An edited version of this paper has been published in the
Journal of Sociocybernetics, Volume 8, Winter 2010



# Conceptualising, Mapping, and Measuring Social Forces

**John Raven and Luciano Gallon**
30 Great King Street,
Edinburgh EH3 6QH,
UK
jraven@ednet.co.uk
www.eyeonsociety.co.uk

Version Date: 13 March 2011.

http://eyeonsociety.co.uk/resources/scio.pdf

## Abstract

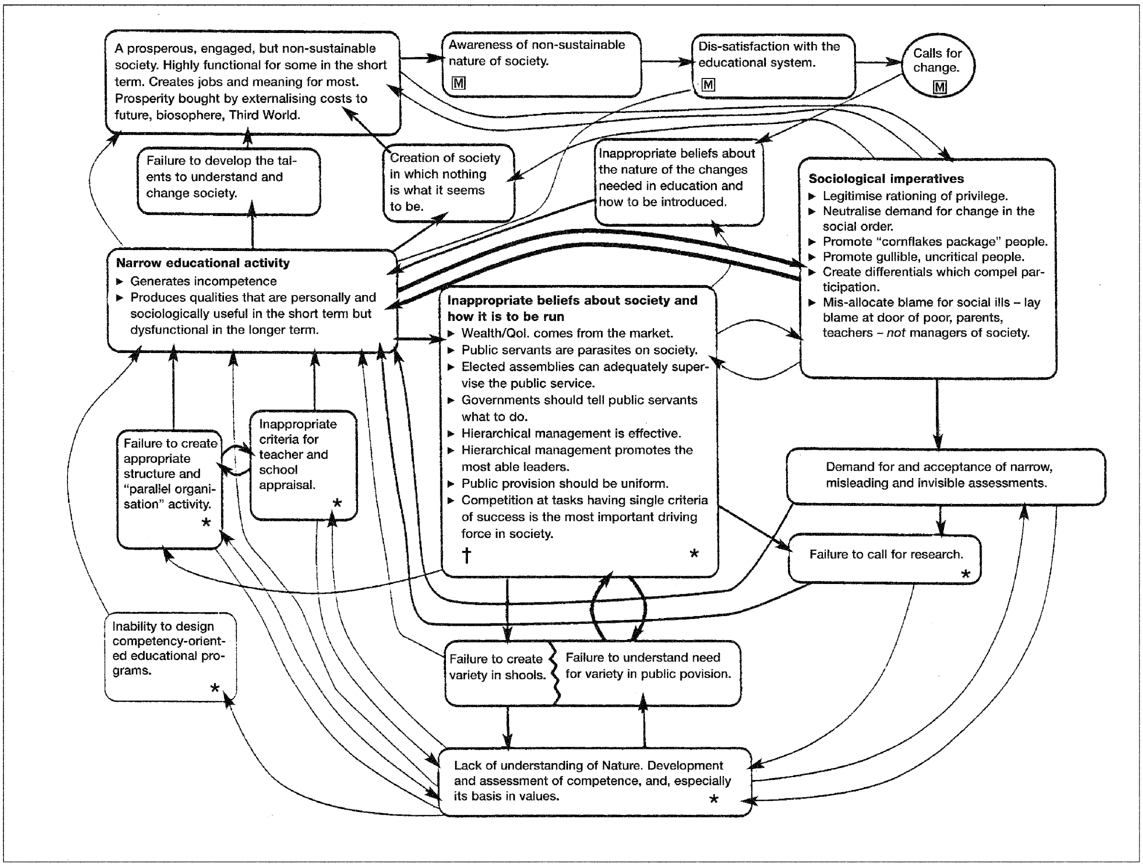
*A map of the socio-cybernetic forces controlling the operation of the "educational" system is first used to highlight some things that can be learned from the preparation of such a diagram and especially to ask how social forces like those represented can be harnessed to achieve the manifest goals of the system more effectively. It is then used to raise more fundamental questions, which it is hoped participants will help to answer, about how "social forces" are to be conceptualised and measured. The huge benefits that would accrue from being able to quantify social forces are illustrated in an Appendix. Ironically, that same appendix again implicitly highlights the fact that attempts to initiate social action on the basis of good information (such as that provided in that very appendix) will continue to have largely counterintuitive and counterproductive effects unless the network of* ***social*** *forces controlling the outcomes is understood and taken into account via a more appropriate socio-cybernetic system for the management of society.*

*****

Some 20 years ago, following 30 years' studying why the educational system in general fails to deliver on its manifest educational goals and, instead, performs mainly sociological functions (see footnote below and Raven, 1994), we found ourselves, following Morgan (1986) (whose diagrammatic representations of the networks of forces or feedback loops controlling the operation of three social systems are reproduced in Appendix 1 below), trying to map what we later came to think of as the network of social forces which undermine the system[*].

[*] It cannot be too strongly emphasised that this paper has been written to provoke discussion of some fundamental issues in systems thinking - and in socio-cybernetics in particular. We have introduced our work on the educational system *in a purely illustrative capacity.* Any discussion here of possible solutions to the manifold problems of the educational system would, so far as the objectives of this paper are concerned, be diversionary. Nevertheless, in order to reduce confusion and misunderstanding, it should be underlined that, when we refer to the "goals of education", we do *not* have in mind the goal of conveying and assessing *knowledge.* In the research which preceded the research discussed here we had shown, first, that the most widely endorsed goals of the system included nurturing such qualities as the confidence and initiative required to introduce change and identifying, developing, and recognising the huge variety of talents that different people possess … that is to say, nurturing and credentialing *diversity*. Second that these opinions are essentially correct: these *are* the qualities people require at work and in society. And, third, that, in reality, schools generally do the opposite. They stifle initiative and adventurous enquiry, instead devoting the vast proportion of time to

The result is shown in Figure 1.




*Intervention in these cells would help change the nature of the qualities nurtured and rewarded in the system. Motives which could be harnessed to do this are marked M.

†These need to be replaced by acceptance of the need to make managed economies work – to find way of giving effect to information concerning the public long-term interest, the need to explicitly create variety and information on the personal and social consequences of the options, and to find ways of holding public servants accountable for, and getting them to at in, the long-term public interest. This means systematic, broadly based, evaluation and participative democracy.

**Figure 1**
*Feedback Loops Driving Down Quality of Education*

What the Figure shows is that:

A. There is no single "explanation of the problem. Multiple, mutually reinforcing and recursive, processes are at work. The dominance of the activities with which schools are preoccupied arises from:

(i) A series of sociological imperatives (e.g., that schools assist in legitimising the rationing of privilege); what happens in schools is not determined by the wishes of parents, teachers, pupils, employers, ministers of education or anyone else but by what is assessed in the sociological process of allocating position and status.

---

inculcating and assessing tiny smatterings of knowledge that is out of date when it is taught, forgotten by the time it is needed, and does not relate to people's needs. Instead of generating and recognising diversity, the system arranges people in a single and misleading hierarchy of "ability" which is then used to allocate position and status, legitimise a divided society, and, ultimately, compel people, largely against their will, to participate in a deeply destructive social order. In other words, the system mainly performs *sociological* rather than educational functions.

(ii) Inappropriate beliefs about the nature of the changes that are needed in education itself, the management of the educational system, and the management of society;

(iii) Society's failure to initiate research which would yield useful insights into such things as (a) the nature of competence and how it is to be fostered and (b) how to manage the educational system to nurture high-level generic competencies;

(iv) The absence of (a) systematically generated variety in, and choice between, educational programmes which have demonstrably different consequences and (b) Information on the consequences of each of these alternatives;

(v) Failure to introduce "parallel organisation activity" to produce innovation within schools, and

(vi) Inadequate dissemination of the results of research into the nature, development, and assessment of generic high-level competencies, and, especially, the implications of the values basis of competence.

B. That widely shared beliefs about how public sector activities should be managed seriously undermine the operation of the system. These beliefs include the notion that it is the job of elected officials (described by John Stuart Mill and Adam Smith as "committees of ignoramuses") to tell public servants … including teachers … what to do and to monitor achievement of the goals or targets thus prescribed using heavy-handed, command-and-control oriented, techniques.

C. The narrow educational process that is implemented has a series of knock-on effects which finally contribute to its own perpetuation. The competencies and beliefs that are nurtured and inculcated in schools reinforce a social order which offers major benefits to "able" people who do what is required of them without questioning that order; it creates endless work which gives meaning to people's lives (but does not enhance the general quality of life); it creates wealth at the expense of the biosphere, future generations, and the third world; and it protects its citizens from a knowledge of the basis of their wealth. The educational system helps to teach a host of incorrect beliefs which collectively result in nothing being what it is popularly or authoritatively said to be (for example, the educational system itself claims to be about promoting the growth of competence when it in fact mainly operates to engage vast numbers of people in "teaching" and "learning" activities of little educational merit but which ensure that those who are most able and willing to challenge the fraudulent nature of the system are routed to social positions from which they can have little influence while those who are least able to do anything except secure their own advantage are promoted into influential positions in society). This double-talk makes it extremely difficult to conduct any rational discussion of the changes needed in society. The sociological imperative that schools help to legitimise the rationing of privilege helps to create a demand for, and encourages acceptance of, narrow, invisible, and mislabelled assessments. Those predisposed to acquire these "qualifications" are not inclined to see the need for, or to commission, genuine enquiry-oriented research or notice other talents in their fellows. Teachers who become aware of the hidden competencies of their "less able" students experience acute distress. The lack of understanding of the nature of competence leads to a failure to underline the need for a variety of value-based educational programmes and thus to the perpetuation of narrow educational activity.

D. That the main motives for change are widespread awareness that there is something seriously wrong with the educational system, and, more specifically, that it fails miserably in its manifest task of identifying, nurturing, recognising, and utilising most people's motives and talents. The most commonly proposed solutions to this problem, based as they are on other misunderstandings, are, however, inappropriate. Another motive for change stems from increasing recognition that we have created a non-sustainable society and that basic change in the way society is run is essential.

E.That there are a number of points at which it should be possible to intervene in the feedback loops to create an upward spiral. These might involve:

(i) Promoting wider recognition that one cannot get value for human effort in modern society unless we introduce better means of monitoring and evaluating the long-term effects of what we are doing and better ways of giving effect to information on such effects. This points to the need to change the way we run society, to the need to introduce more, and more appropriate, social research and evaluation activity, and to find ways of holding public servants and politicians accountable for seeking out and acting on information in an innovative way in the long-term public interest;

(ii) Introducing the "parallel organisation" activities that are required to promote innovation within schools;

(iii) Establishing a greater variety of distinctively different, value-based, educational programmes and providing information on the short and long-term, personal and social, consequences of each;

(iv) Creating public debate about the forms of supervision – the nature of the democracy – needed to ensure that public servants seek out and act on information in an innovative way in the public interest and,

(iv) Disseminating what is already known about the nature, development, and assessment of competence and its implications.

Standing further back from the Figure what we see is that:

1. It is impossible to achieve significant benefits by changing any one part of the system … such as curriculum or examinations or teacher training on its own … without simultaneously making other changes – otherwise the effects of the change will either be negated by the reactions of the rest of the system or produce counterintuitive, and usually counterproductive, changes elsewhere. On the other hand, it is equally clear that command-and-control-based system-wide change based on uninformed opinion will achieve little.
2. Pervasive, *systems-oriented*, changes are required to move forward. But these changes, although collectively system-wide, cannot be centrally mandated because there are too many new things to be done.
3. Since what happens is not determined by the wishes of any particular group of people but by the sociological functions the system performs for society – *i.e. by the system itself* - the widespread tendency to single out and *blame* parents, pupils, teachers, public servants, or politicians is entirely inappropriate. *Their* behaviour is determined by the system. One needs to take these social forces seriously and ask how they can be harnessed in an analogous way to that in which marine engineers harness the potentially destructive forces of the wind: They will not go away!
4. It is vital to generalise the observation made in (3): We need to fundamentally re-frame the way we think about the causation of behaviour in a way which parallels one of the transformations Newton introduced into physics. Before Newton, if objects moved or changed direction, it was because of their *internal* properties: they were *animated.* After Newton it was mainly because they were acted upon by a network of invisible *external* forces which could nevertheless be mapped, measured and harnessed. Observation (3) implies that we need a similar transformation in the way we think about the causes of human behaviour.
5. The network of forces depicted (a) has the effect of driving attempts to deal with the problems based on single-variable common-sense interventions ever more narrowly, and ineffectively, around the triangle at the top left of the Figure, and (b) diverts attention from the developments, indicated in the bottom part of the figure, that are so essential to move forward.

6. The *causes* of the symptoms (and thus the appropriate place to start reform) are far removed from those symptoms.
7. The system does not merely reproduce itself – it leads to the production of ever more elaborate versions of itself; it is self-elaborating; autopoietic.

Although we did not, at the time, describe what we next tried to do in these terms, we then set about asking how these social forces could be harnessed to push the system in the direction in which most people wanted it to go instead of crashing it against the rocks. This is analogous to thinking out how to map and harness the forces acting on sailing boats in order to be able to sail *into* the wind*. Other analogies include amplifying and damping down electrical currents derived from sensors in a control system for a missile.

The result is shown in Figure 2.

We were very proud of this Figure. It generated important new insights into how to create a pervasive climate of experimentation, innovation, and learning via comprehensive (holistic) evaluation, public debate, and feedback … exactly the opposite of the arrangements embedded in centralised command-and-control thinking.

Despite the importance of all of these insights, we have belatedly realised that the socio-cybernetic governance system we designed (i.e. that summarised in Figure 2) was *not* analogous to what would have emerged from an attempt to use an understanding of the forces acting on sailing boats to invent ways of harnessing those forces to push the boat where its captain and crew wanted it to go. Instead, we had, in effect, suggested replacing the existing equipment (i.e. sails etc.) by a marine engine.

So now a more fundamental problem is bothering us: How are we to conceptualise, map, and measure social *forces* in a manner which is indeed analogous to doing these things for the physical forces acting on a sailing boat?

Note that, to undertake this task for a sailing boat, Newton first had to articulate the concept of "force" itself … before that there had just been the wind, the waves, and the gods. He had to show that whatever this invisible "thing" was, it was something which was common to understanding

* To repeat: A brief discussion of the way in which physical forces can be mapped and harnessed will be found in Appendix 2.

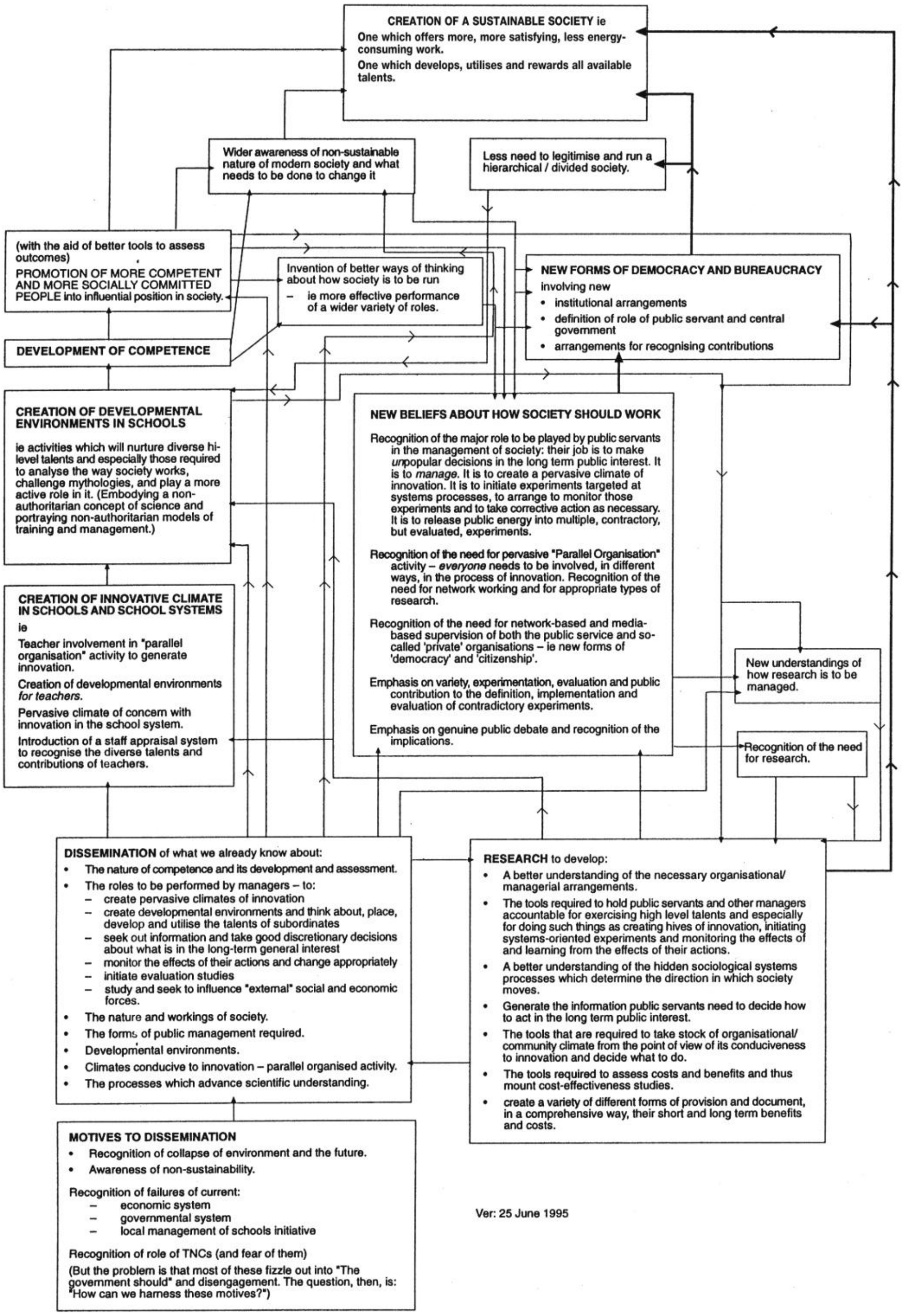



**Figure 2**
New Societal Managements Arrangements

some aspects of the behaviour of winds, waves, falling apples, and the movement of the planets. To do this he had to show that these invisible forces were *measurable.* (Making the invisible visible has been a constant component in scientific advance.) And then he had to show how the various separate forces acting on a sailing boat could be mapped, measured, and integrated. He could then leave the task of re-designing sailing boats to harness those forces to someone else: ships' designers.

In the foregoing discussion of Figure 1, we have made continuous use of the term "force". We must now take up the question of the nature, or status, of these "forces". At the most basic level, Figure 1 is analogous to a map of the interacting gravitational forces controlling the orbits of the planets. But the nature of the *social* forces involved has yet to be elucidated. What is clear is that the links in the diagram are not flows of e.g. resources as in the models developed by Forrester (1971) and Meadows *et al*. (2008)[*]. Nor are they flows of "information" as in networks of emails. Nor are they flows of e.g., people from one section of the "educational system" to another. The contents of the boxes are not people or stocks of food or components. Only if the links really are *forces* in some sense analogous to physical forces does it make sense to ask how they can be harnessed (as in the forces acting on a sailing boat) or amplified or damped down (as in electrical energy flowing through a radio). It is worthy of note, however, that, just as one can "feel" the force of gravity acting on an object held at arm's length or the force of an electric current passing though that same arm, so can one "feel" social pressures. Note, too, that one does not have to fully "understand" the nature of these forces before one can set about measuring and harnessing them.

So these are the questions I would like the audience for this session to help me answer: How are we to think about these social forces? How are we to measure them? How are we to map them?
It may be helpful to note in passing that this is, in a sense, the problem that has hampered the advance of ecology: How to map the multiple interactions between all the plants and animals in a particular ecological niche?

Although the question of how to harness them is really a question for someone else – such as political scientists – experience has shown that attempts to resolve practical questions can sometimes lead to theoretical advance … so we should perhaps not exclude this question.

The huge benefits which would stem from being able to map and measure social forces so as to be able to actually quantify the operation of a social system having multiple interacting and recursive feedback loops are dramatically illustrated in Appendix 4, taken from Forrester (and the Club of Rome), 1971/1995. This documents the extensive, generally counterintuitive, effects that can be seen from a systems analysis of this type to be likely to follow from various types of common-sense-based intervention in the World economic, population, resource, and environmental quality system. It is vital to find out how to document the probable effects of different types of intervention in *social* systems.

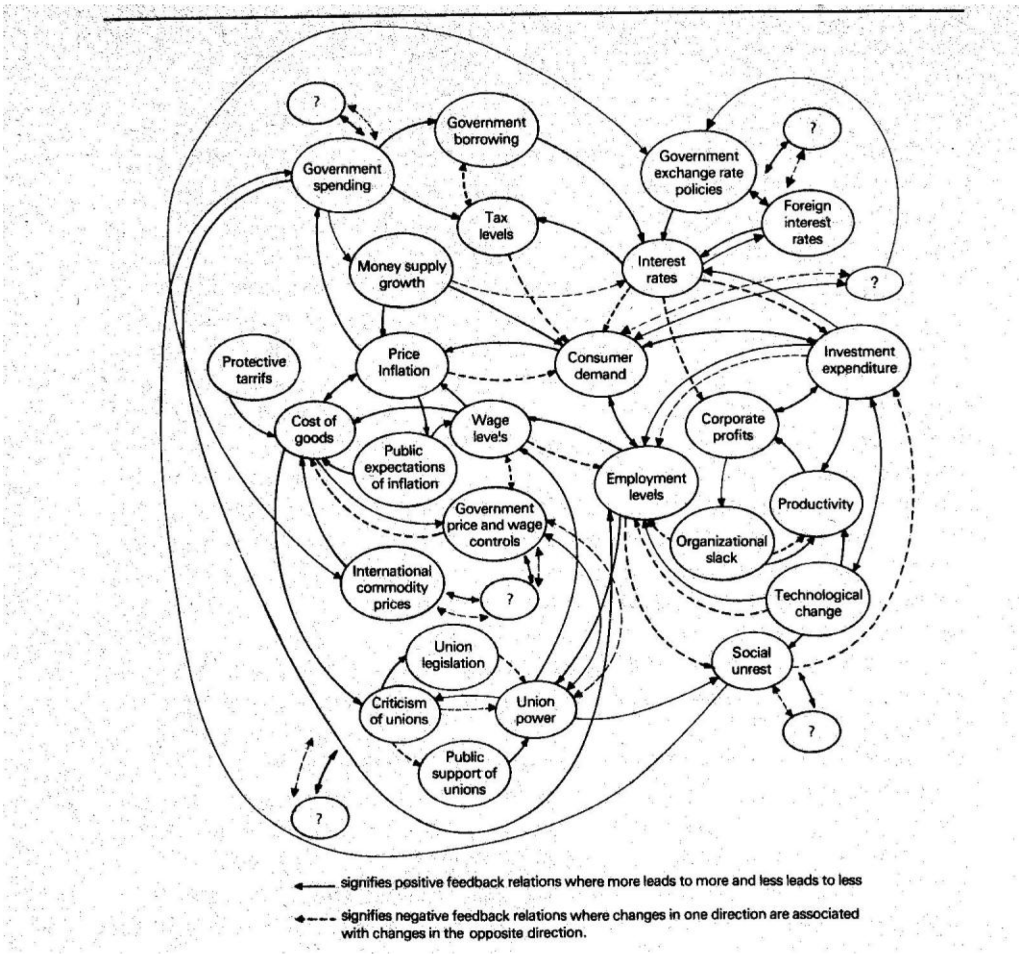
And here is Forrester's Achilles heel. For, having used his systems thinking to indicate the kinds of things that urgently need to be done, it then becomes necessary to get someone to act on this information. Yet our starting point was, precisely, that it is precisely the network of forces controlling such actions that we need to map and understand if we are to avoid serious counterintuitive and counterproductive outcomes of well-intentioned interventions.

[*] Some of these are, thanks to the help of Luciano Gallon, reproduced in Appendix 3 below.

**Appendix 1.**
**Morgan's Diagrams of the Networks of Social Forces and Feedback Loops Constituting three Socio-cybernetic (guidance and control) Systems**

The easiest way to give the reader a feel for the nature of the work on which we were trying to build when we, some 20 years ago, prepared Figure 1 is by reproducing the diagrams Morgan himself constructed to represent three social systems … or perhaps the socio-cybernetic (guidance and control) processes controlling the operation of those systems. The first of these dealt with the network of mutually supportive and interacting forces and feedback loops that contribute to price inflation. It is reproduced in Figure 3.

**Figure 3**
*Price inflation as a system of mutual causality*




As Morgan comments "When we understand the problem of price inflation as a system of mutual causality defined by many interacting forces, we are encouraged to think in loops rather than in lines. No single factor is the cause of the problem. Price inflation is enfolded in the nature of the relations that define the total system. Many of the links represented in this diagram are deviation-amplifying (heavy lines); negative-feedback relations (dotted lines) are more sparse. Positive feedback thus gains the upper hand. The system can be stabilized by strengthening existing negative-feedback loops and by creating others. Many government policies implicitly attempt to have this effect. For example, wage and price controls introduce negative-feedback loops that attempt to moderate the wage-price spiral. Government or media criticism of trade unions as unreasonable, greedy "villains" attempts to weaken the positive-feedback loop between public support and union power in the hope that it will moderate the power of trade unions to negotiate higher wages.

“In understanding this kind of mutual causality, we recognize that it is not possible to exert unilateral control over any set of variables. Interventions are likely to reverberate throughout the whole. It is thus necessary to adjust interventions to achieve the kind of *system* transformation that one desires.”

The next diagram Morgan presents deals with positive and negative feedback loops in the Power industry (Figure 4).

***Figure 4***
***Positive and Negative Feedback Loops in the Power Industry.***

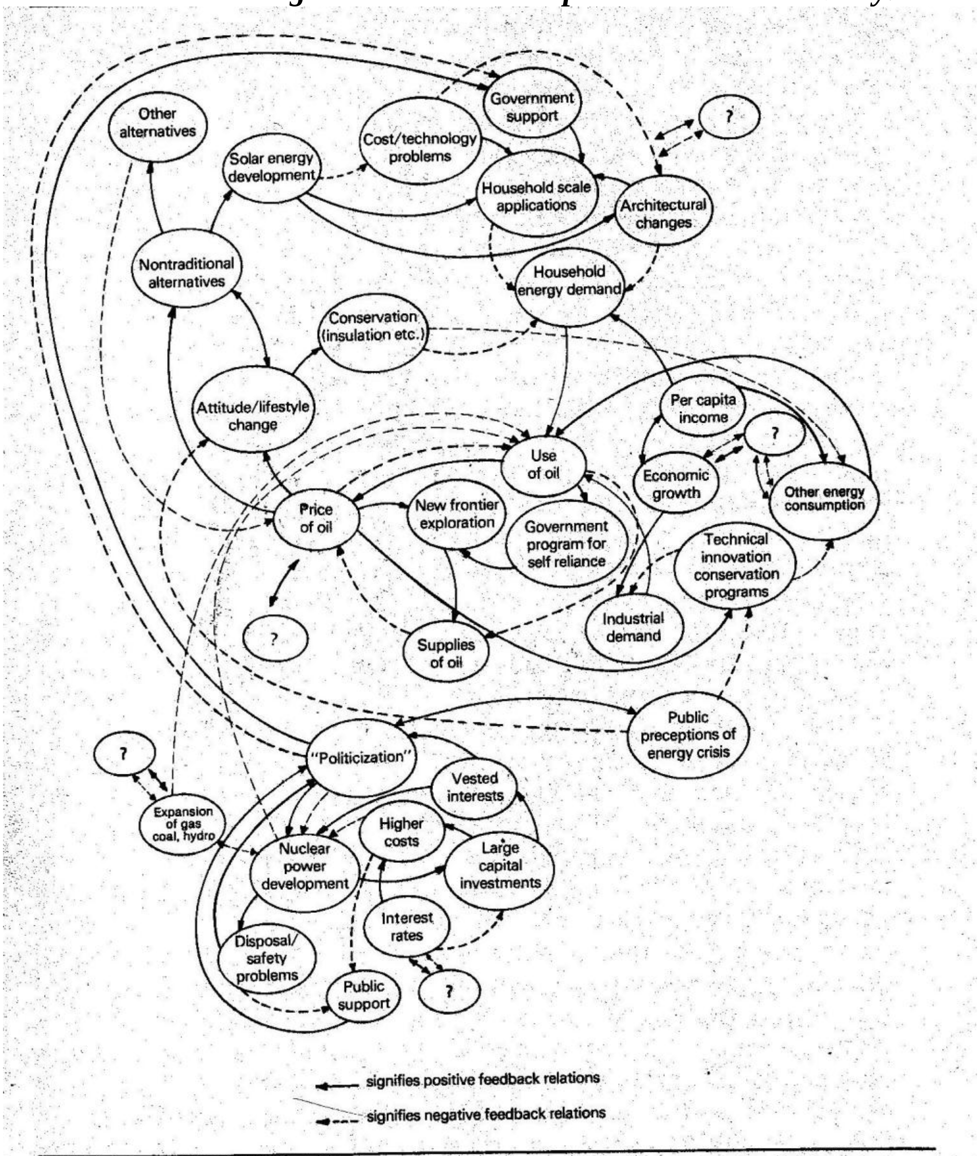



**Exhibit 8.3. Positive and negative feedback in the power industry**

His final Diagram deals with the Watergate cover up

***Figure 5***
***Cover Up and Exposure in the Watergate Affair.***

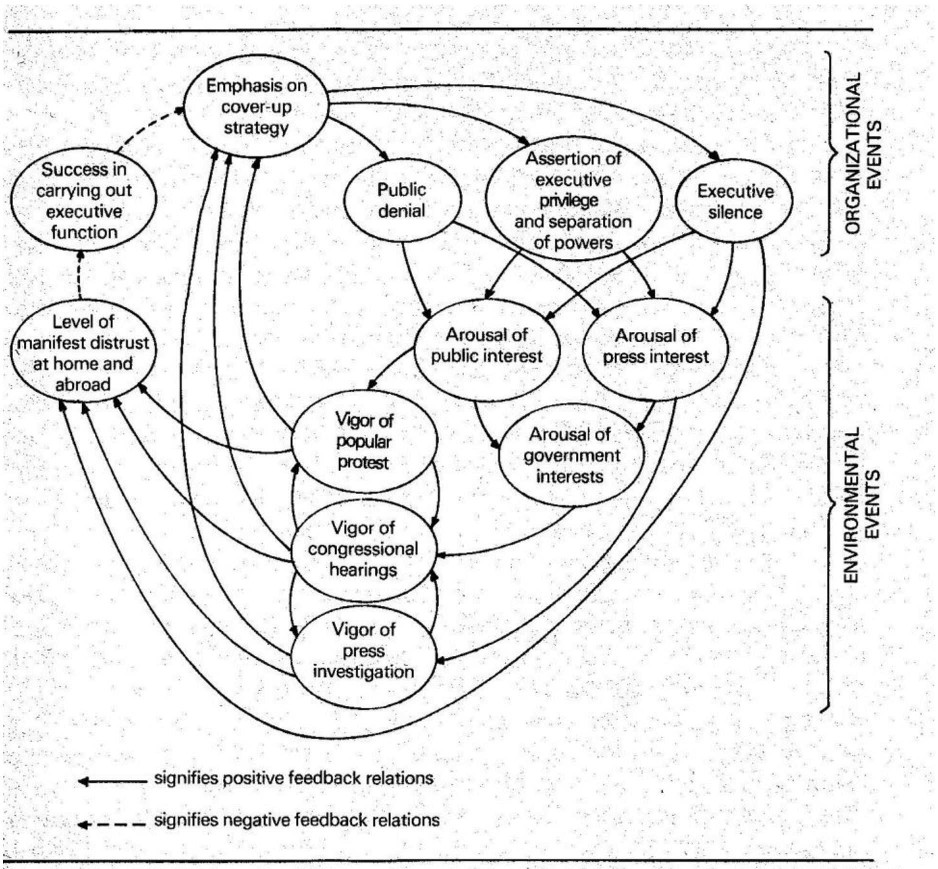



**Exhibit 8.4. The Watergate affair: positive and negative feedback in the Nixon White House**
SOURCE: Miles (1980: 214).

Morgan makes the following general comments … which are strongly reinforced by observations made in the current paper.

"When we analyze situations as loops rather than lines we invariably arrive at a much richer picture of the system under consideration. There are many levels at which a system can be analyzed, and the choice of perspective will very much depend on the nature of the problem with which one is dealing. As noted earlier, systems always contain wholes within wholes, and one often finds that the problem with which one starts quickly becomes part of a larger problem requiring a broader focus. It is thus often necessary to supplement analysis conducted at one level (e.g of socioeconomic trends at a macro level) with a richer picture of the dynamics of a set of relations that seem particularly important (e.g., organizational and interorganizational relations among a specific set of institutions). This broadening or deepening of analysis adds to the complexity of the overall picture, but often brings benefits in that it may identify new ways of solving the problems of specific concern. For when the problem is reframed, new opportunities often come into view.

“In conducting this kind of analysis it may not always be possible to map the loops defining a system with the degree of certainty and completeness that one might desire. In complex systems the degree of differentiation is high, and there are usually numerous intervening processes shaping any given set of actions.”

In the light of comments that have been made on our own work in the 20 years since we embarked upon it, it seems worth yet again underlining three things: First, many of the feedback processes depicted in these diagrams mutually reinforce *many* of the other feedback processes shown. These multiple lines *cannot* meaningfully be omitted and reduced to single, simple, lines. There *is* no single most important cause or explanation of “the problem” - nor remedy for it. Second: One cannot change any one part of the system on its own. Either the change one introduces will be negated by the reactions of the rest of the system or it will result in entirely unanticipated and counterintuitive effects elsewhere. Third: The overall system becomes self-perpetuating, self-elaborating, in a word “autopoietic”. (The significance of autopoietic processes is discussed more fully in other articles on this website, perhaps most fully in Raven, 2009.)

# Appendix 2
## Mapping and Summing Physical Forces

It has emerged that some readers are not as familiar with the procedures involved in mapping, measuring, and summating physical forces as had been assumed. The following note has therefore been prepared with the help of Luciano Gallon, to whom heartfelt thanks are due.

The most basic illustration we can think of is predicting in which direction, and with what force, a group made up of two boys pulling on ropes attached to a goat's collar will move – see Figure 6.

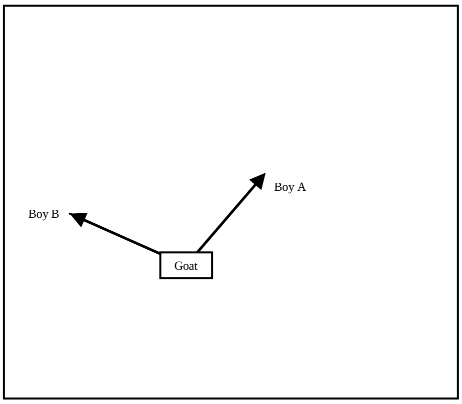



**Figure 6**
Two Boys and a Goat

To progress the analysis, both the direction and strengths the three forces can be represented as in Figure 7, where the lengths of the lines (vectors) shows how strongly each is pulling in the direction shown.

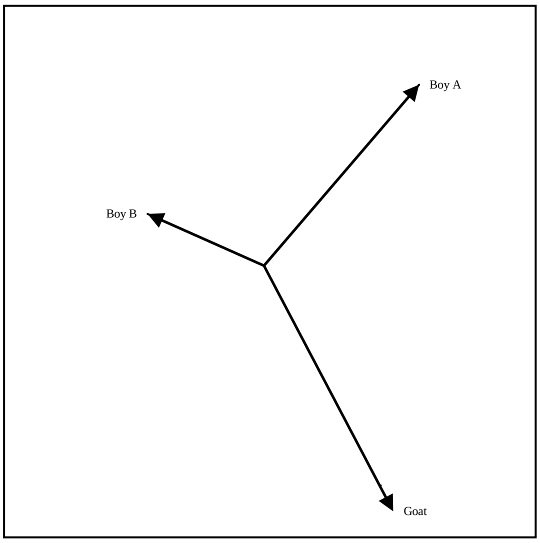



**Figure 7**
The Struggle between the Boys and the Goat Expressed in Vectors

The direction and strength of the outcome of this struggle can be calculated by dropping perpendiculars onto any two dimensions (or orthogonal axes) inserted into Figure 7 at random (Figure 8). Summing these intersects, or coordinates, (i.e. $A_x + B_x + G_x$ and $A_y + B_y + G_y$) (treating coordinates to the left of the origin on the X axis and below the origin on the Y axis as negative) gives the coordinates ($R_x$ and $R_y$) of the final vector resulting from the struggle (**R** in Figure 8). This shows the strength and direction of the outcome. (In this case, the goat wins!)

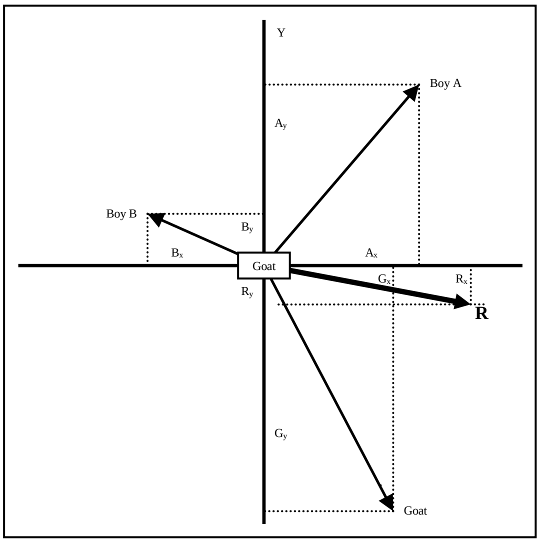


**Figure 8**
Calculating the Outcome of the Struggle with the Goat

Mapping and summating the forces acting on a sailing boat is more complicated, but the process is the same. Even an oversimplified diagram has to include the force of the wind on the sails, the resulting thrust on the mast and, via the ropes attached to the outer corner of the sail, toward the stern of the boat, the effect of the rudder, and, most importantly from the point of view of our discussion here, the force of the sea on the keel (see Figure 9).

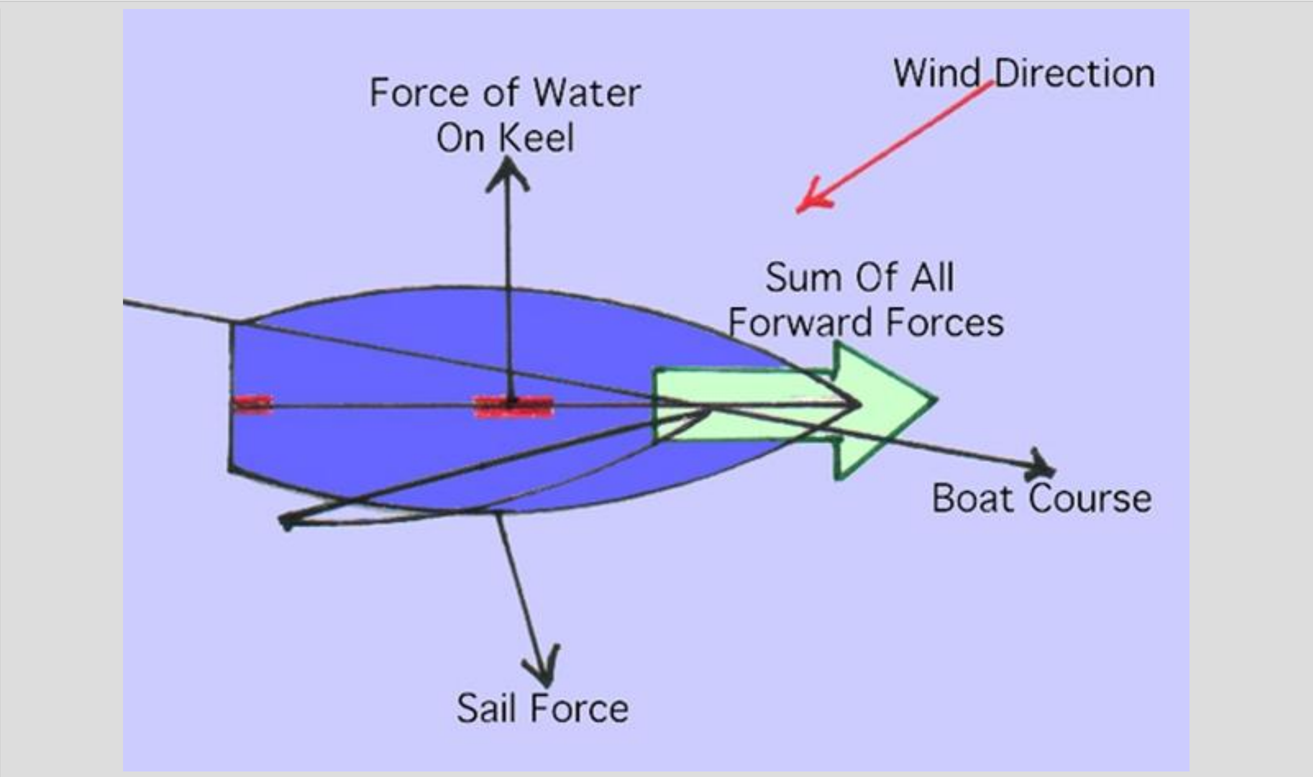



**Figure 9**
Forces Acting on a Sailing Boat

Why is the keel so important to us?

Prior to Newton, not only had the concept of "force" – so obvious to us now – not been articulated, the movement of sailing boats was to a much greater extent than later in the lap of the Gods. Boats could only sail *with* the wind. If their captains wanted to reach a destination upwind, they had to hove-to and pray for a favourable wind.

The first thing Newton did was show that what he hypothesised to be a "force" in this invisible wind could be *measured*. He did this by first jumping with the wind and measuring how far he could jump and then jumping into the wind and making a similar measurement. The difference between the two gave him the strength of the wind.

(In the context of this discussion it is worth noting that a key thing Franklin did in order to substantiate the concept of "electricity" was to show that its strength could be assessed – "measured" – from the relative strengths of the electric shocks he experienced in his arms.)

Back to Newton and sailing boats.

Among other things, Newton also formulated a number of “laws of motion”.

Among these, was the law that “To every force there is an equal and opposite reaction”.

Now. Where is the equal and opposite reaction to the force of the wind on the sailing boat?

In the sea?

OK. If so, how can it be harnessed?

Answer “By adding a keel to the sailing boat”. And that is precisely what is shown in Figure 6. Harnessing the invisible force in the sea is key to getting the boat to sail *into* the wind.

It is important to note that *none* of the above is “common sense” … indeed, from the common sense perspective that preceded Newton, it is just madness … I mean, its just crazy to suggest that there is a force in the sea! The necessary developments could not have been taken unless Newton had articulated the concept of force and shown that it was measurable and behaved in predictable – law-like - ways.

Newton went on to do something else which is even closer to what we are trying to do here – namely to map the forces determining the orbits of the planets and compute their cumulative strengths.

First, he needed the concept of “gravity”. Then he had again to demonstrate that it could be measured. And then that the results were consistent. Indeed they were. Indeed they were. And very surprising: bags of coal and desert spoons if dropped from the top of a tower, reached the ground at the same time. (Actually, this last discovery had been made earlier, but we do not need to concern ourselves with this here.)

And then he had to find a way of integrating all the interacting pulls of every planet on every other.

To perform that task he had to invent calculus.

We do not have to do that.

But my thesis *is* that we *do* have to embrace an exactly parallel series of problems if we wish to develop better ways of thinking about the nature, measurement, and harnessing of social forces.

## Appendix 3
## Predicting Socio-Economic Change from Recursive Interactions between Social and Economic Indices:
## The Forrester/Club of Rome Models[4].

In the report they prepared for the Club of Rome, Forrester (1971) and Meadows et al. (1972) mapped the recursive interactions between numerous economic, resource, and environmental quality indices in a range of domains.

A simplified version of the overall model (reproduced from Forrester, 1971) is shown in Figure 10. Some of the details of what lies behind it (extracted from Meadows et al. (2008)[5]) are shown in the diagrams which follow. Meadows et al. (2008) provide links to an interactive version of the model which allows researchers to study the effects of introducing changes of their own choosing.

This material was originally introduced both to provide a comprehensible analogy to illustrate what we have been trying to do and, at the same time, to enable readers to appreciate the distinction between the social forces which cannot be measured with the tools currently available to us and those that it is currently possible to quantify. However, the material in Appendix 4, which shows the scenarios which result from changing certain parameters illustrates the huge – and often counterintuitive – benefits which would stem from studying the operation of systems *qua* systems instead of continuing to introduce what are essentially single variable interventions based on common sense and very incomplete mental maps of the interactions between variables. The latter usually entirely neglect recursive effects of the kind illustrated in our own and Morgan's diagrams.

[4] I am deeply grateful to Luciano Gallon for drawing my attention to the existence of these models and helping me to download them.
[5] A series of projections derived from inserting different assumptions into the model will be found in Appendix 4.

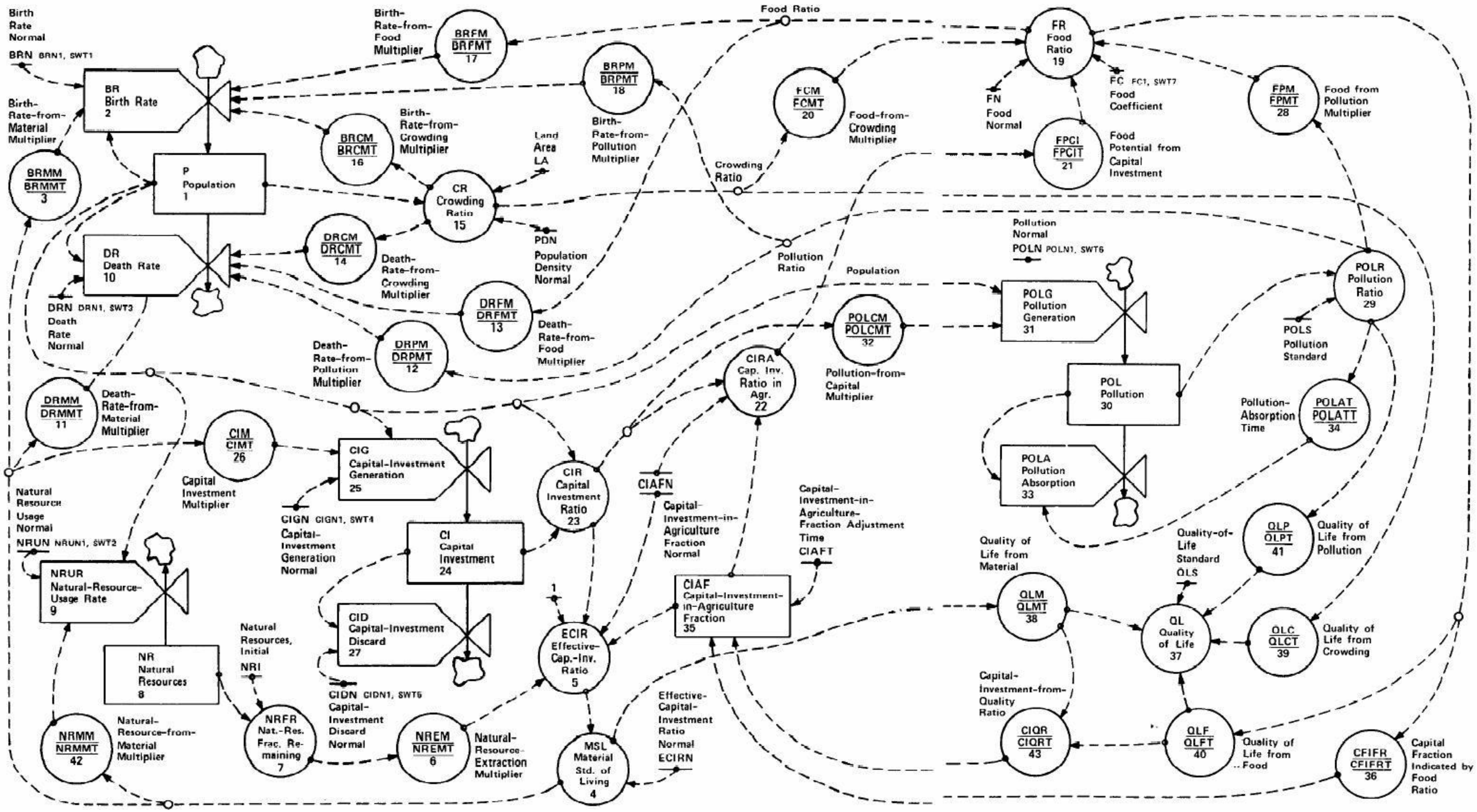
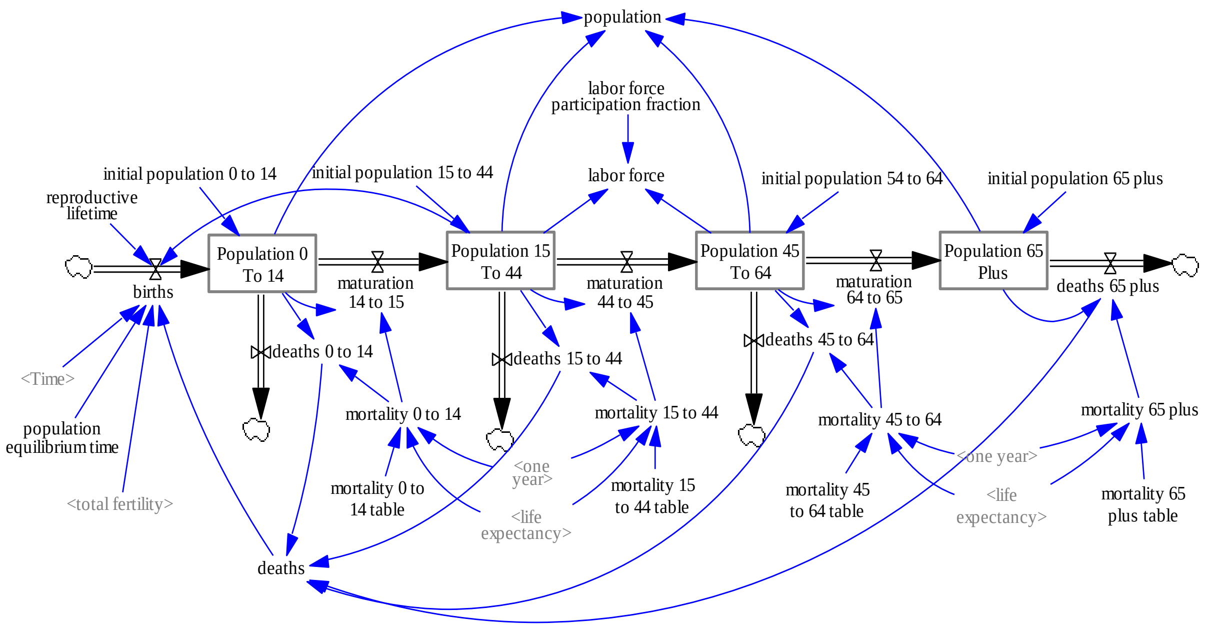



Fig. 10 Simplified World Model used to analyse the effects of changing population and economic growth over the next 50 years. The model includes interrelationships of population, capital investment, natural resources, pollution, and agriculture and background variables which influence, and are influenced, by them.

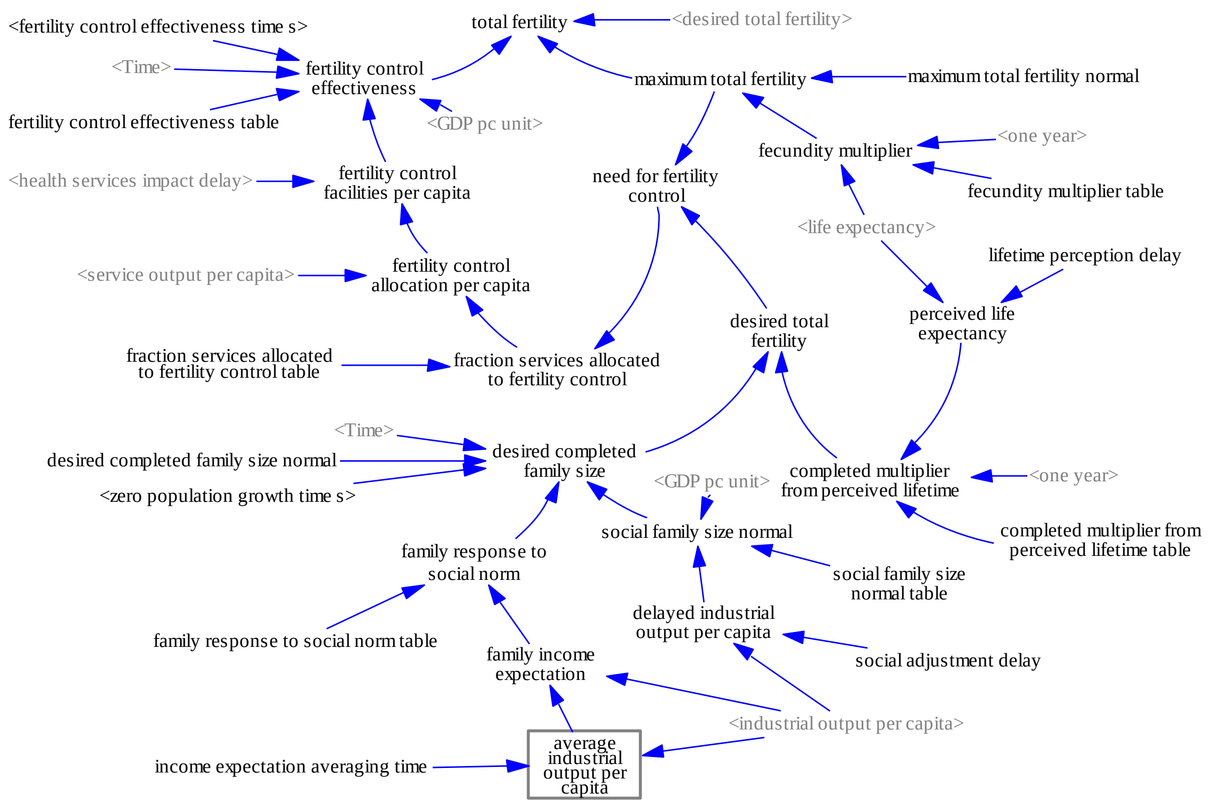
I have to confess that I am not entirely clear how weights are assigned to indicate the strength of the contributions of the components indicated in the models below as they add up in different scenarios. The *way* many of the social forces exert their effect remains unclear. The preceding variables clearly *influence* the subsequent ones. But *how* do they influence them … and how is the differential strength of their influence calculated to compare with the strength of influence of other variables? Also, although this is not the case in the Forrester model shown in Figure 10, despite the use of curved lines, the *directions* of influence seem mostly to be one-way, linear. There are very few negative, never mind self-elaborating, self-amplifying, autopoietic, loops.

It is therefore not at all clear to me that the authors have achieved even the initial, subjective, level of measurement of the strength of the wind and electricity achieved by Newton and Franklin respectively - never mind the more sophisticated measures that came later. In the end, therefore, I am not sure that they help us to understand or measure – and thus how to damp down, amplify, or harness – the patterns of influence represented in Figure 1.

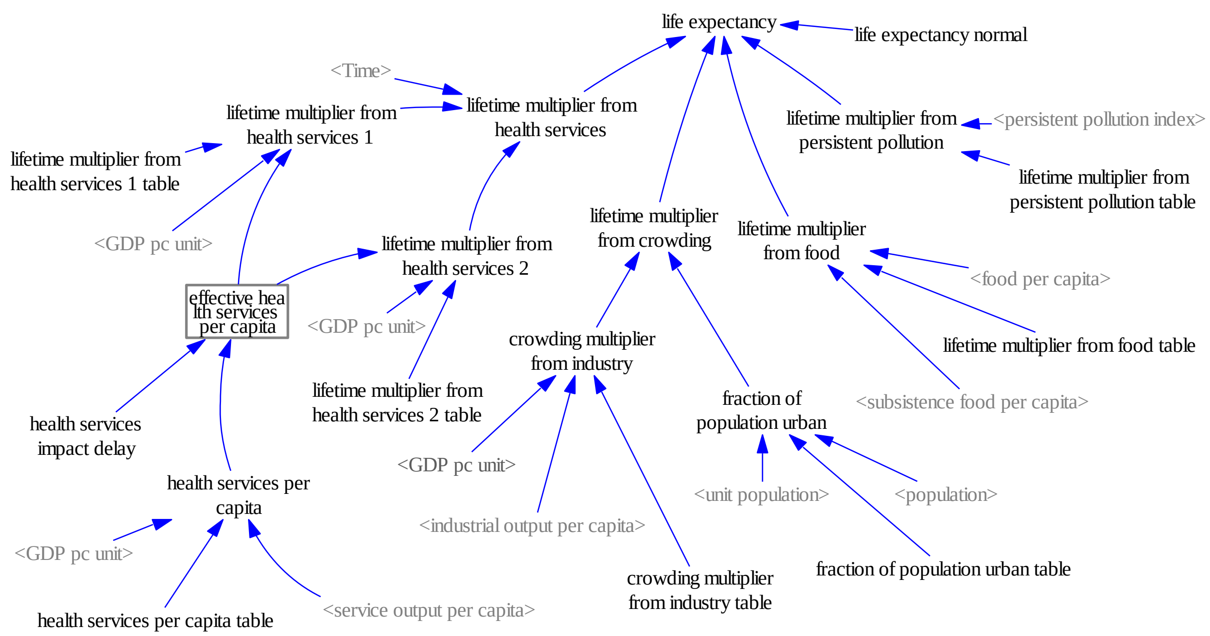
Demographics



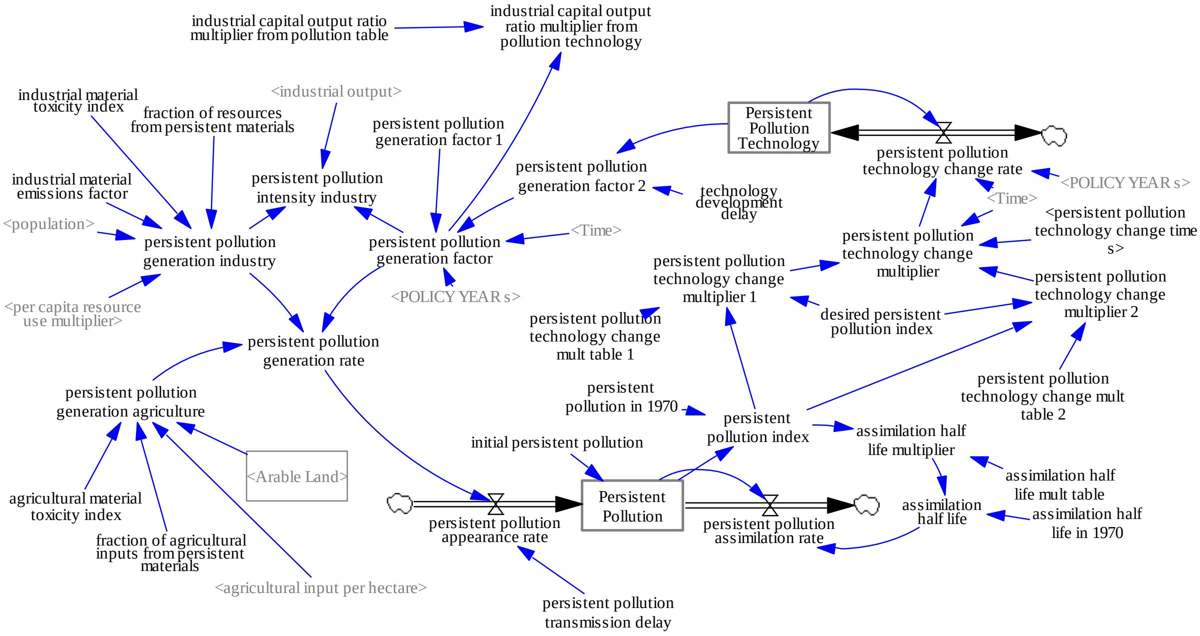
# Fertility



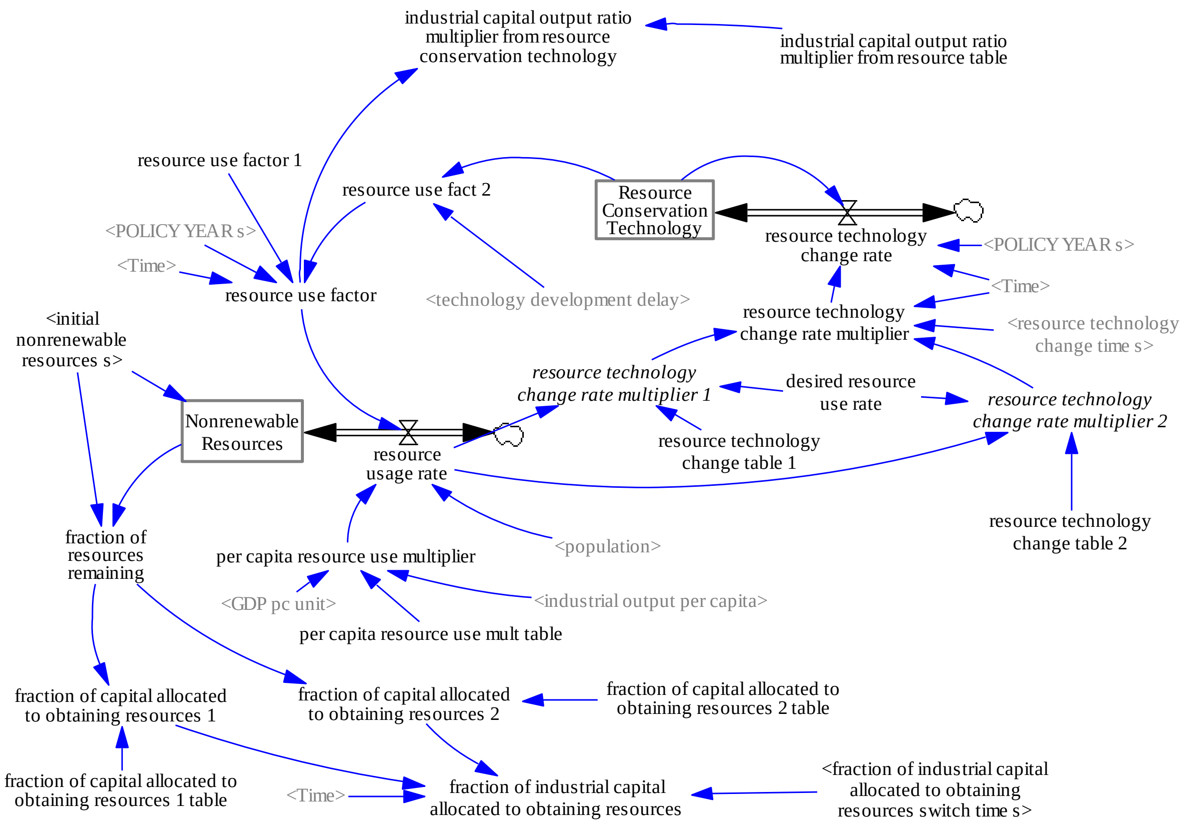

# Life Expectancy



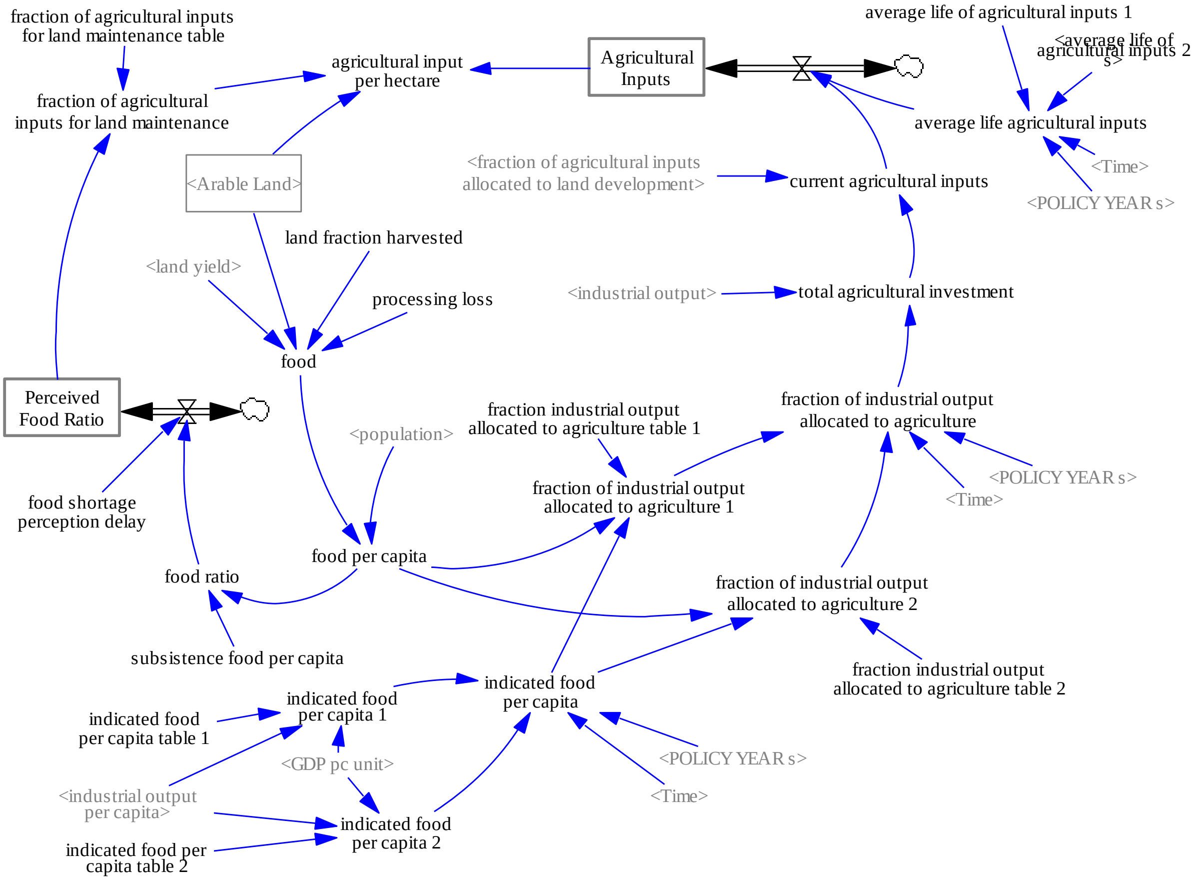
# Persistent Pollution



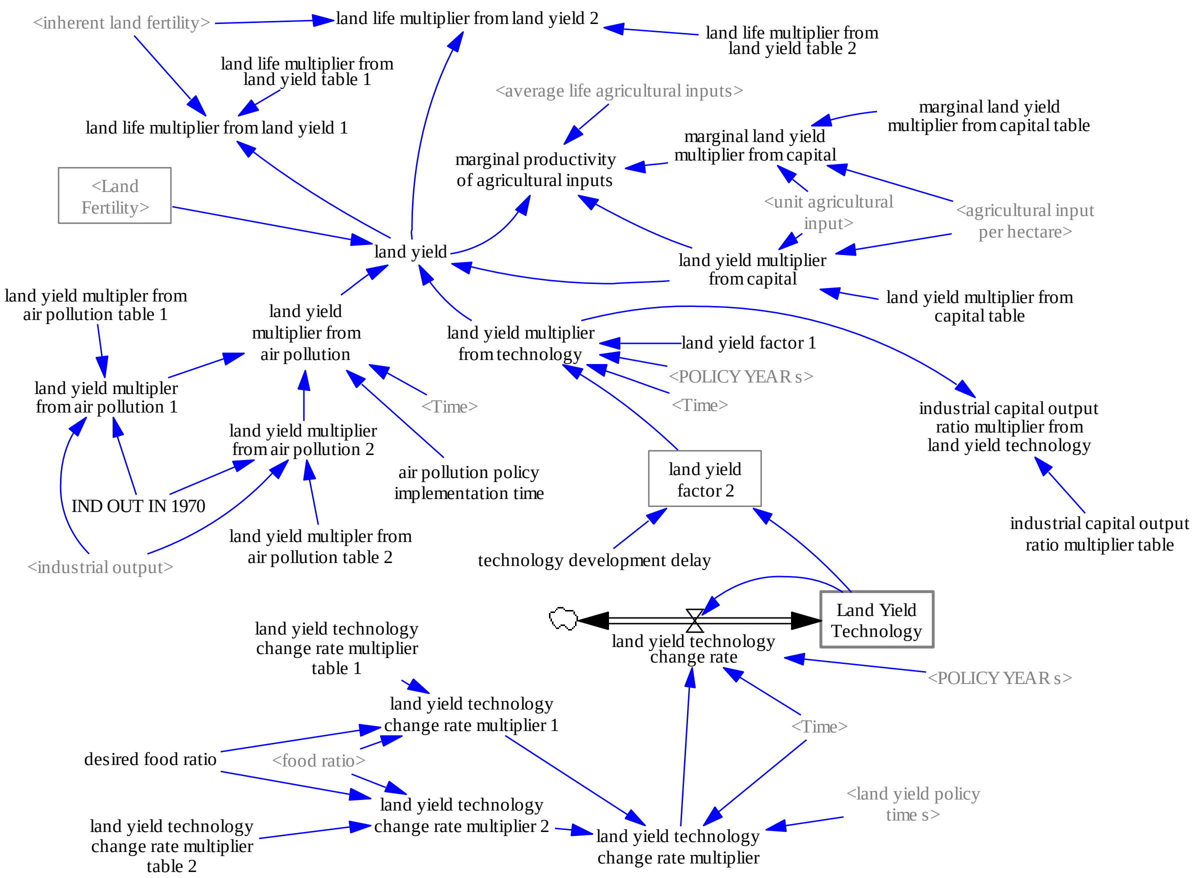

# Non Renewable Resources



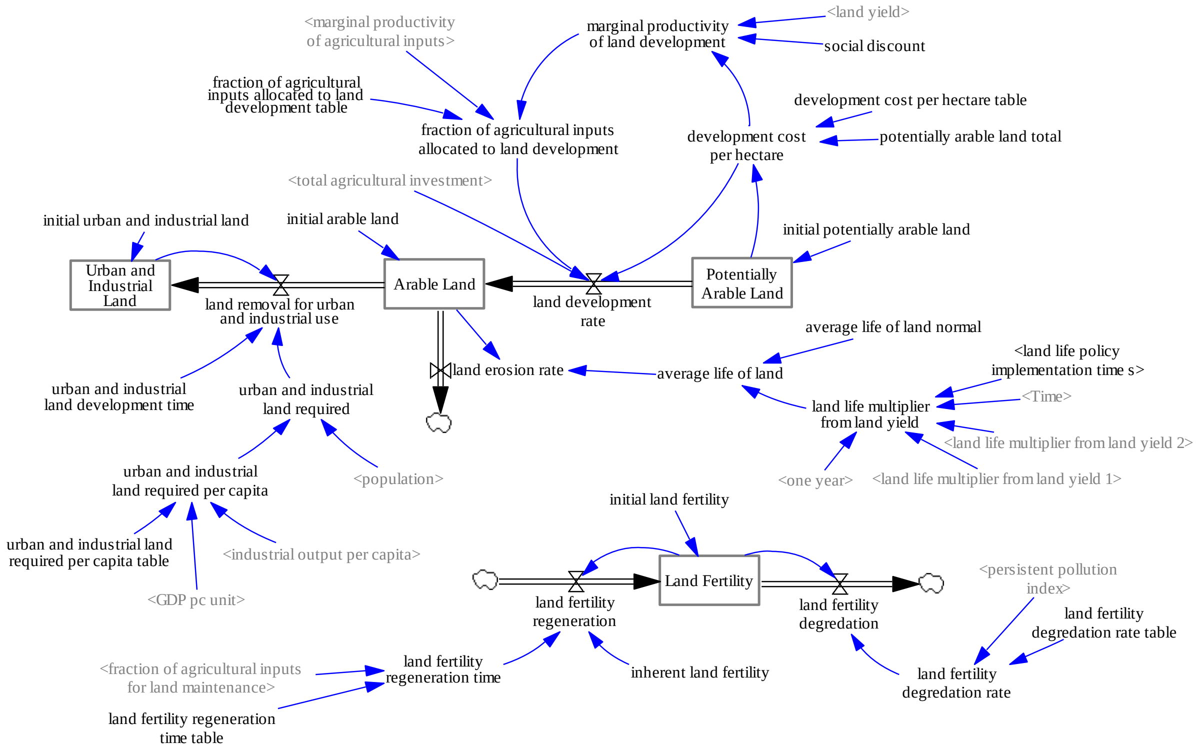
# Food Production



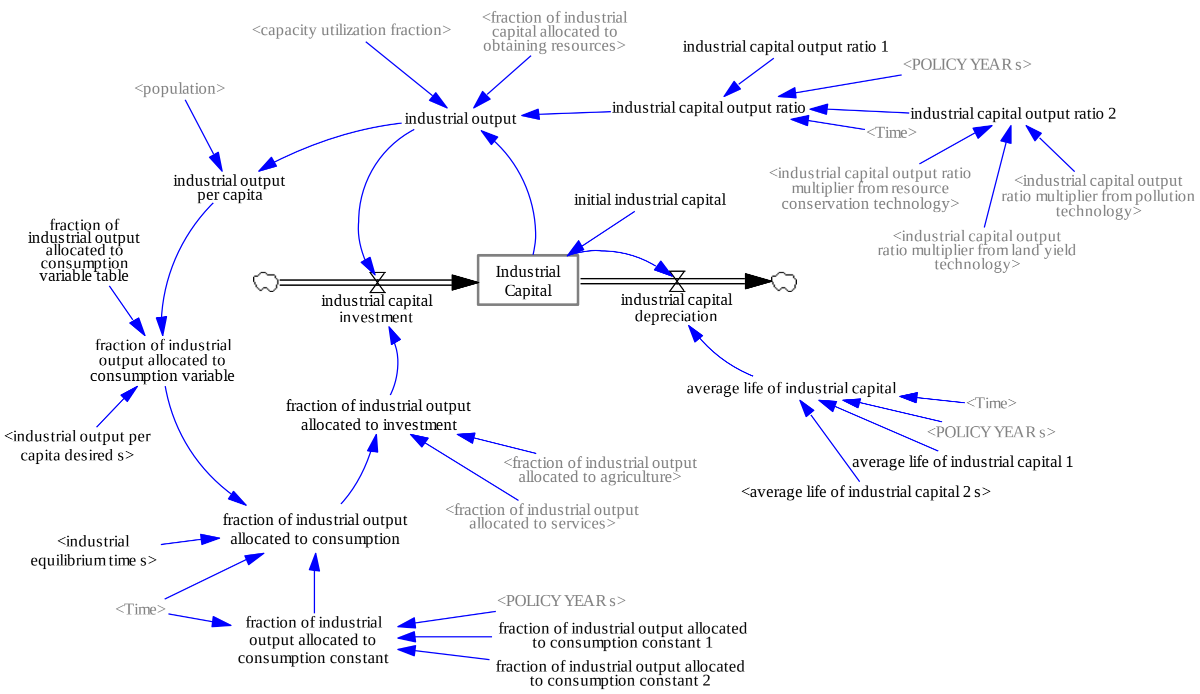
# Agricultural Production



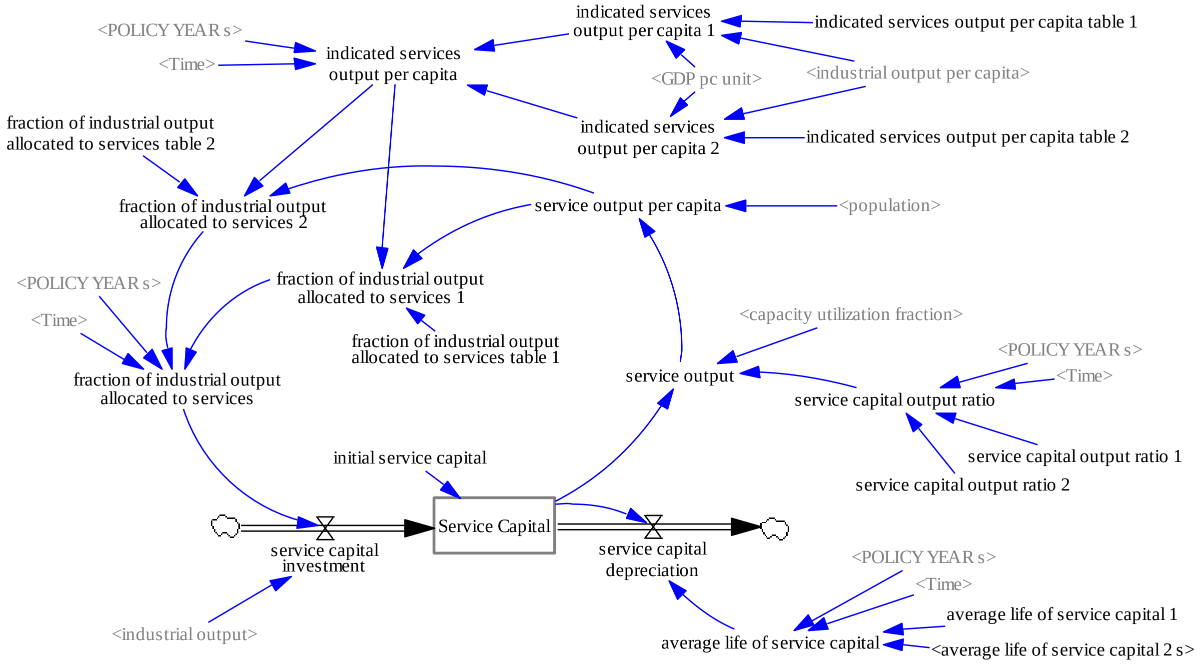
# Land Development Loss Fertility



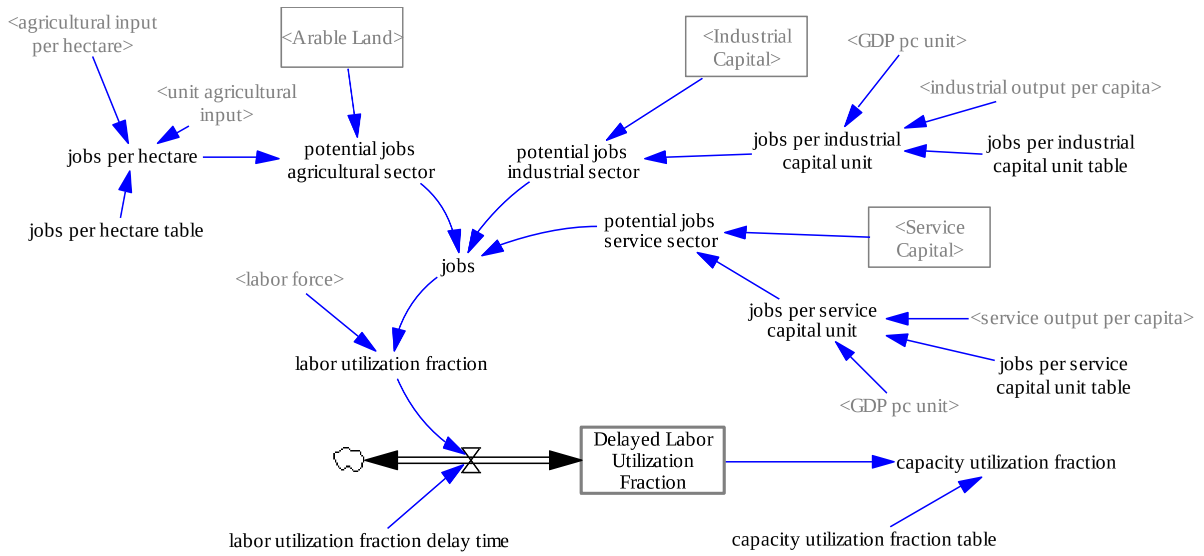

# Industrial Productivity

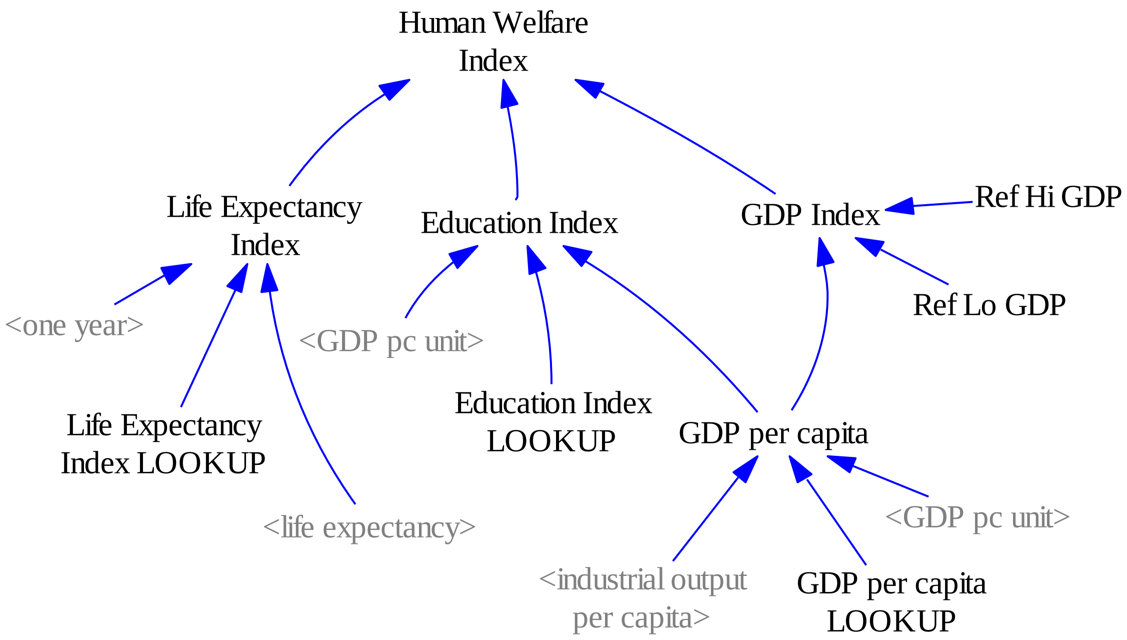


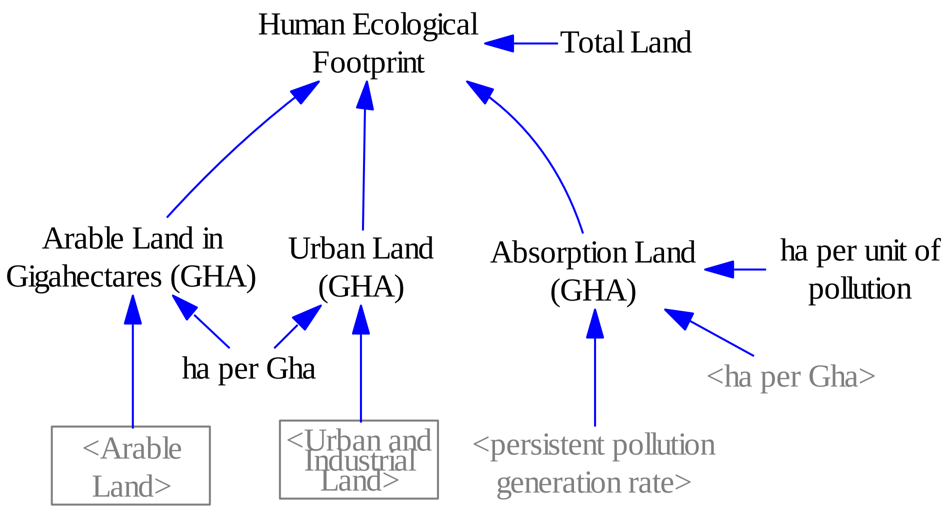
# Services Output



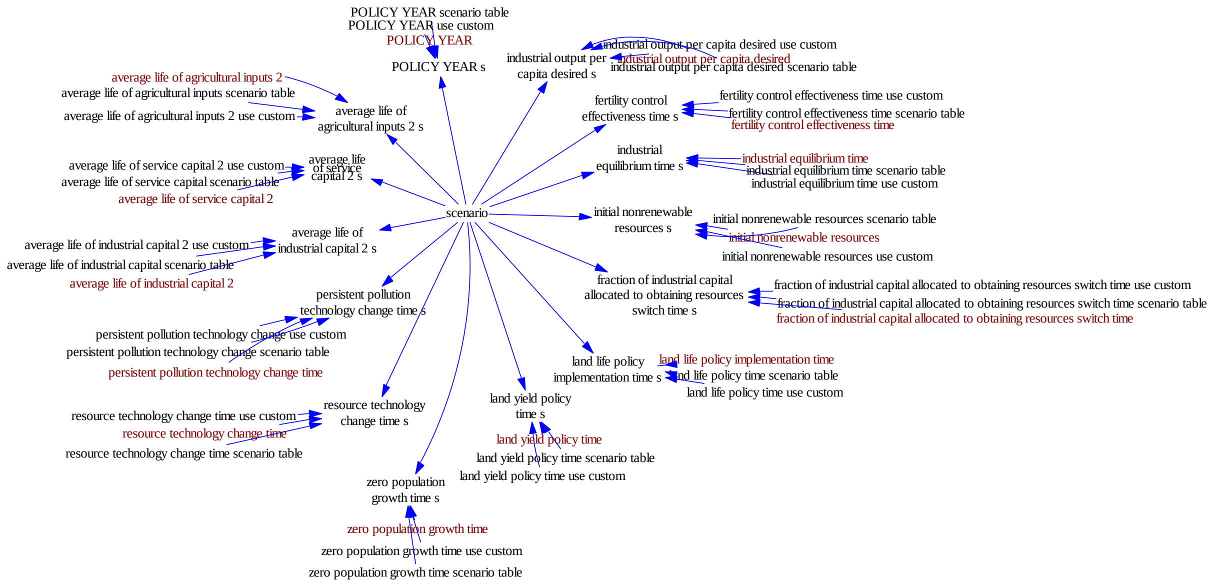

# Jobs




Human Welfare Index
Life Expectancy Index
Education Index
GDP Index
Ref Hi GDP
Ref Lo GDP
<one year>
<GDP pc unit>
Education Index LOOKUP
GDP per capita
Life Expectancy Index LOOKUP
<life expectancy>
<GDP pc unit>
<industrial output per capita>
GDP per capita LOOKUP


Human Ecological Footprint
Total Land
Arable Land in Gigahectares (GHA)
Urban Land (GHA)
Absorption Land (GHA)
ha per unit of pollution
ha per Gha
<ha per Gha>
<Arable Land>
<Urban and Industrial Land>
<persistent pollution generation rate>

# Scenario Inputs




All this structure is just a way to allows changes to the scenario number to be used to replicate each scenario. When the scenario number is 0 (or ... use custom is 1) the ...s values used match exactly the input constant (shown in magenta).

## Appendix 4
## Some illustrations of the Counter-Intuitive Effects of Common-Sense-Based Interventions

Derived from: NonRPMarticles: Excerpts from Forrester HEADINGS.doc

As we have seen, Forrester (1971) developed a systems model somewhat akin to those developed by Morgan to document the mutual and recursive feedback loops between population, capital investment, natural resources, pollution and agriculture. Plus many background variables, such as birth and death rates, which contribute to and are affected by them in a recursive manner.

The big difference is that the strengths of the effects are quantified and its major limitation – and it is a very serious one – is that it does not deal with the kinds of *social* forces depicted in our Education diagram and Morgan's diagrams.

A more elaborate form of this model was the one used in Meadows' (1972) submission (entitled *The Limits to Growth)* to the *Club of Rome's Project on the Predicament of Mankind.*

Unlike the normal, and incomplete, mental maps we all carry around in our heads, and are used as a basis for most government planning, not only are many more of the mutual and recursive effects shown, each assumption is explicit and can be subjected to scrutiny and modification.

The assumptions built into the models are derived from common discussions and assertions about the world system.

The main difference from the Morgan/Raven models discussed earlier is that these inputs and outcomes can be quantified using the economic and production methods currently available.

Forrester gives several striking examples of the, generally counterintuitive, effects of changing some of the assumptions fed into the model. Many of these are similar to the 10 scenarios presented in Meadows et al. (2004), which were themselves derived from experimentation with what became an interactive version downloadable from Meadows et al. (2008). This can be used to discover, in real time, what would happen if one were to intervene in any way – or combination of ways – one may choose.

Many of the results of such experiments are dramatic and frightening.

In this way they illustrate the vital importance of studying systems *qua* systems and, in particular, of finding ways of conceptualising and measuring social forces of the kind depicted in our own or Morgan's diagrams.

*****

Figure 2 in this Appendix (which would have been Figure 11 if all Figures in the text had been numbered consecutively) shows the trends that would occur in the six main outcomes if things are left pretty much as they are so that industrialization is eventually suppressed by falling natural resources.

It starts with estimates of conditions in 1900.

On the basis of the assumptions fed into the model, quality of life peaked in the 1950s and by 2020 will have fallen far enough to halt further rise in population. Declining resources, and the consequent fall in capital investment, exert further pressure which gradually reduces world population.

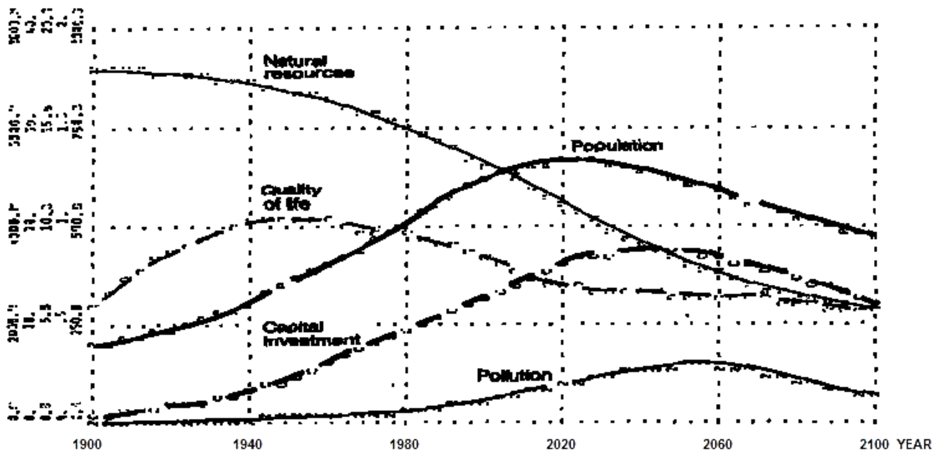



**Fig. 2. Basic world model behavior showing the mode in which industrialization and population are suppressed by falling natural resources.**

Forrester comments that we may not be fortunate enough to gradually run out of natural resources in this way.

Science and technology may find ways to use more plentiful metals and alternative ways of generating energy so that resource depletion does not intervene.

But, if this happens, it only leaves the way open for another growth-resisting pressure to arise.

Figure 3 shows what happens if the resource shortage is avoided.

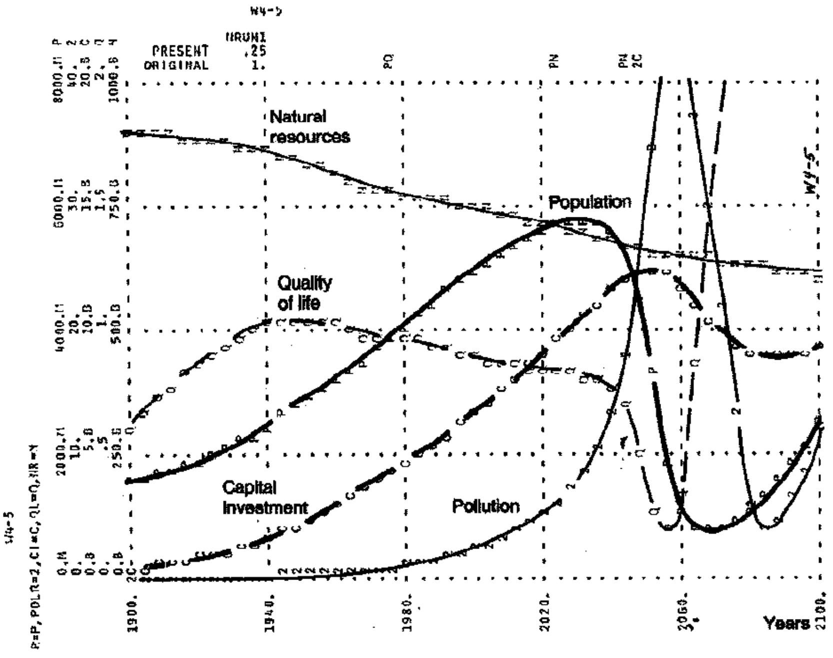



Fig. 3. A pollution crisis is precipitated by lower usage of natural resources. In 1970, natural resource usage is reduced 75 per cent by more effective technology without affecting material standard of living.

Here the only change from the assumptions fed into Figure 2 concern the rate of usage of natural resources. In Figure 3, resources are, after 1970, consumed at a rate 75 per cent less than assumed in Figure 2.

In this way the standard of living is sustained with less drain on the expendable and irreplaceable resources.

*The outcome is even less attractive than it would have been if things had been left alone!*

By not running out of resources, population and capital investment are able to rise until a pollution crisis is created. Pollution then acts directly to reduce birth rate, increase death rate, and depress food production. In this case, population, which peaks in 2030, declines by 83% within 20 years. Forrester notes that this would be a disaster of unprecedented proportions.

Generalising: What we have here is a dramatic illustration of the everyday experience that common-sense based interventions aimed at fixing one problem within a poorly understood system create unexpected problems somewhere else in the system.

*****

Let us now ask what would happen if one set out to sustain quality-of-life – which, according to this model, begins to decline from 1950.

One option might be to increase the rate of industrialization by raising the rate of capital investment.

Figure 4 shows what happens if the “normal” rate of capital accumulation is increased by 20 per cent in 1970.

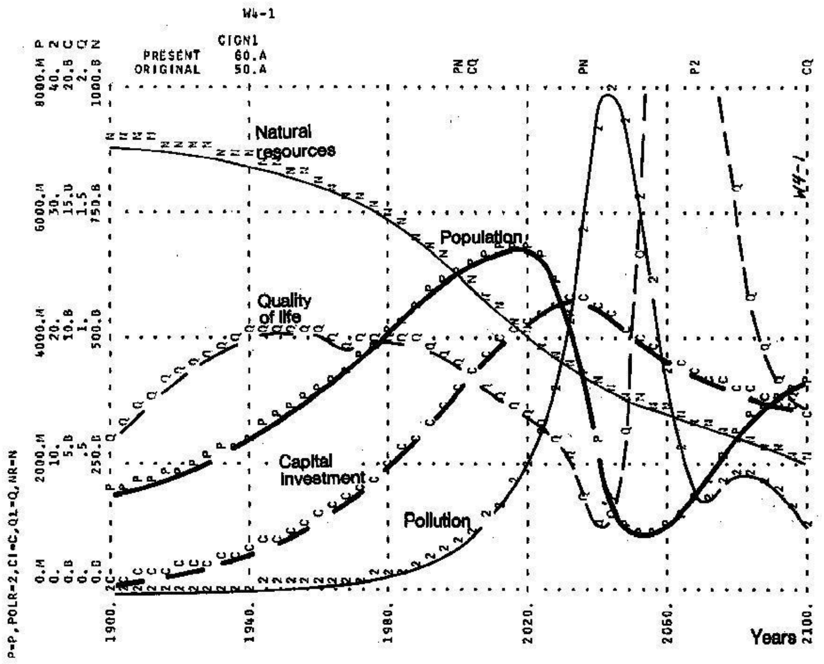



Fig. 4. In 1970, the rate of capital accumulation is increased 20 per cent in an effort to reverse the decline in quality of life. The pollution crisis occurs before natural resources are depleted.

Again, a pollution crisis appears.

This time the cause is not more efficient use of natural resources but an upsurge of industrialization that overtaxes the environment before resource depletion has a chance to depress industrialization.

Again, an “obviously desirable” policy has caused troubles worse than these that the policies were originally introduced to correct.

Figure 5 retains the 20 per cent additional capital investment rate after 1970 from Figure 4 and in addition explores the effects of birth rate reduction in the hope of avoiding crisis.

Here the normal birth rate has been cut in half in 1970.

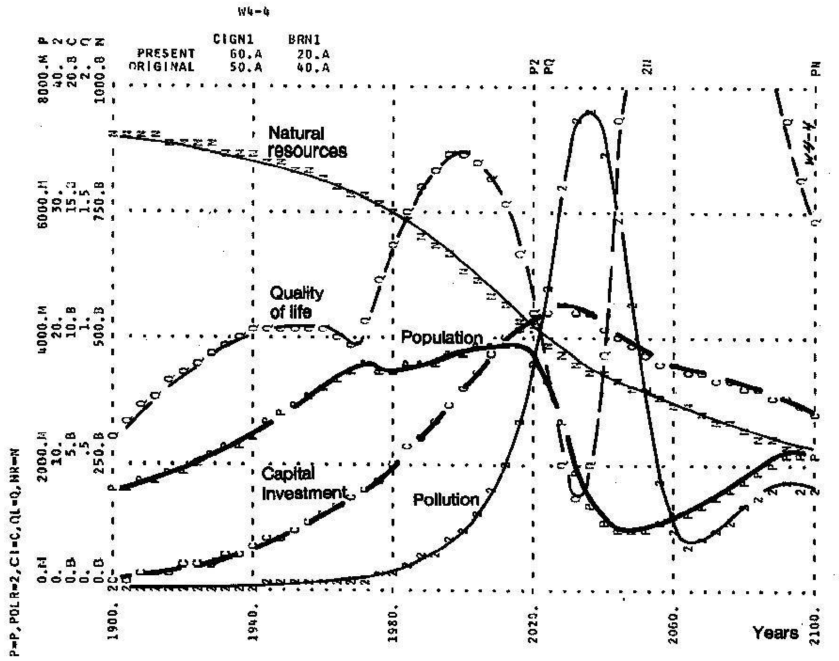



Fig. 5. In 1970 the 20 per cent increase in capital accumulation of Figure 4 is retained and "normal" birth rate is reduced 50 per cent. Capital investment continues to grow until a pollution crisis develops. After an initial decline, population is again pushed up by the rapid rise in quality of life that precedes the collapse.

What then happens is that Quality-of-Life surges upward for 30 years for the reasons that are customarily expected.

Although not shown in the figure, food-per-capita grows, material standard of living rises, and crowding does not become as great.

But the more affluent continue to use natural resources and to accumulate capital plant at about the same rate as in Figure 4.

In other words, the 50 per cent reduction in normal birth rate in 1970 was indeed sufficient to start a decline in total population.

But the rising quality-of-life and the decline in the pressures act start the population curve upward again so that the end result is much the same.

Load on the environment is more closely related to industrialization than to population, so the pollution crisis occurs at about the same time as in Figure 4.

In other words, the 50 per cent reduction in normal birth rate in 1970 was indeed sufficient to start a decline in total population.

But the rising quality of life and reduction in pressures start the population curve upward again.

The bottom line is that the end result is much the same.

Figure 6 combines the reduced resource usage rate and increased capital investment rate of Figures 3 and 4.

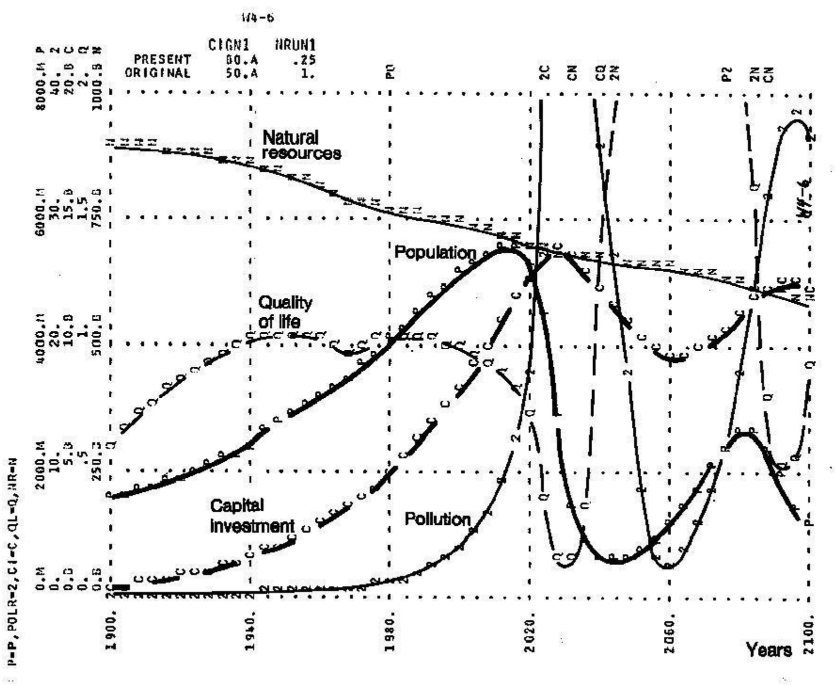



Fig. 6. The 20 per cent increase of capital investment from Figure 4 and the 75 per cent reduction of natural resource usage from Figure 3 are combined.

The result is that population collapse occurs slightly sooner and more severely.

Figure 7 shows what happens if technology finds ways to reduce the pollution generated by industrialization by 50 per cent from that shown in Figure 6.

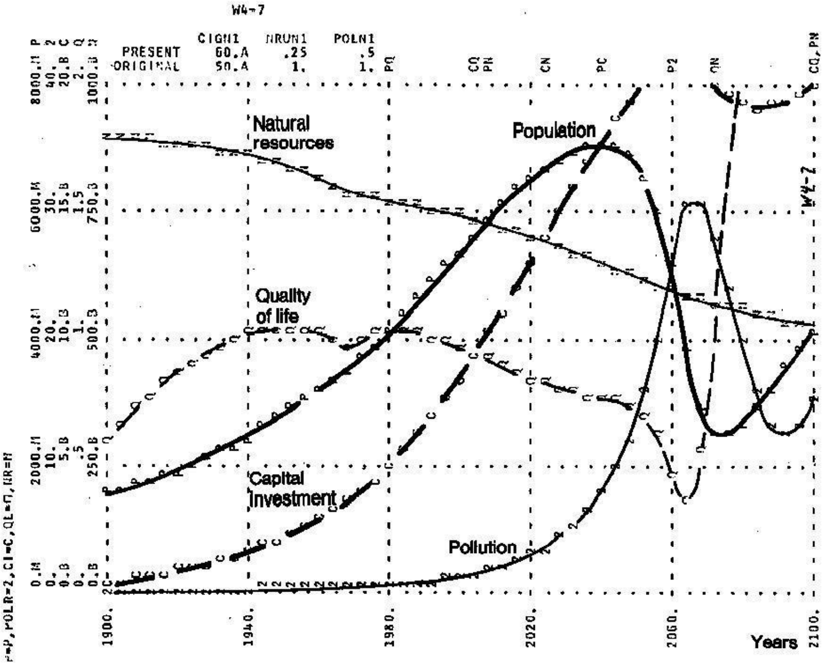



Fig. 7. Increased capital investment rate and reduced natural resource usage from Figure 6 are retained. In addition in 1970 the normal rate of pollution generation is reduced 50 per cent. The effect of pollution control is to allow population to grow 25 per cent further and to delay the pollution crisis by 20 years.

Pollution rate, other things being the same, is reduced by 50 per cent from that shown in Figure 6.

The result is to postpone the day of reckoning by 20 years and to allow population to rise by another 25% before it collapses.

Thus the “solution” “reducing pollution” has, in effect, caused more people to suffer the eventual consequences.

In this way, Figure 7 again reveals the dangers of partial, “common-sense” based solutions. Actions at one point in a system to relieve one kind of distress produce unexpected results in some other part of the system.

If the interactions are not sufficiently understood, the consequences can be as bad as, or worse, than those that led to the initial action.

More optimistic scenarios are also available, if requiring more disciplined and concerted public action.

Figure 8 shows how the world system reacts if several policy changes are adopted simultaneously in the year 1970.

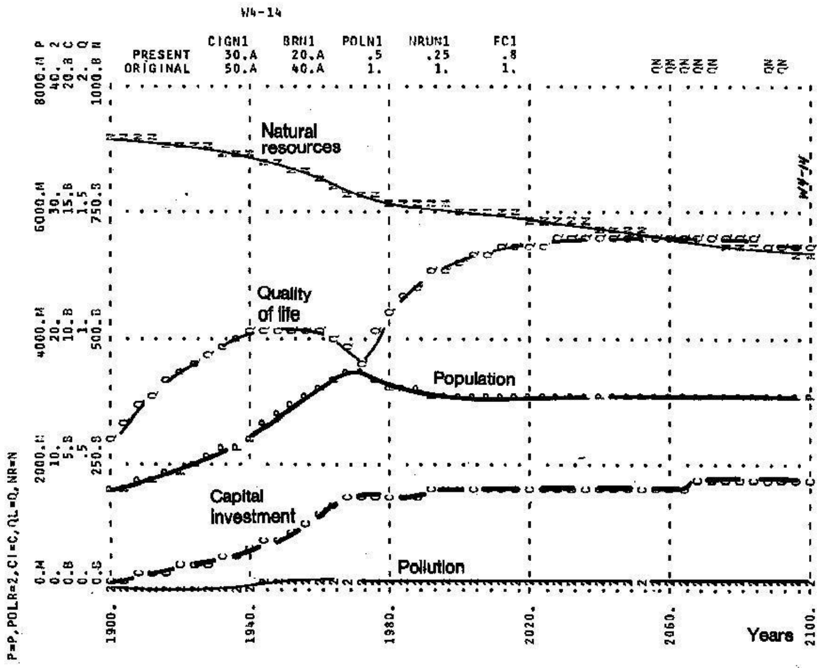



Fig. 8. One set of conditions that establishes a world equilibrium at a high quality of life. In 1970 normal capital investment rate is reduced 40 per cent, normal birth rate is reduced 50 per cent, normal pollution generation is reduced 50 per cent, normal natural resource usage rate is reduced 75 per cent, and normal food production reduced 20 per cent.

Population is stabilized.

Quality-of-life rises about 50%.

Pollution remains at about the 1970 level.

But would such a world be accepted?

It implies an end to population and economic growth.

The rate of capital accumulation has been reduced to 40% below its previous value.

The birth rate has been reduced to 50% of its earlier value.

The rate of pollution generation has been reduced to 50% of its value before 1970.

The rate of food production has been lowered 20% from its previous value.

Reducing the investment rate and emphasis on agriculture are counterintuitive and unlikely to be accepted without extensive system studies and years of argument – perhaps more years than are available.

It may be easier for people to understand and take the steps necessary to reduce pollution and consumption of natural resources.

Among the changes experimentally introduced in Figure 8, achieving a dramatic reduction in worldwide birth rate would be the most improbable.

Even if technical and biological methods become available to help reduce birth rates, the improved condition of the world as a whole that would arise from the changes envisaged in Figure 8 might remove the incentive to sustain the lower birth weight.

## References


Forrester, J. W. (1971/1995). *Counterintuitive Behavior of Social Systems***.** Original text appeared in the January, 1971, issue of the *Technology Review*, The Alumni Association of the Massachusetts Institute of Technology. All figures are taken from *World Dynamics* by Jay W. Forrester, Pegasus Communications, Waltham MA. http://sysdyn.clexchange.org/sdep/Roadmaps/RM1/D-4468-2.pdf

Forrester, J. W. (1971/73). *World Dynamics*. Waltham, MA: Pegasus Communications. (Second edition has an added chapter on physical vs. social limits.)

Kanter, R. M. (1985) *The Change Masters: Corporate Entrepreneurs at Work*. Hemel Hempstead: Unwin Paperbacks.

Meadows, D. H. (2009). *Thinking in Systems: A Primer*. London: Earthscan.

Meadows, D. H., Meadows, D., & Behrens, W. W. (1972). *The Limits to growth: A Report for the Club of Rome's Project on the Predicament of Mankind*. London: Macmillan.

Meadows, D. H., Meadows, D. L., & Randers, J. (2004). *The Limits to Growth: The 30-Year Update.* London: Earthscan.

Meadows, D. H., Meadows, D. L., & Randers, J. (2008). www.Vensim\models\sample\WRLD3-O03\World3_03_Scenarios.wmfView

Morgan, G. (1986). *Images of Organization*. Beverly Hills, CA: Sage.

Raven, J. (1994). *Managing Education for Effective Schooling: The Most Important Problem Is to Come to Terms with Values*. Unionville, New York: Trillium Press. www.rfwp.com (also available from the author at 30, Great King Street, Edinburgh EH3 6QH.)

Raven, J., & Navrotsky, V. (2001). The development and use of maps of socio-cybernetic systems to improve educational and social policy. *Journal of Mental Changes*, *7(1-2),* 19-60. http://eyeonsociety.co.uk/resources/ravnav3.pdf or, better, http://www.eoswiki.co.uk/wiki/index.php/The_Development_and_Use_of_Maps_of_Socio-Cybernetic_Systems_to_Improve_Educational_and_Social_Policy%2C_with_particular_reference_to_sustainability

Raven, J. (2009). The emergence of hierarchy, domination and centralisation: Reflections on the work of Murray Bookchin. *Journal for Perspectives of Economic, Political, and Social Integration, 14(1-2),* 11-75. Also available at: http://www.eyeonsociety.co.uk/resources/Bookchin.pdf