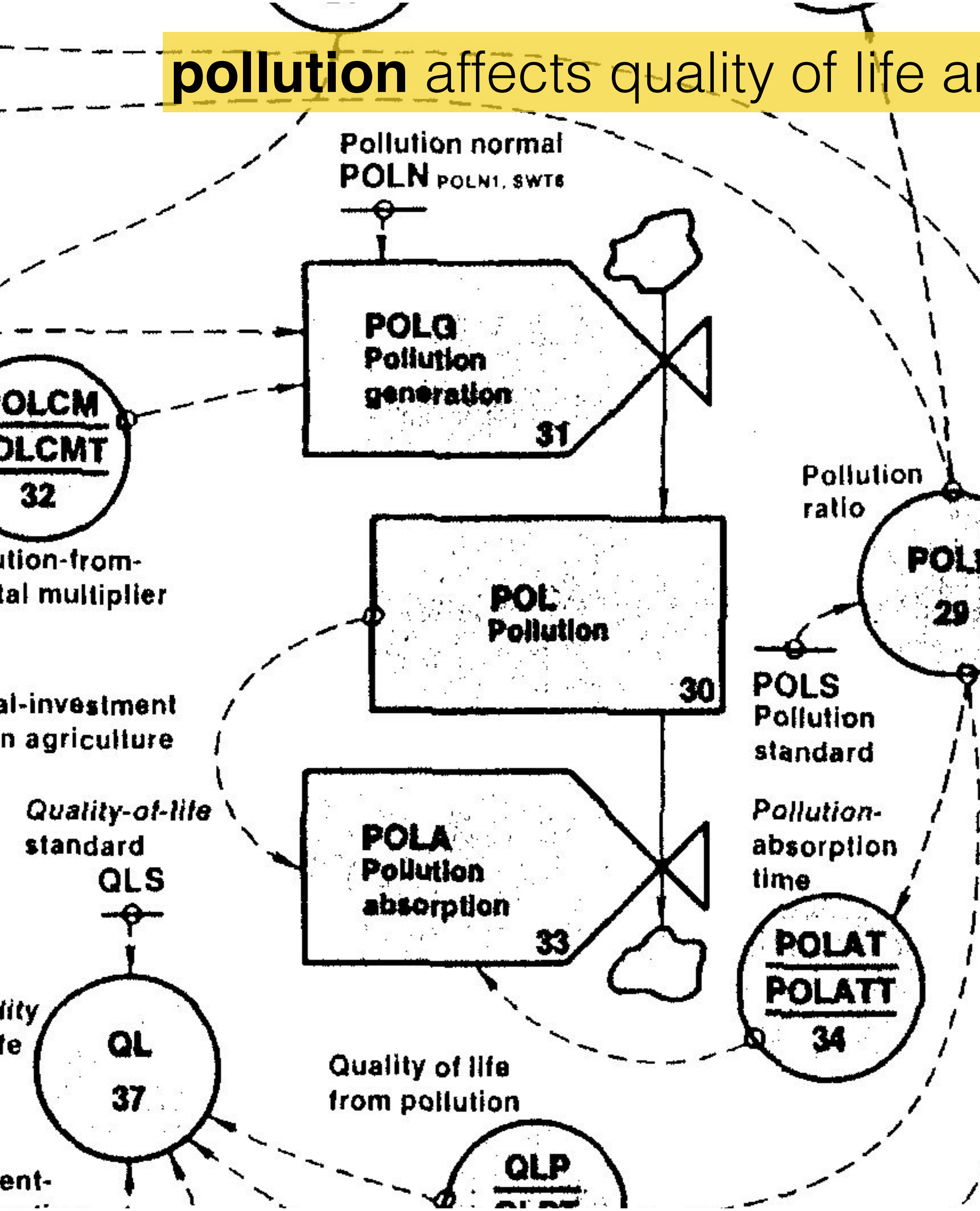
Open system: One source, one external sink.

All natural resources (renewable and non-renewable, material and energy) modeled as a single stock.

Usage rate is determined by **population** and "**Material standard of living**", which also determines "**quality of life**".



pollution affects quality of life and life expectancy



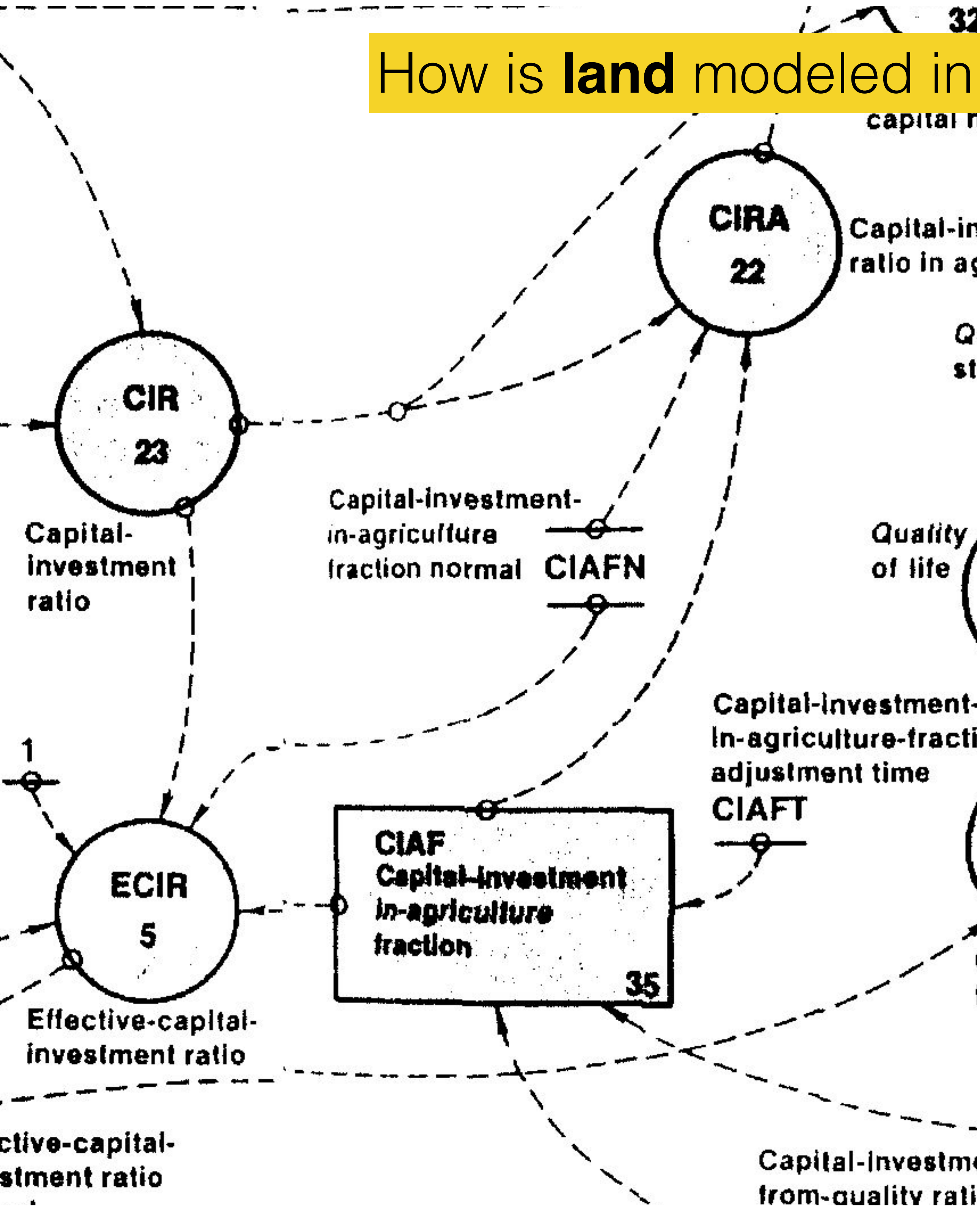
Open system: external sources and sink. No units.

Pollution absorbtion is exponential (see feedback loop)

Pollution generation inputs from **population** and **capital investment** (affluence?)

Pollution outputs to **death rate, Quality of Life** (QOL). QOL has no outputs. Just an index.

How is **land** modeled in World 1?

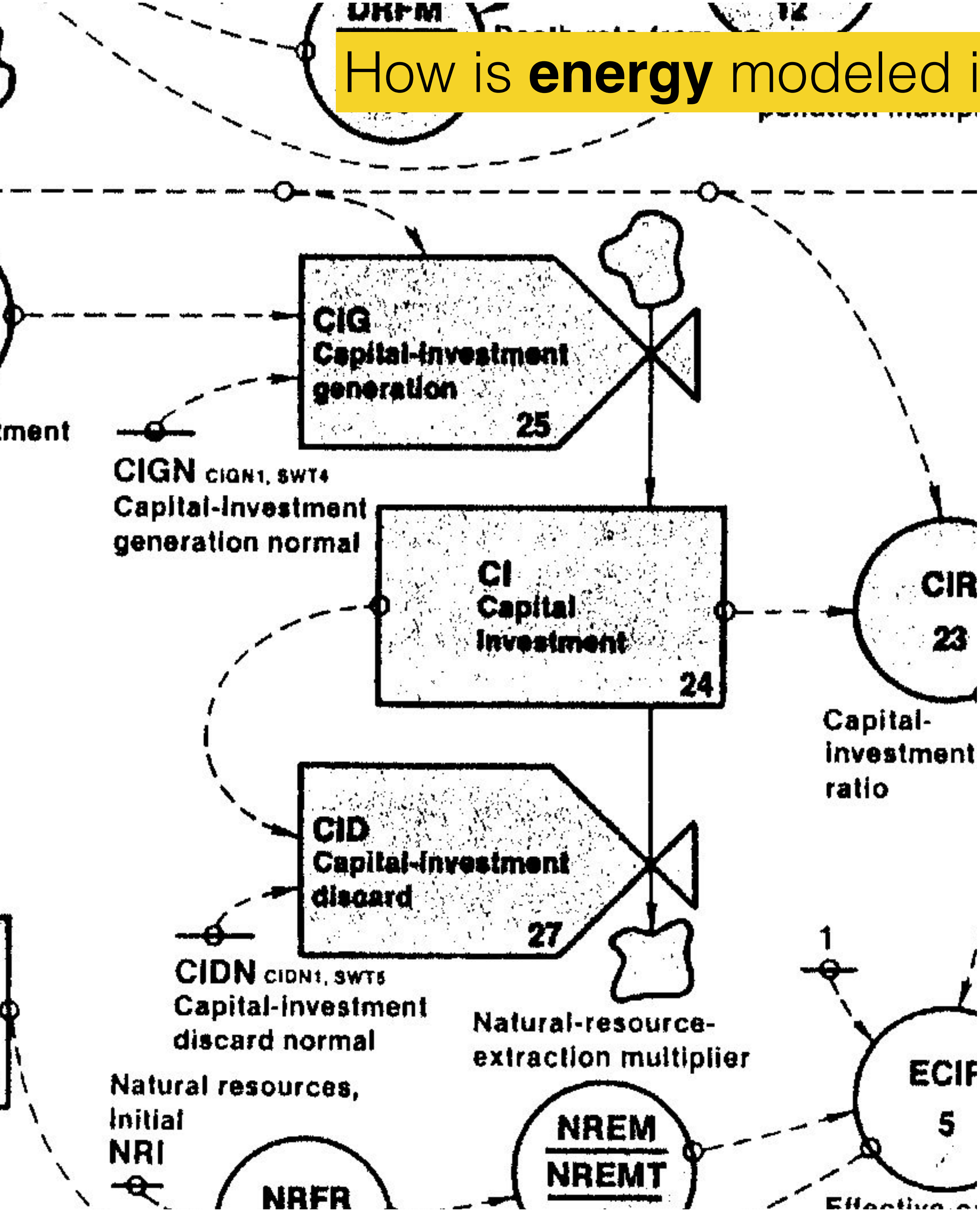


Variable, not stock: capital investment in agriculture.

Input variables are Food, Quality of life from food, quality of life from Matereials

Output to Food Potential, which becomes Food per capita, which inputs to birth and death rates

How is **energy** modeled in World 1?



Capital investment (CI) stock: open system

Input to CI from **population** and **Material Standard of Living**.

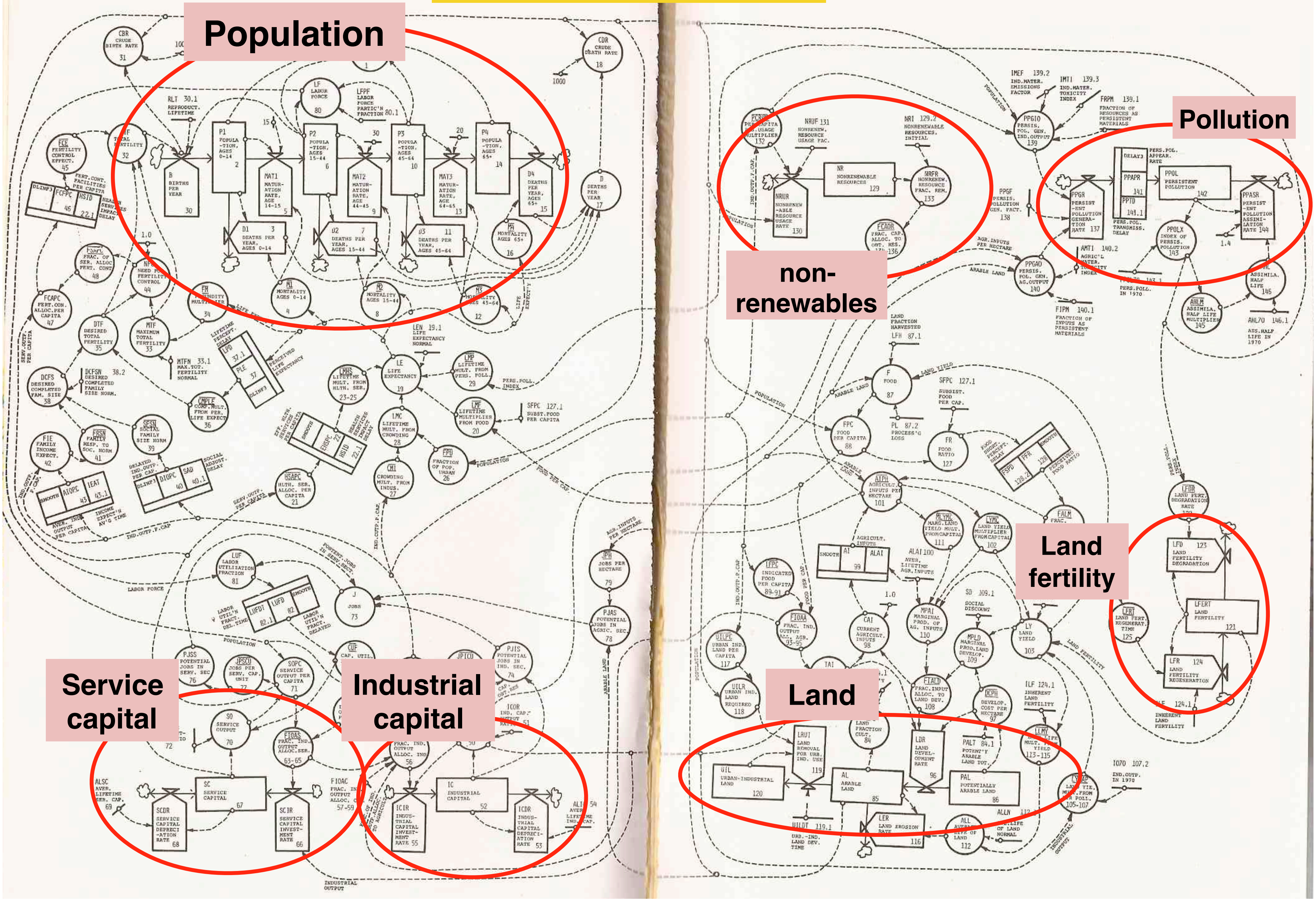
Output to **agriculture**, **material standard of living**, and **pollution.**

NOTE: I call this energy.

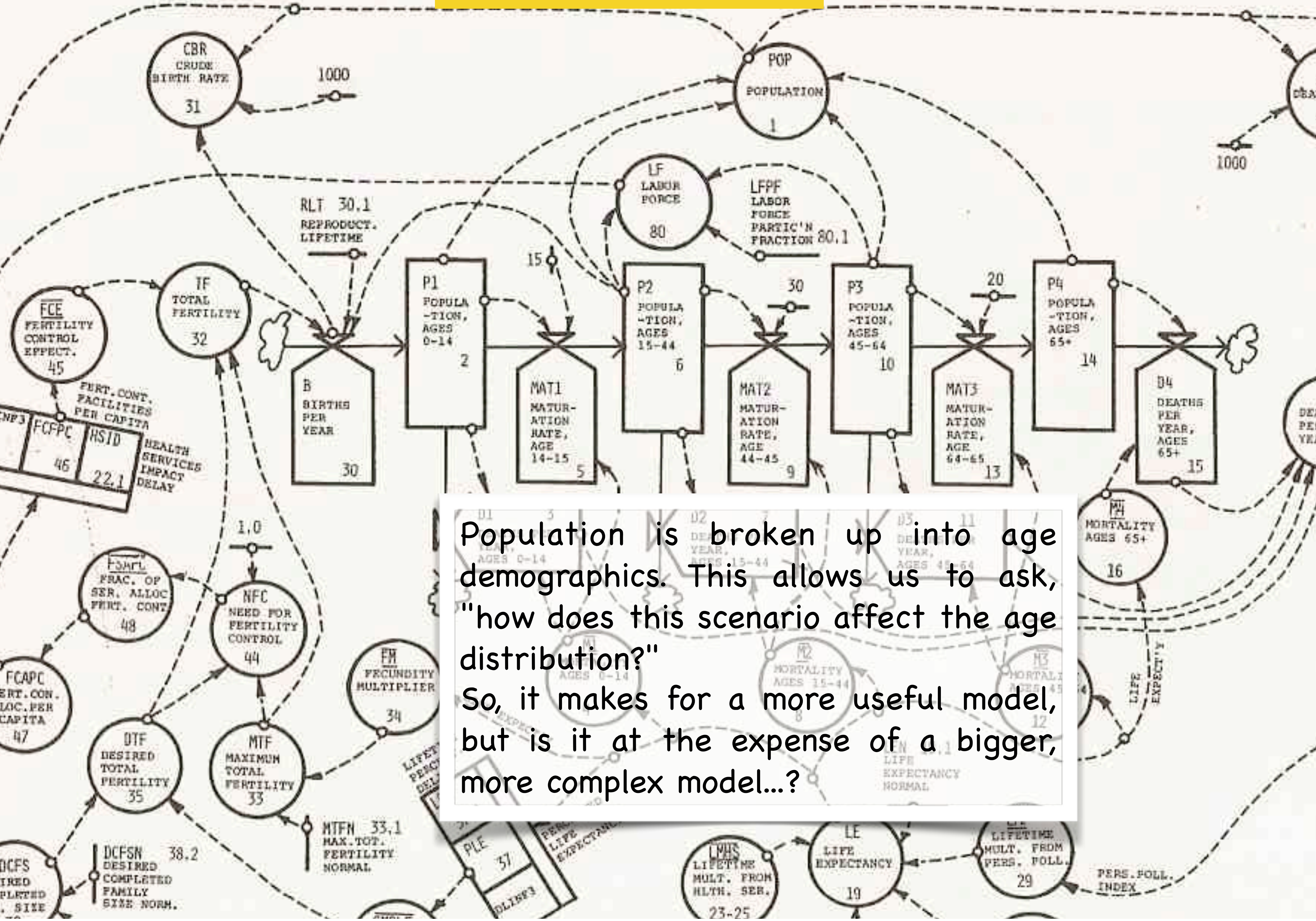
1972 World model

- Non-renewables are separate from natural resources.
- Population is broken up into age demographics.
- Adds service capital, labor force.
- Land is modeled as two open systems of stocks: 1) land (potential, arable, degraded) and 2) land fertility.

World model 1972



World model 1972



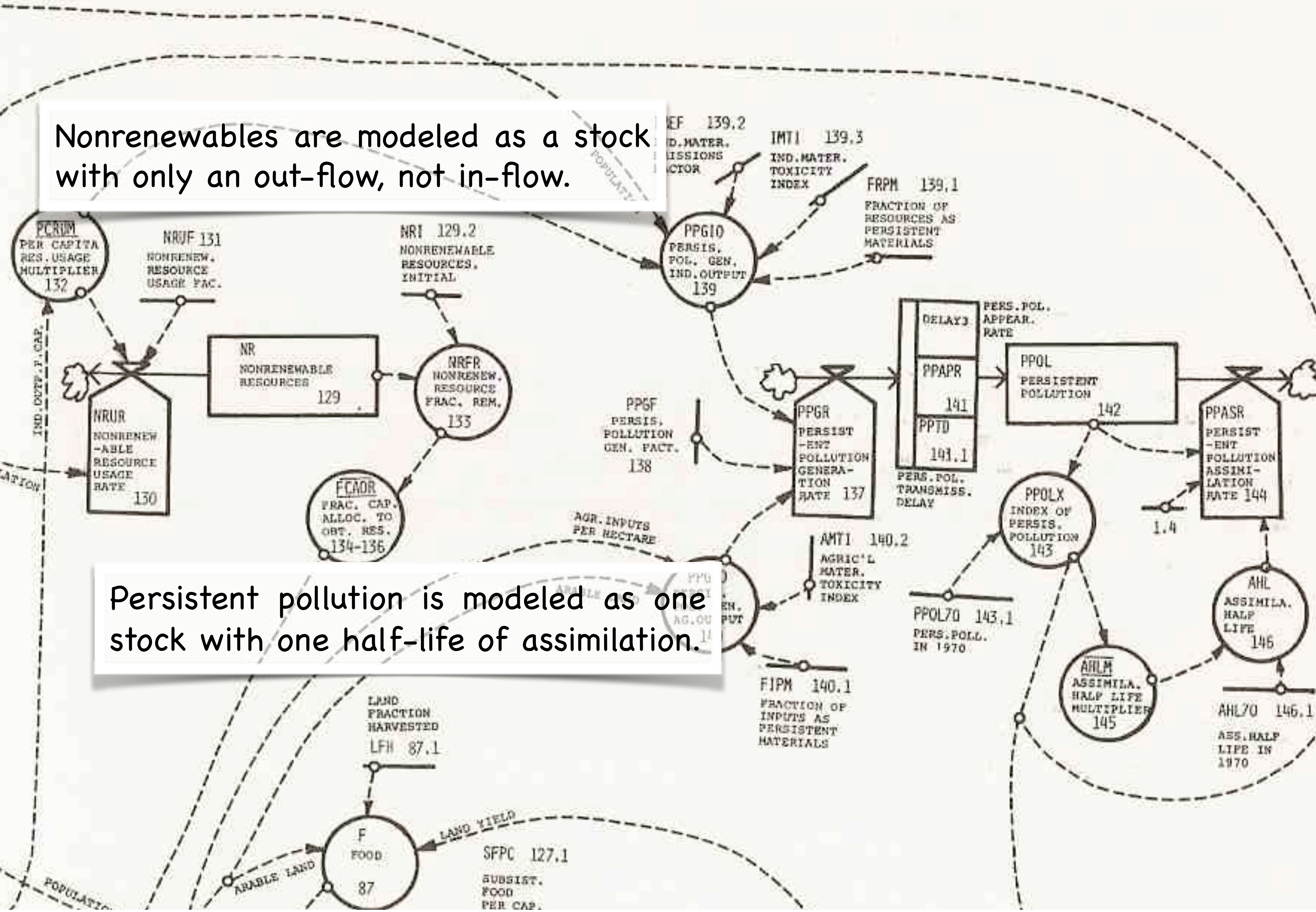
Population is broken up into age demographics. This allows us to ask, "how does this scenario affect the age distribution?"

So, it makes for a more useful model, but is it at the expense of a bigger, more complex model...?

World model 1972

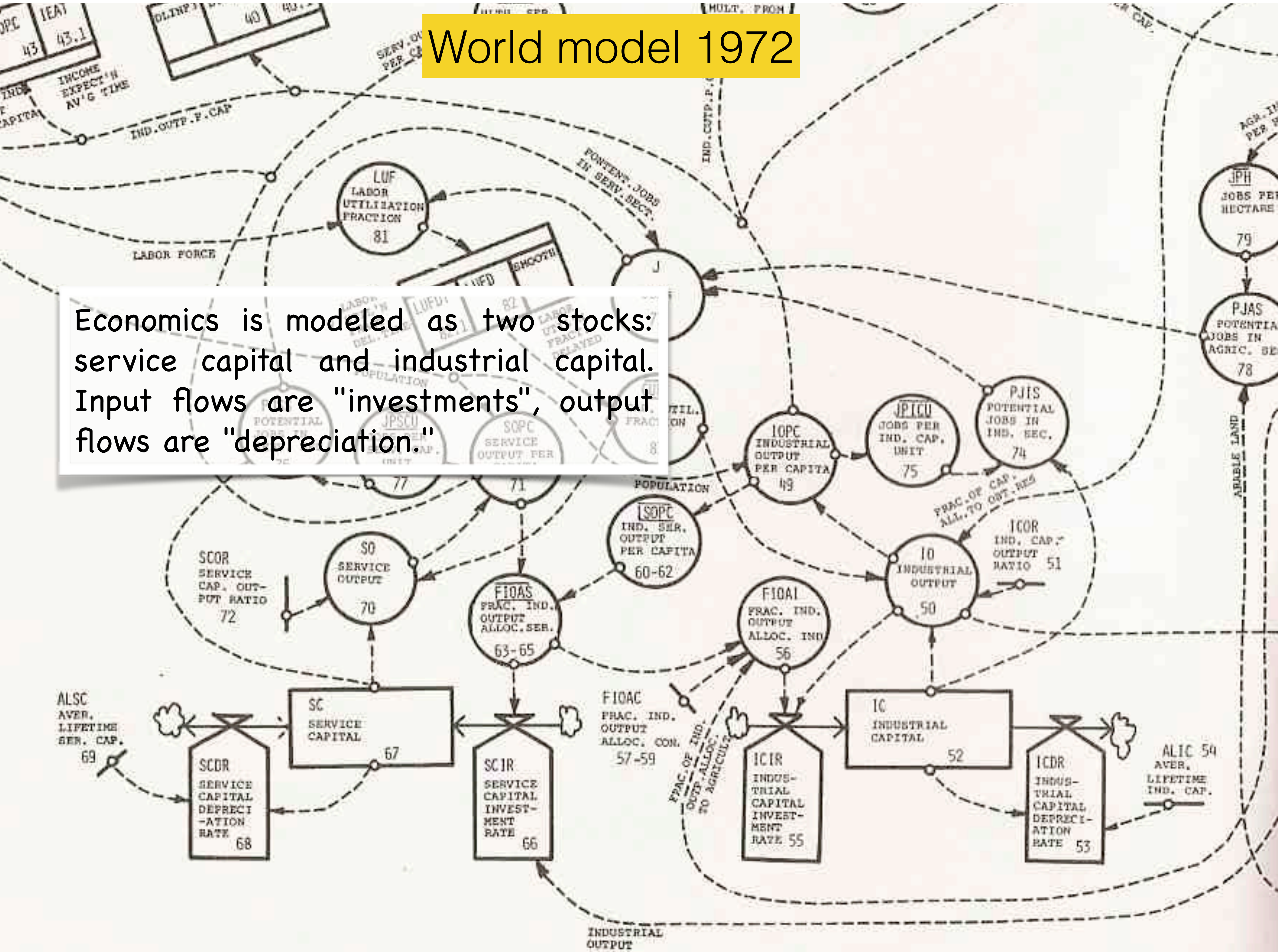
Nonrenewables are modeled as a stock with only an out-flow, not in-flow.

Persistent pollution is modeled as one stock with one half-life of assimilation.

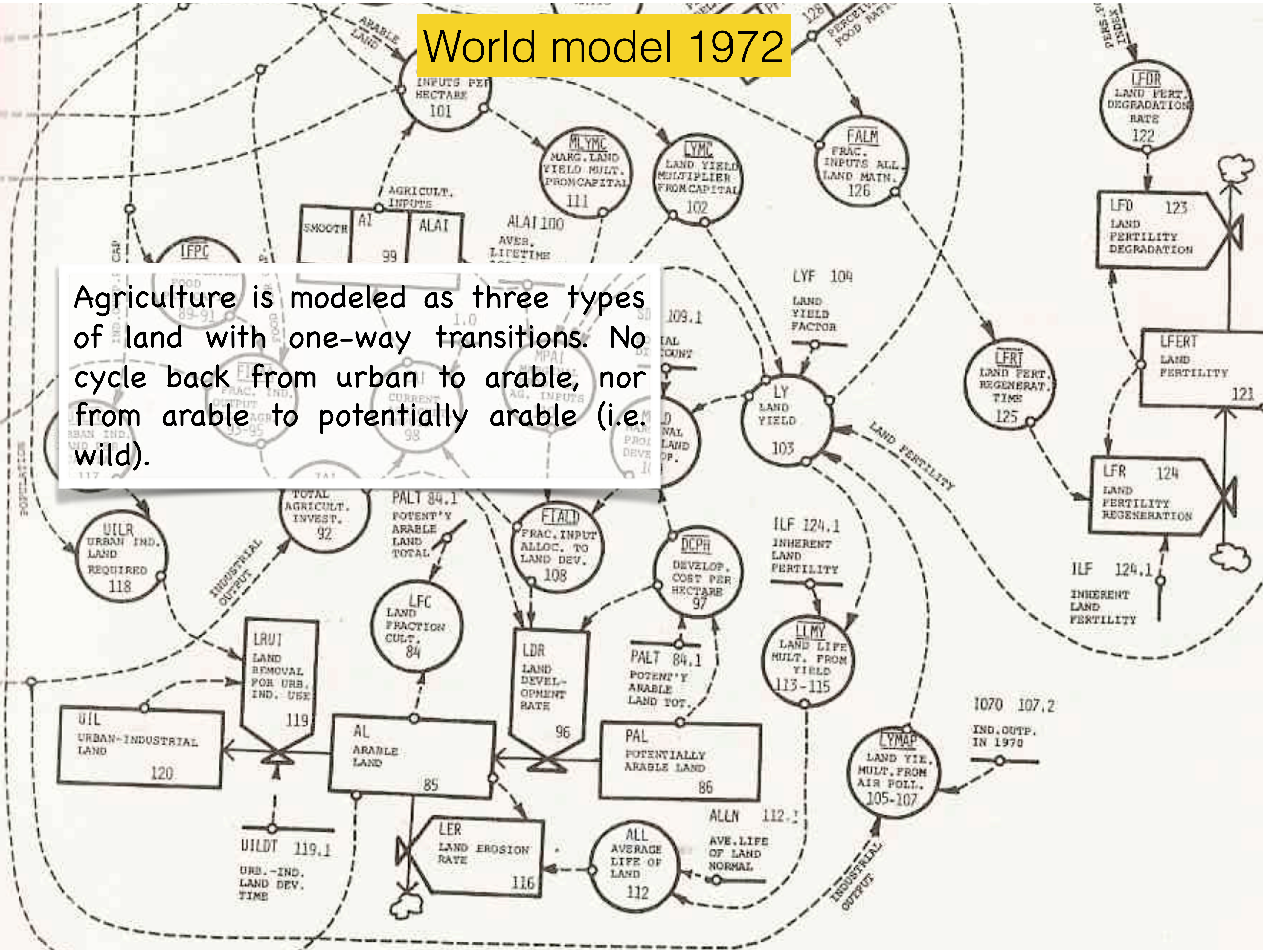


World model 1972

Economics is modeled as two stocks: service capital and industrial capital. Input flows are "investments", output flows are "depreciation."

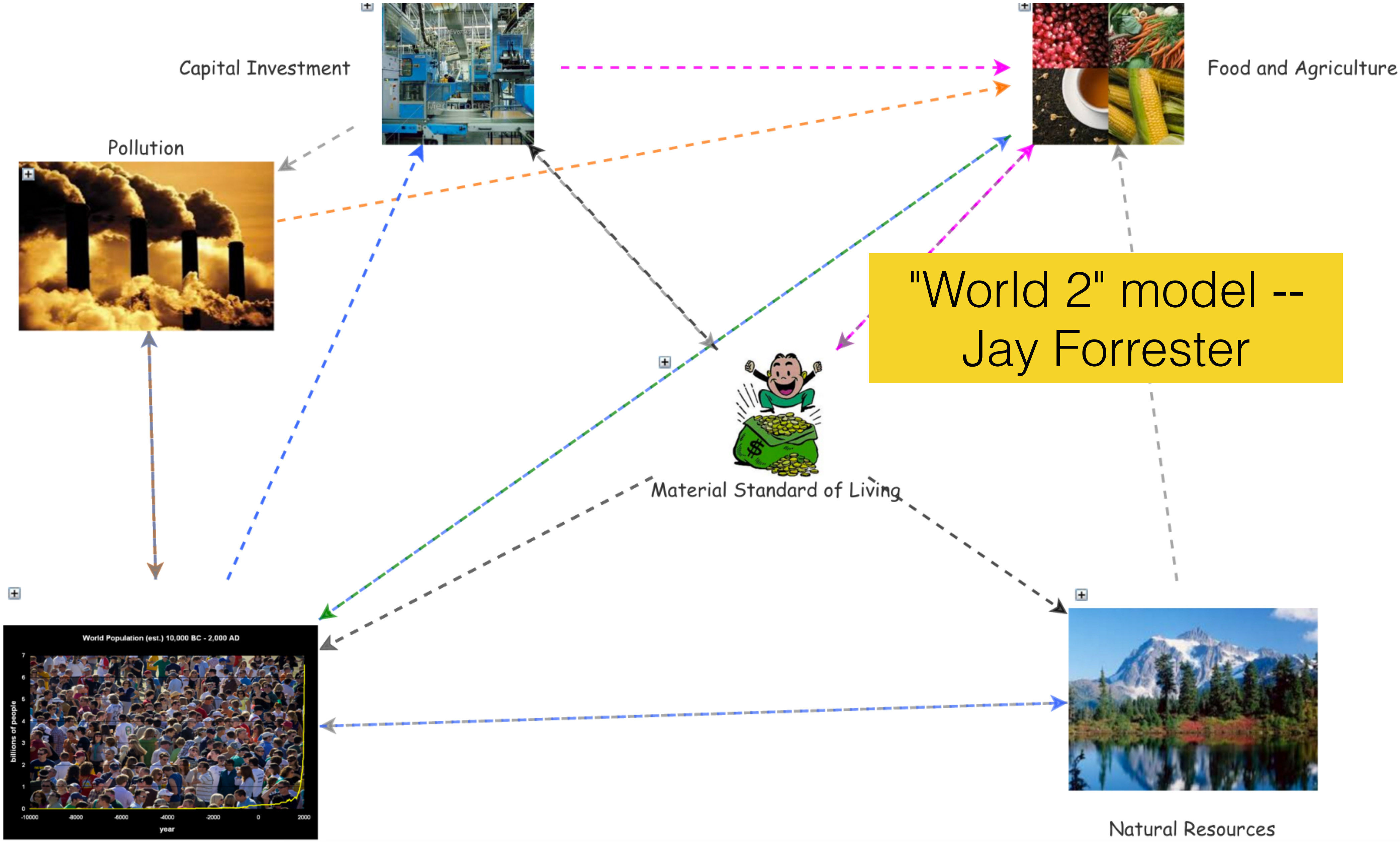


World model 1972



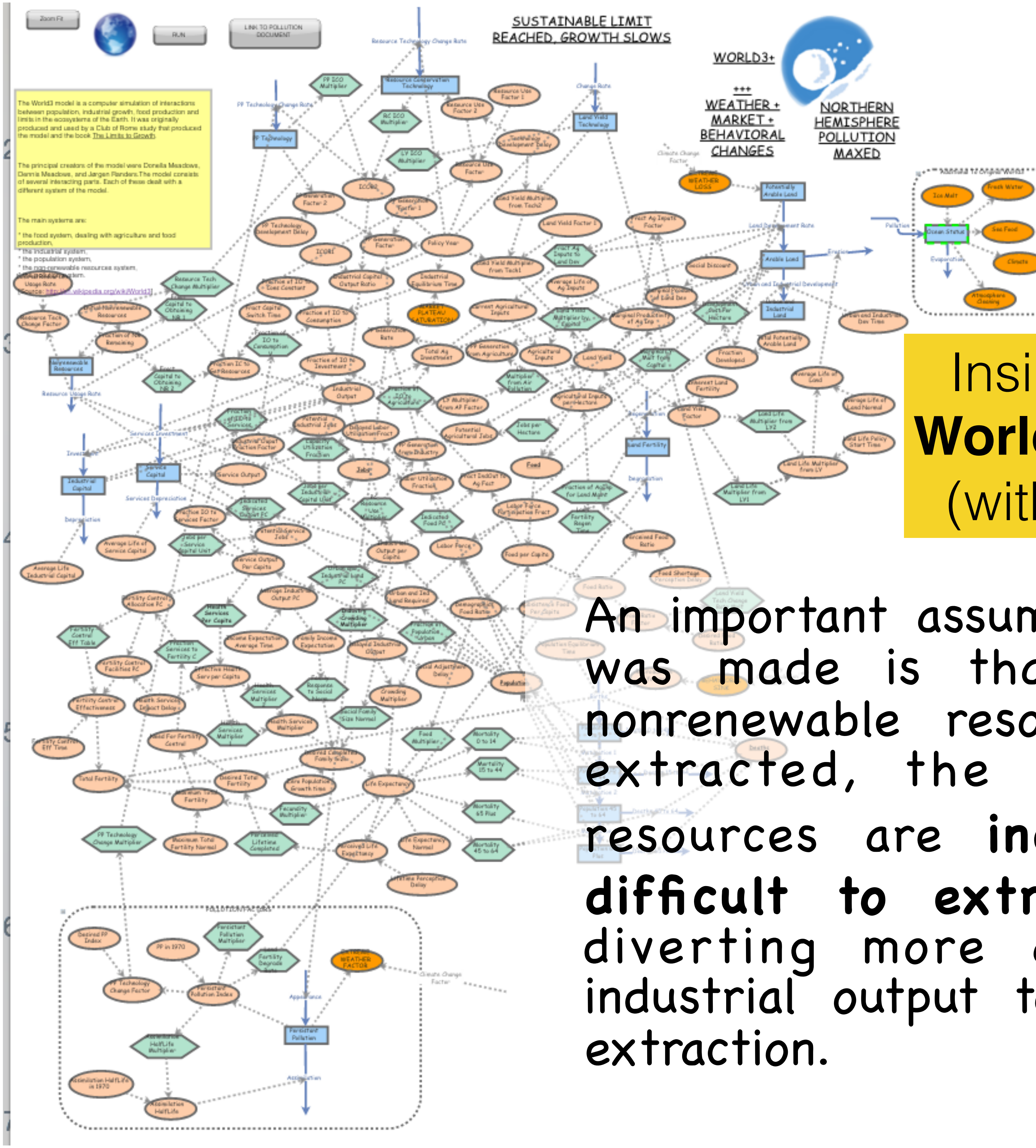
Agriculture is modeled as three types of land with one-way transitions. No cycle back from urban to arable, nor from arable to potentially arable (i.e. wild).

"World 2" model -- Jay Forrester



- Similar to World 1 (1971 version)
  - Open systems for population, natural resources, capital investment (physical capital), capital investment in agriculture, pollution.
  - central variable in Material Standard of Living (MSL)
  - single demographic
  - non-renewable resources are not explicitly modeled

Forrester, Jay Wright, World dynamics. Vol. 59. Cambridge, MA: Wright-Allen Press, 1971.



InsightMaker
World3+ model
(with climate)

An important assumption that was made is that as the nonrenewable resources are extracted, the remaining resources are **increasingly difficult to extract**, thus diverting more and more industrial output to resource extraction.

More work needs to be done on modeling

From the author of LtG

"Dana" Meadows

- Donella Meadows in "Groping in the Dark: The First Decade of Global Modelling"

"We have **great confidence in the basic qualitative assumptions** and conclusions about the instability of the current global socioeconomic system and the general kinds of changes that will and will not lead to stability. We have relatively **great confidence in the feedback-loop structure** of the model, with some exceptions which I list below. We have a **mixed degree of confidence in the numerical parameters** of the model; some are well-known physical or biological constants that are unlikely to change, some are statistically derived social indices quite likely to change, and some are pure guesses that are perhaps only of the right order of magnitude. The structural assumptions in World3 that I consider **most dubious** and also sensitive enough to be of concern are:

- the constant capital-output ratio (which assumes no diminishing returns to capital),
- the residual nature of the investment function,
- the generally ineffective labour contribution to output."

recent

Modeling Sustainability: Population, Inequality, Consumption, and Bidirectional Coupling of the Earth and Human Systems.

Safa Motesharrei[1,+,*], Jorge Rivas[2,+], Eugenia Kalnay[1,+], Ghassem R. Asrar[3], Antonio J. Busalacchi[4], Robert F. Cahalan[5,6], Mark A. Cane[7], Rita R. Colwell[1], Kuishuang Feng[1], Rachel Franklin[8], Klaus Hubacek[1], Fernando Miralles-Wilhelm[1,3], Takemasa Miyoshi[9], Matthias Ruth

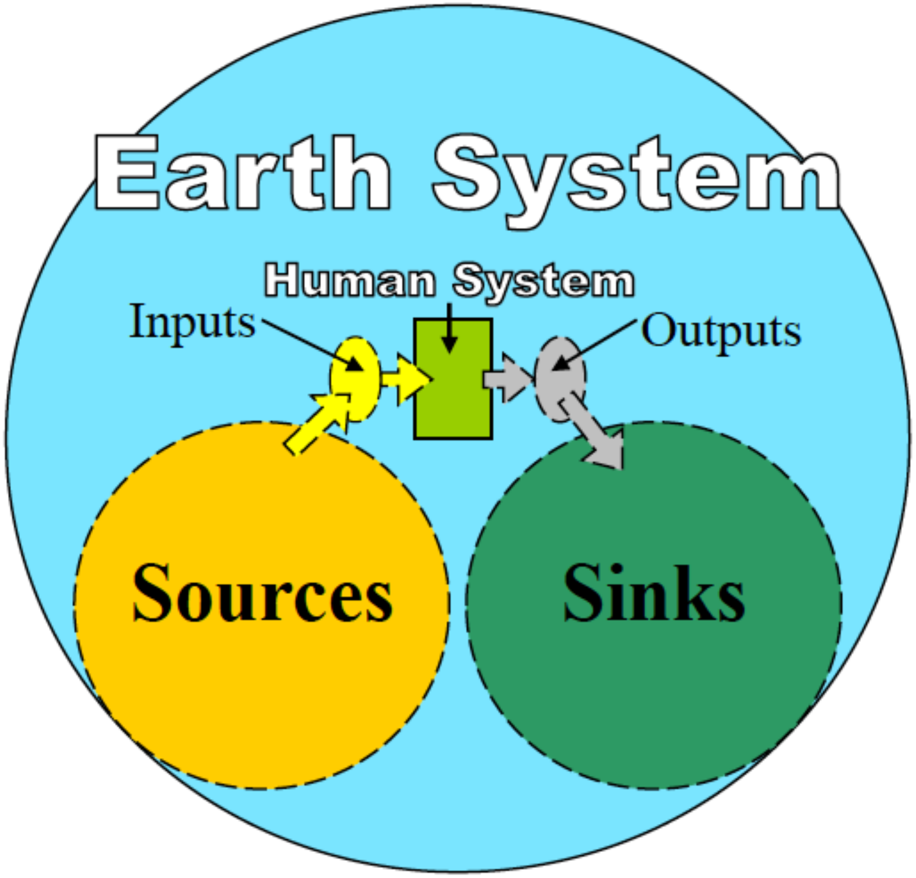
Over the last two centuries, the impact of the **Human System has grown dramatically, becoming strongly dominant within the Earth System** in many different ways. Consumption, inequality, and population have increased extremely fast, especially since about 1950, threatening to overwhelm the many critical functions and ecosystems of the Earth System. Changes in the Earth System, in turn, have important feedback effects on the Human System, with costly and potentially serious consequences. However, **current models do not incorporate these critical feedbacks**. We argue that in order to understand the dynamics of either system, **Earth System Models must be coupled with Human System Models through bidirectional couplings representing the positive, negative, and delayed feedbacks that exist in the real systems.** In particular, key Human System variables, such as demographics, inequality, economic growth, and migration, are not coupled with the Earth System but are instead driven by exogenous estimates, such as UN population projections. This makes current models likely to miss important feedbacks in the real Earth-Human system, especially those that may result in unexpected or counterintuitive outcomes, and thus requiring different policy interventions from current models. The importance and imminence of sustainability challenges, the dominant role of the Human System in the Earth System, and the essential roles the Earth System plays for the Human System, all call for collaboration of natural scientists, social scientists, and engineers in multidisciplinary research and modeling to develop coupled Earth-Human system models for devising effective science-based policies and measures to benefit current and future generations.

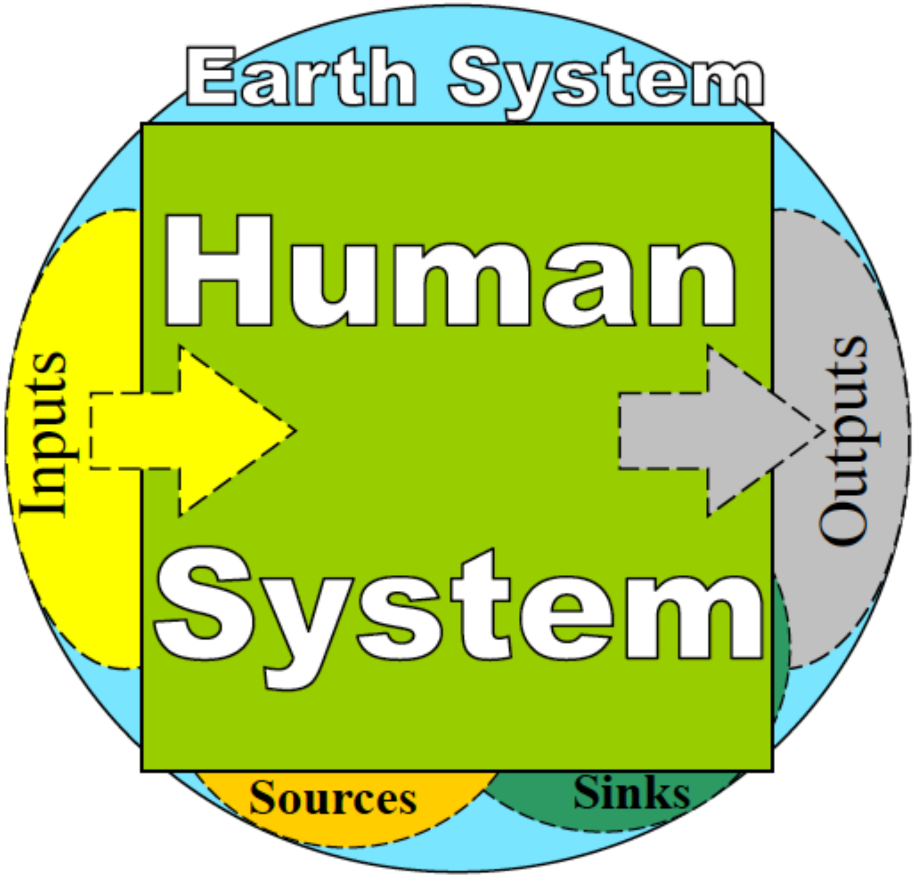
The Past: "Empty World"

When the Human System was small relative to the Earth System, the two could be modeled separately.

The Present: "Full World"

The Human System has grown so large that both must now be modeled coupled to each other.





Motesharrei, Safa, et al. "Modeling Sustainability: Population, Inequality, Consumption, and Bidirectional Coupling of the Earth and Human Systems." National Science Review (2016): nww081.

OXFORD
UNIVERSITY PRESS

From: **Bidirectional coupling between the Earth and human systems is essential for modeling sustainability**

Natl Sci Rev. 2016;3(4):397-398. doi:10.1093/nsr/nww094

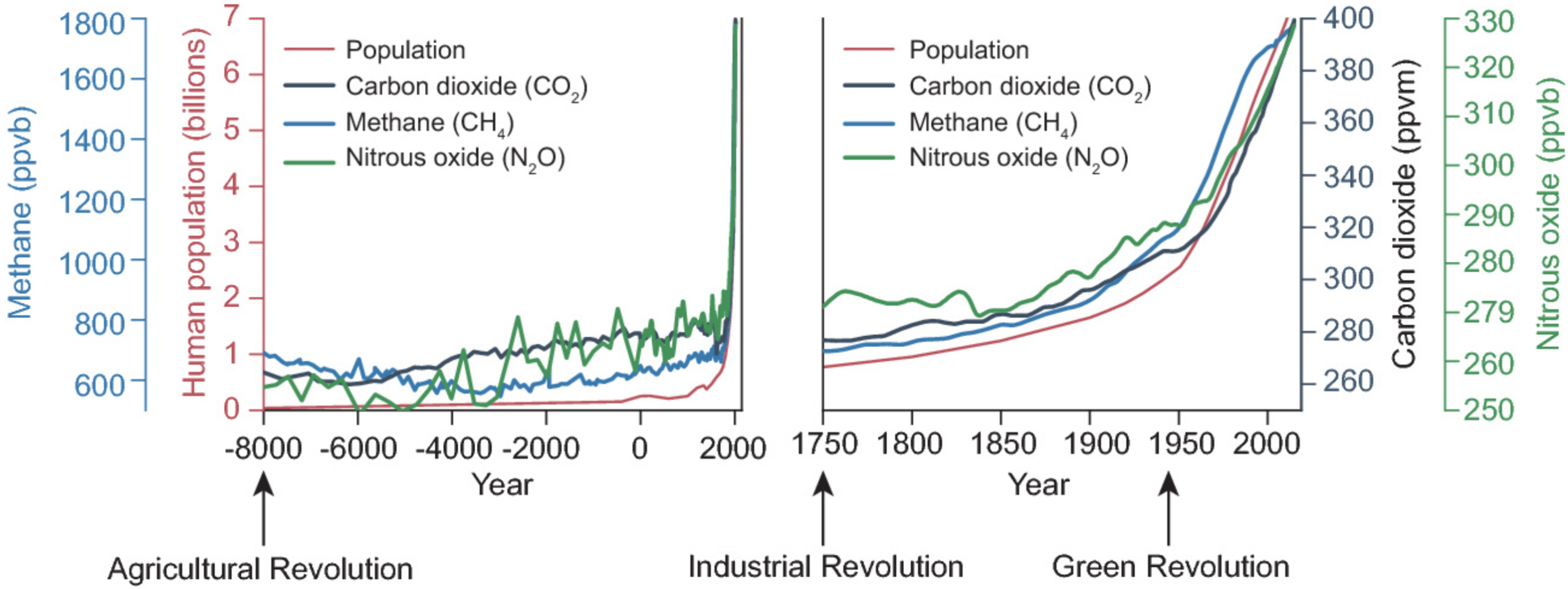


Figure Legend:

World population and atmospheric concentrations of major greenhouse gases since the beginning of the Agricultural Revolution about 10 000 years ago until the present (left), with a magnified timescale for the period after the beginning of the Industrial Revolution (right). Code, data, data sources, calculation of the rates of change and additional configurations of the figure are available at https://dx.doi.org/10.6084/m9.figshare.4029369.

In World 3

What is overmodeled?

demographics, economics

What is undermodeled?

cycles, feedback

Circular mentality

" You have noticed that everything an Indian does in a **circle**, and that is because the Power of the World always works in circles, and everything **tries to be round**.

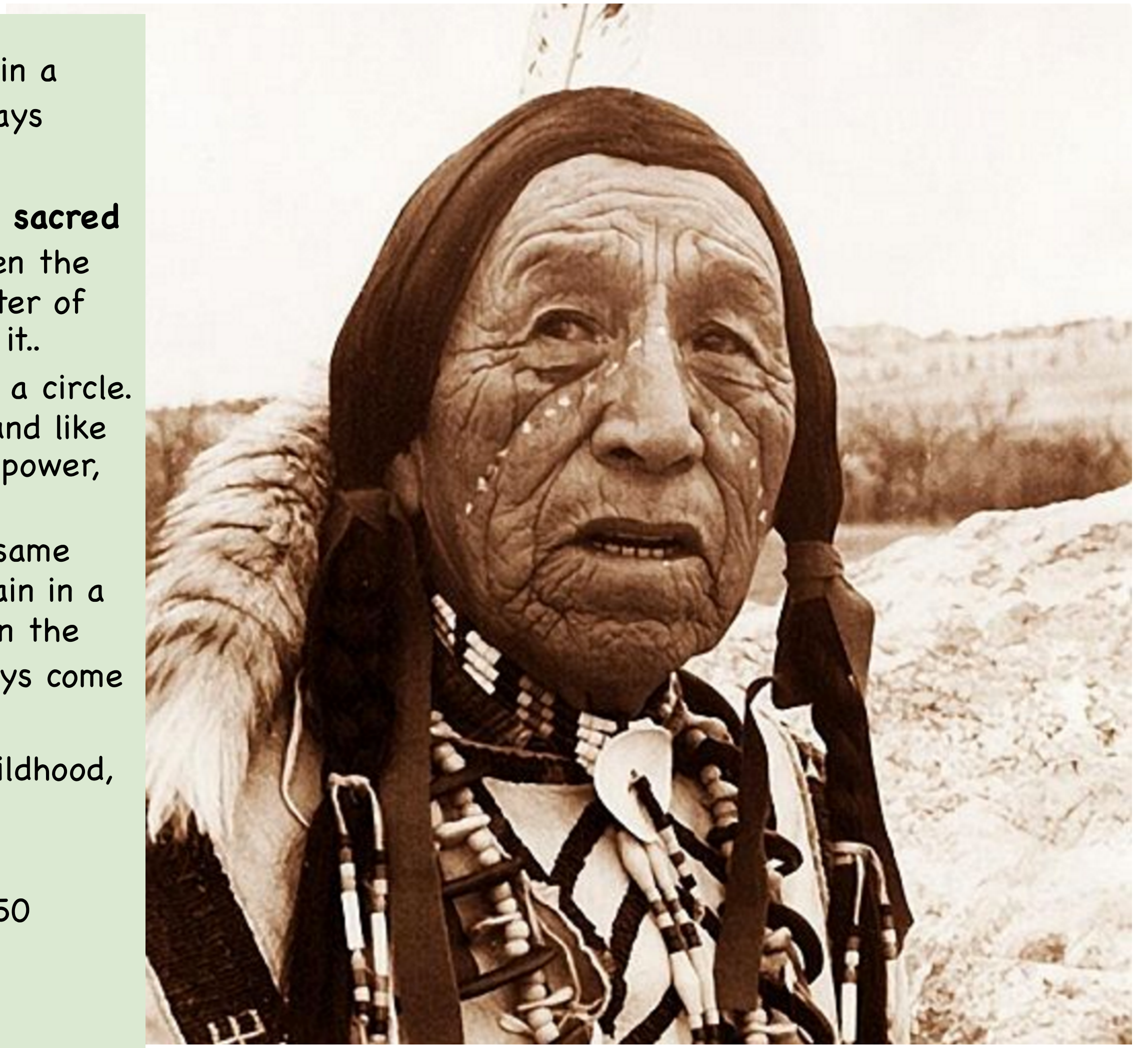
In the old days all our power came to us from the **sacred hoop** of the nation and so long as the hoop was unbroken the people flourished. The flowering tree was the living center of the hoop, and the circle of the four quarters nourished it..

Everything the power of the world does is done in a circle. The sky is round and I have heard that the earth is round like a ball and so are all the stars. The wind, in its greatest power, whirls.

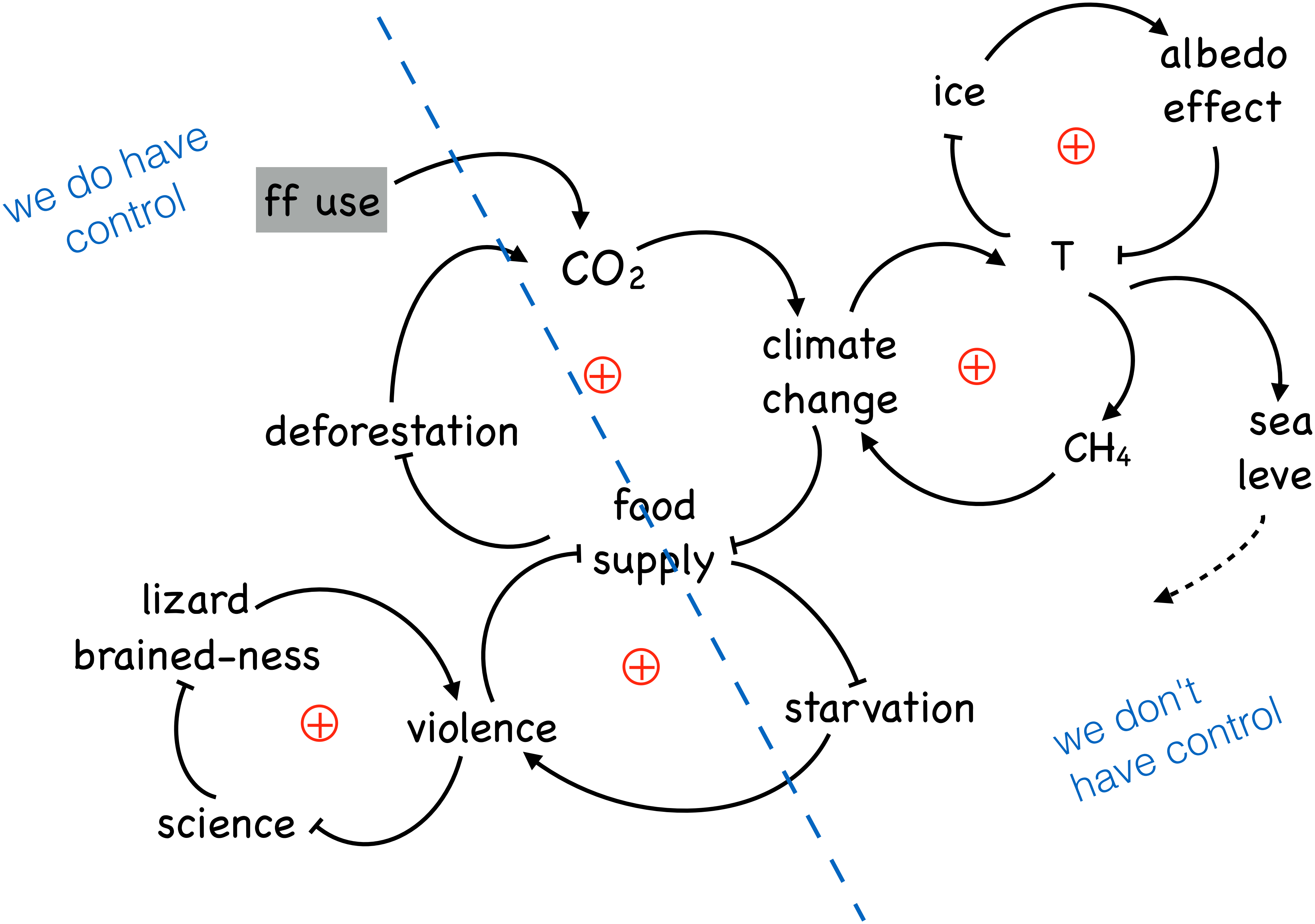
Birds make their nests in circles, for theirs is the same religion as ours. The sun comes forth and goes down again in a circle. The moon does the same and both are round. Even the **seasons form a great circle** in their changing and always come back again to where they were.

The **life of a man is a circle** from childhood to childhood, and so it is in everything where power moves.. "

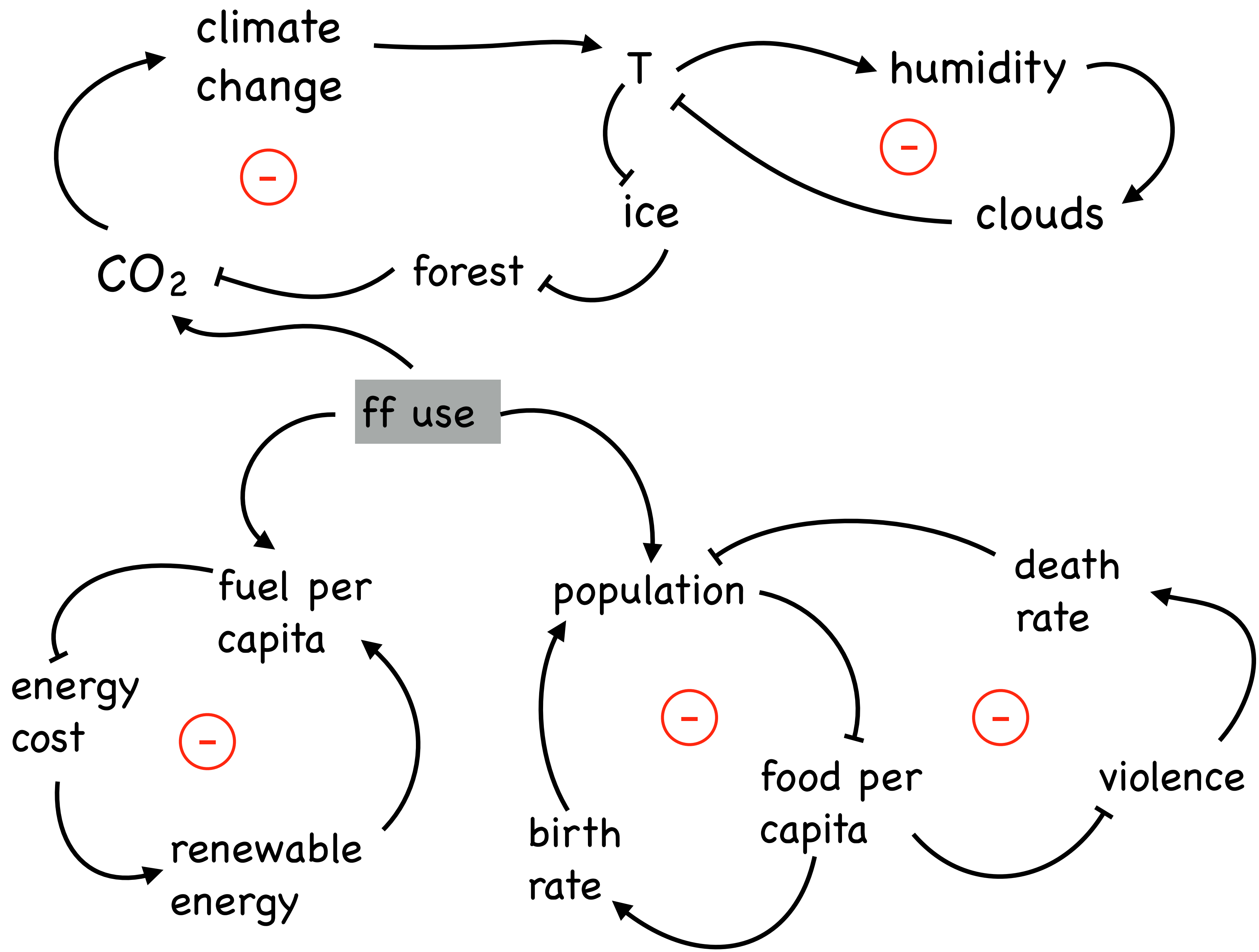
Black Elk, Holy Man of the Oglala Sioux 1863-1950



Cycles: Positive feedback loops



Cycles: Negative feedback loops




DAMEELLENMACARTHUR

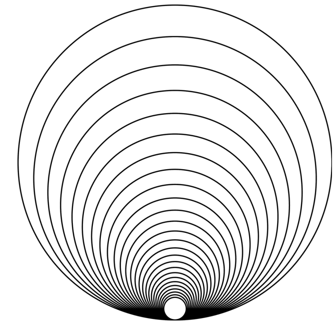
structural change

Linear Economy -->
Circular Economy

A **circular economy** is an **economic system** that takes the reusability of products and materials and the conservation of natural resources as starting point. It also strives for value creation for people, nature and the economy in each part of the system. Ideally, making **materials circulate infinitely** makes an economy circular. This means that the **economic system functions through ecological principles**, whereby:

- All resources can be used in other parts of the economic system in a sustainable way (clean, safe, social) and all <u>waste is used as resource</u>
- <u>Renewable resources</u> and the usage of present-day physical processes in a smart way will become the basis of the economy
- The mining of biological and geological resources is done in a <u>sustainable</u> manner
- <u>Renewable energy</u> is used
- <u>New types</u> of organisations and business modes arise to make this possible.

Official document, Dutch Second Chamber 35 750 XIII http://www.netherlandscircularhotspot.nl/



What are the cycles of circularity?

In the technical aspect of the circular economy, there are five cycles of circularity. The <u>**tightest cycle** has the highest *value*</u>; the least tight cycle has the lowest value.

1. Product **maintenance**
2. Product **reuse / redistribution**
3. Product **refurbishment / remanufacture**
4. Product **recycling**
5. **Reprocessing** of technical nutrients

What are the principles behind a circular economy?

A circular economy is built on five principles. Also, system thinking is of high importance when considering a circular economy.

1. Design out waste
2. Build resilience through diversity
3. Rely on energy from renewable sources
4. Think in systems
5. Waste is food

when one hoop break, other hoops hold the system together

Ellen MacArthur (2013), Towards the Circular Economy 1, p.24

IMSA, Unleashing the power of the Circular Economy, p.16,45
Meadows (1999), Leverage points: places to intervene in a system

gradually becoming circular

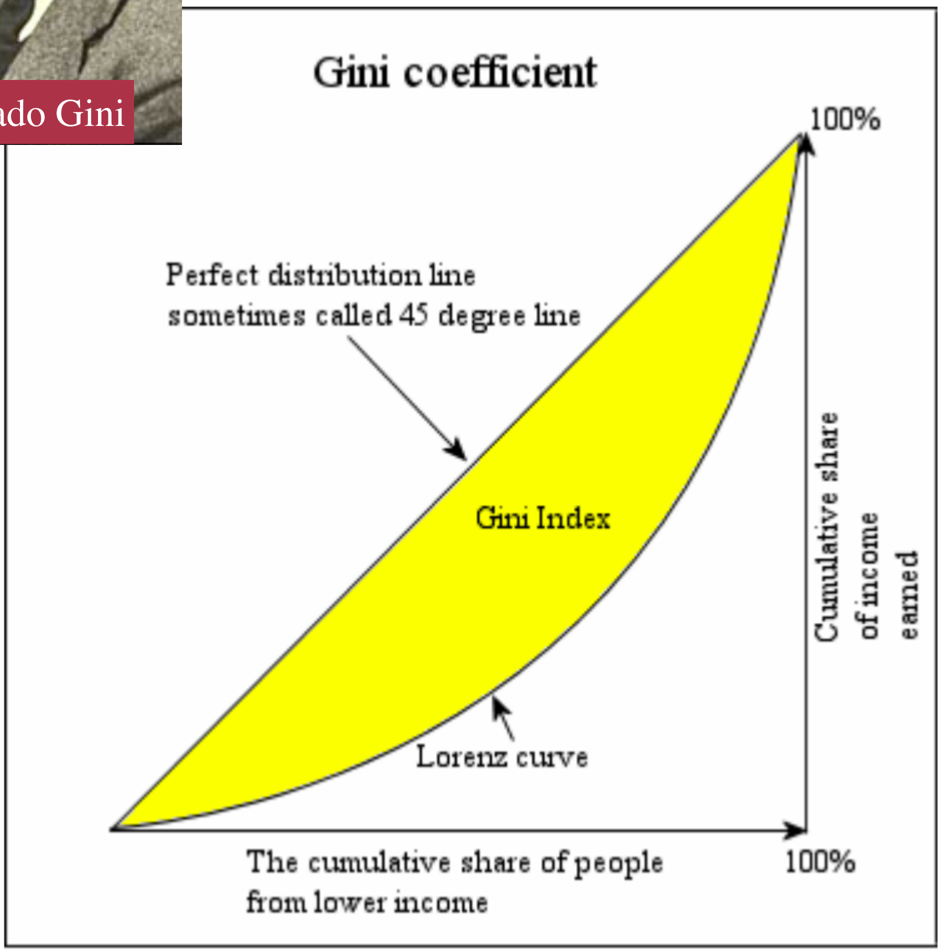
Linear economy with feedback loops is the **transition state** between a completely **linear economy** and a completely **circular economy**.

In our current linear economic model, many elements can already be made partially circular. Think of reduced resource extraction, of increased recycling, of changing business models from product to service, of increased cooperation in the production chain and of diferent financing methods. Although many feedback loops can be implemented relatively easy, a complete circular economy is not yet within reach.

Ellen MacArthur (2013), Towards the Circular Economy 1, p.24

Gini coefficient

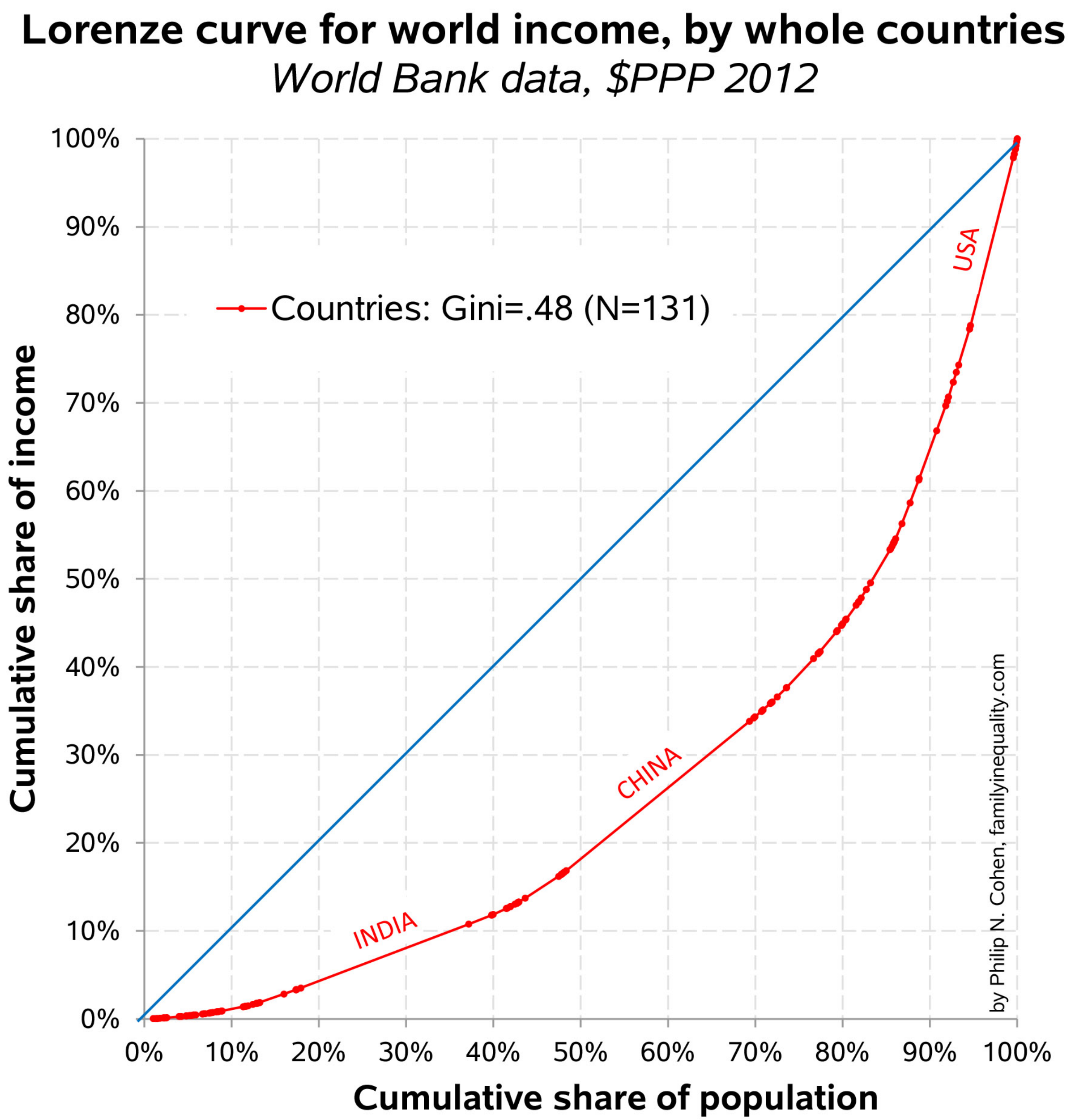
abundance



species

- Measure of inequality in a dataset.
- Invented to describe income inequality.
- Area over Lorenz curve and under the diagonal.
- $0 \leq G \leq 1$
- $G=0$ represents perfect equality
- $G=1$ represents a perfect inequality.

$$G = 1 - 2\int_0^1 L(X)\, dX$$



Lorenze curve for world income, by whole countries
World Bank data, $PPP 2012
Countries: Gini=.48 (N=131)
Cumulative share of income
Cumulative share of population
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
INDIA
CHINA
USA
by Philip N. Cohen, familyinequality.com

Chart 1

Converging fortunes

Latin America is the region with the highest inequality in the world, but one of only two—along with south Asia—where inequality is falling.

(average Gini coefficient by region and income level, five-year averages)

Sources: Author's calculations based on OECD Income Distribution Database: Gini, Poverty, Income, Methods and Concepts; World Bank, PovcalNet: An Online Poverty Analysis Tool; and CEDLAS and World Bank, Socioeconomic Database for Latin America and the Caribbean.

Note: Regional averages were calculated as the averages of within-country inequality for the countries for which data were available; thus, country coverage varies markedly by region.

Modeling Inequality

- How is Gini directly related to : (if at all) ?

	positively correlated	negatively correlated	caused by	affected by	not related
Affluence					
LEB					
HDI					
✓ Conservation					
QOL					
Available Capital					
Technology					