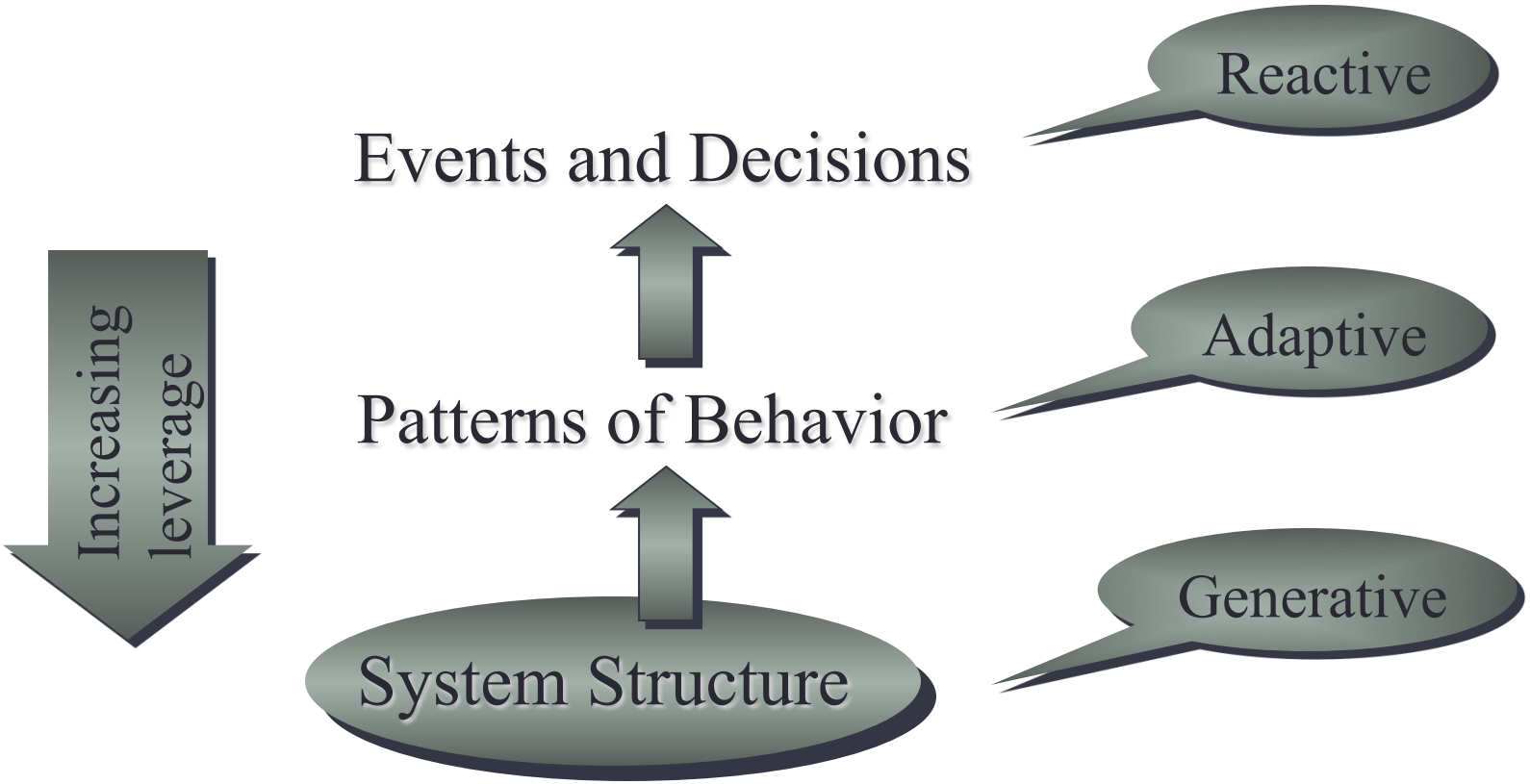
SYSTEMS MAPPING

The Systems Perspective



Adapted from G. Richardson, U of Albany

The majority of information exists in mental models

Forrester 1991

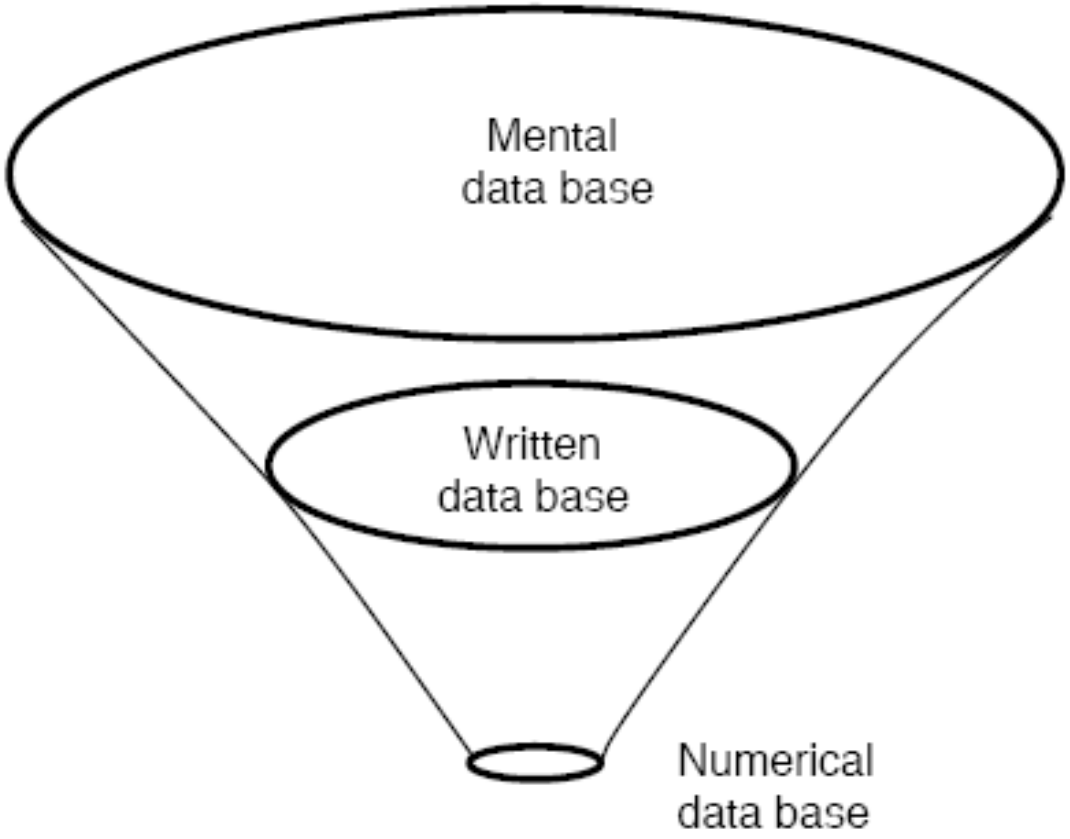


Figure 4. Decreasing information content in moving from mental to written to numerical data bases.

Limits to Growth (Meadows et al 1972)

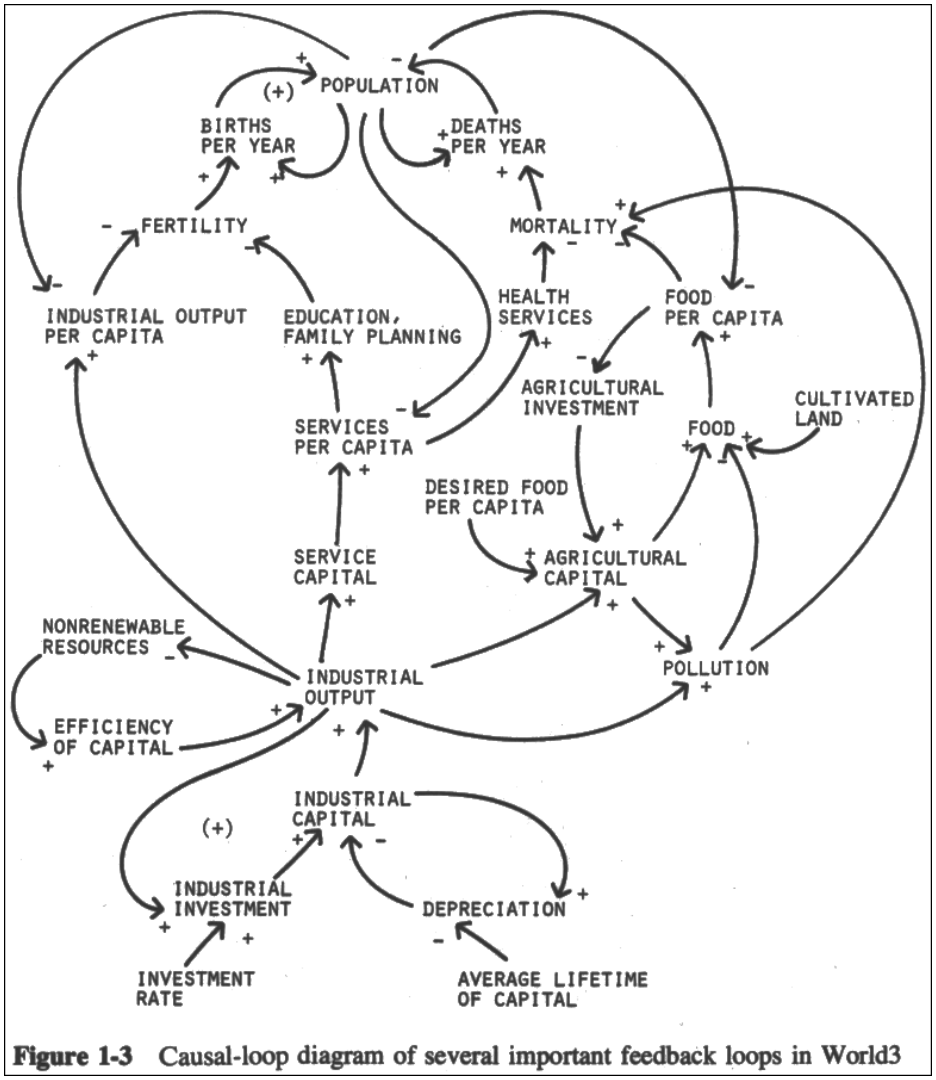
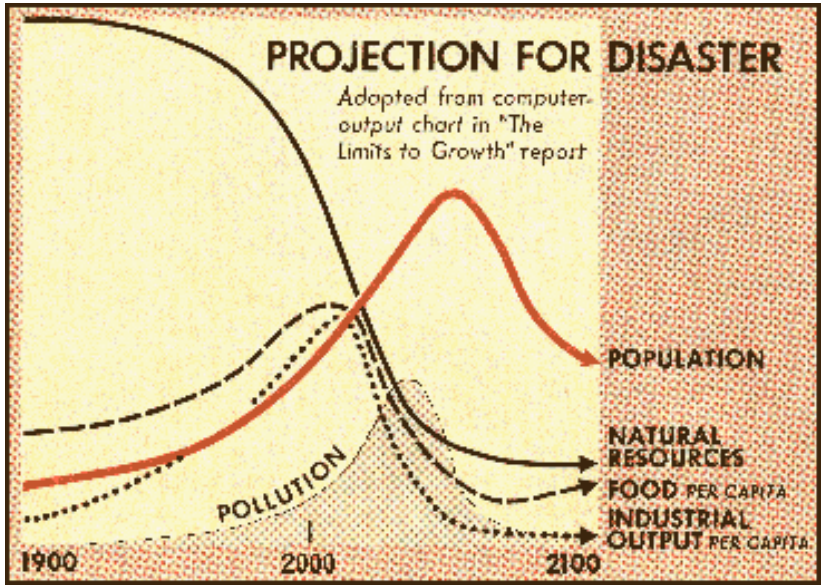


Figure 1-3 Causal-loop diagram of several important feedback loops in World3



Collaborative Systems Modeling

Policy Sci (2009) 42:211–225
DOI 10.1007/s11077-009-9080-8

A fresh look at a policy sciences methodology: collaborative modeling for more effective policy

Kristan Cockerill · Lacy Daniel · Leonard Malczynski · Vincent Tidwell

Collaborative SD modeling
Cockerill et al (2009)

- **Include experts, public and/or stakeholders in model development and governance or policy choices considered**
  - Consensus or **dialogue tool**
  - Enable structured dialogue among participants
  - Integrate scientific information, local knowledge, and values into the policy process
  - Develop a deeper level of understanding of system among participants
  - Increase agreement about root problems
  - Gain appreciation for uncertainty inherent in data and methods in studying complex systems
  - Personal Transformation “seeing problems and possible solutions in a new way”

A systems perspective

Focuses on patterns of behavior (not just specific events)

Focuses on policy structure (not just discrete decisions)

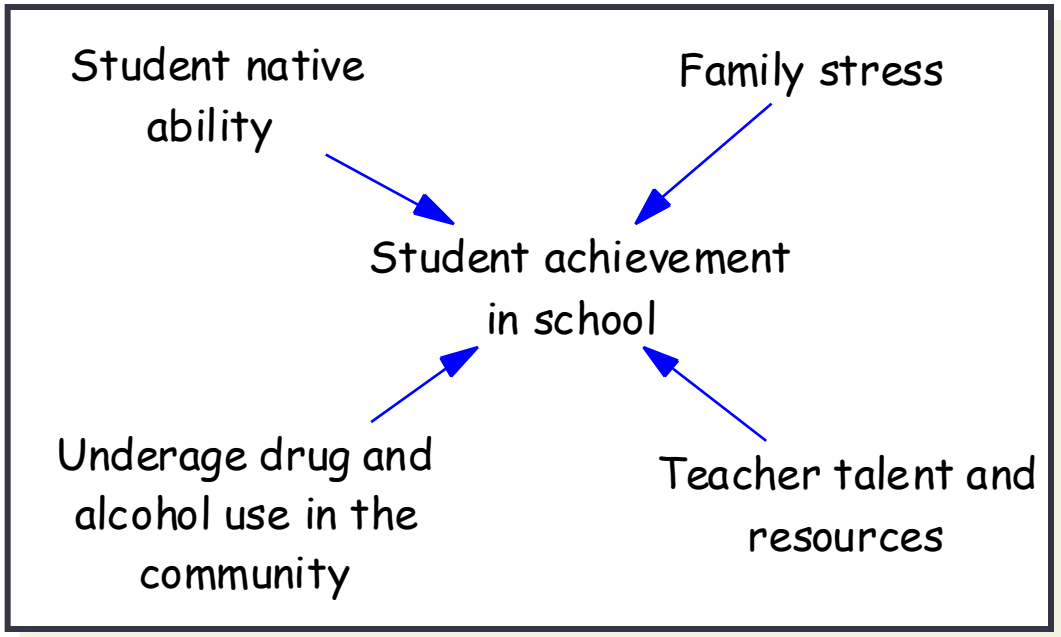
- Causal structure: "feedback" loops
- Delays
- Perceptions (a kind of accumulation)
- Pressures
- Affects, emotions, (ir)rationalities
- Stocks or Accumulations (populations, resources…)

- **Allows for the integration of natural and social world variables**

Causal Diagrams

"Ceteris paribus"...
All other influences held constant as we assign polarities.

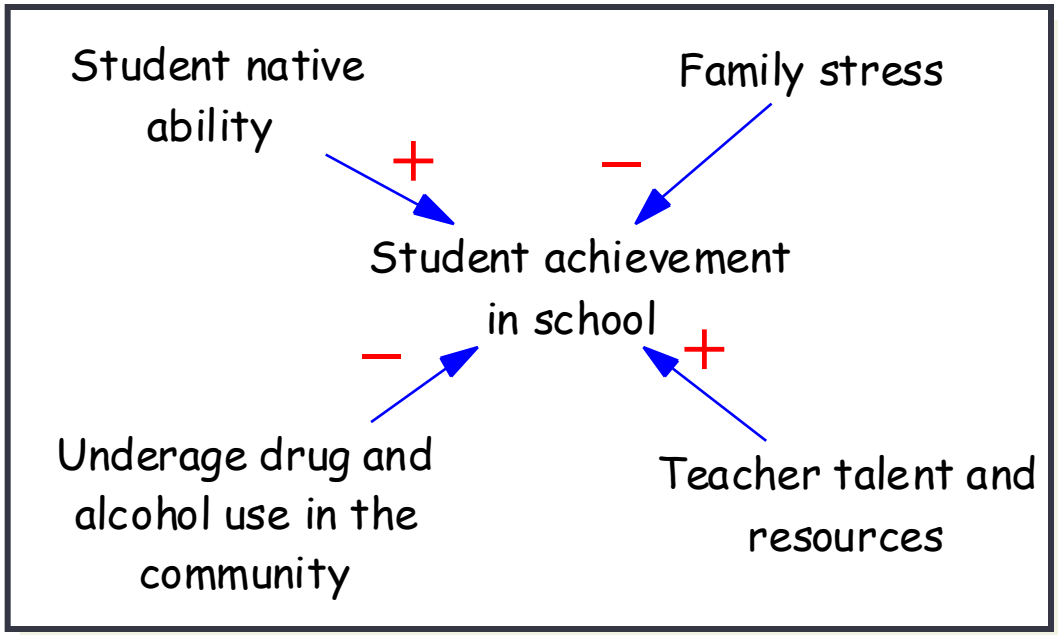
- Causal mapping is a powerful tool for representing structure in complex systems.
- Arrows indicate *causal* influence.



Polarities of Causal Links

- Positive and negative signs show the direction of causality:

  + = “direct” relation
  – = “inverse” relation



Definitions of Link Polarities

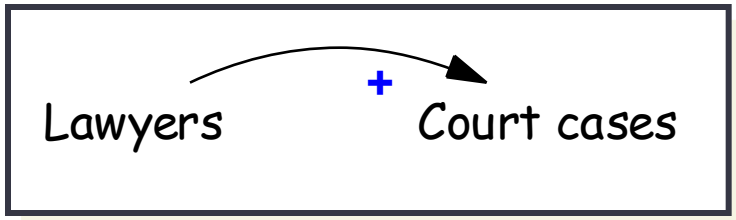
ΔA leads to ΔB in the *same* direction

ΔC leads to ΔD in the *opposite* direction

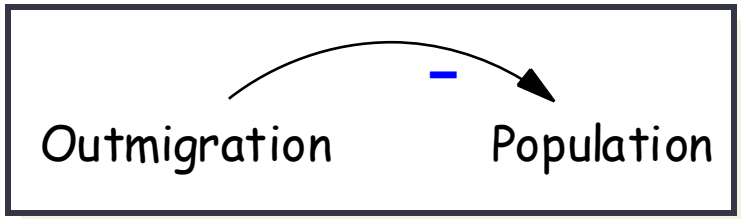
All words phrases are expressed as *quantities* that have a clear sense of increase or decrease.

No verbs — the action is in the causal arrows.

Examples



More lawyers mean ***more*** litigation; fewer lawyers, less litigation

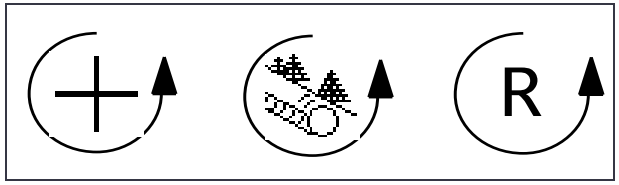


Emigration ***subtracts*** from population: An increase in emigration means less (a decrease means more) than we'd have without the change

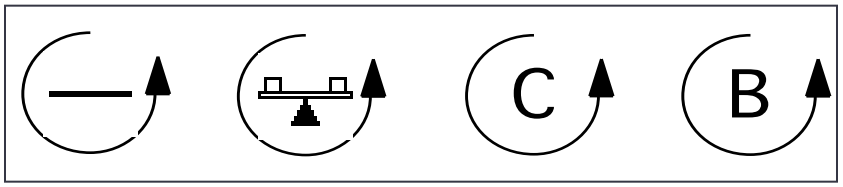
"Ceteris paribus"...
All other influences held constant as we assign polarities.

Two kinds of feedback loops

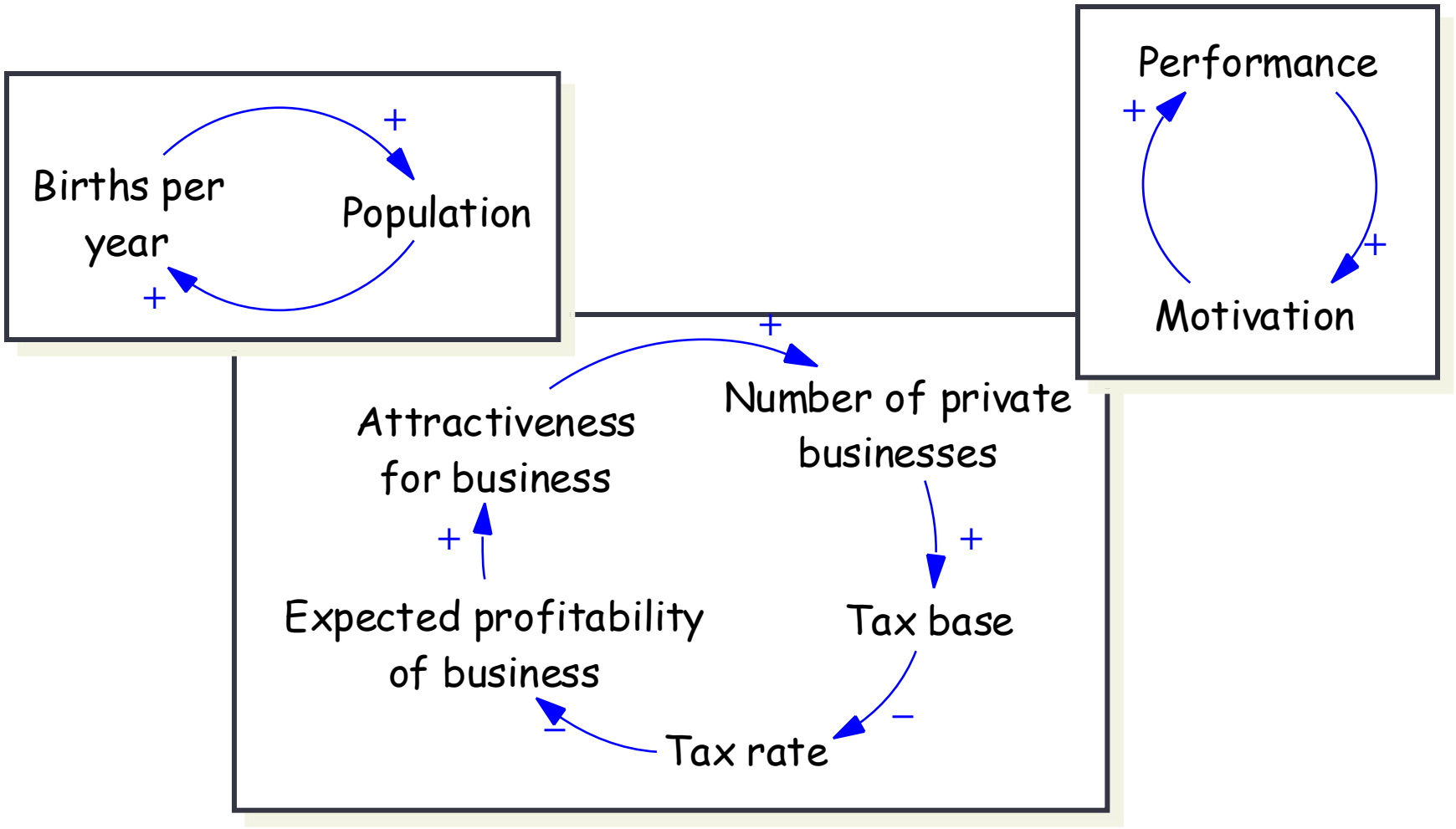
- **Reinforcing loops**
  - growth producing
  - destabilizing
  - accelerating
  - even number of –'s
  - "positive" loops
- **Symbolized by**



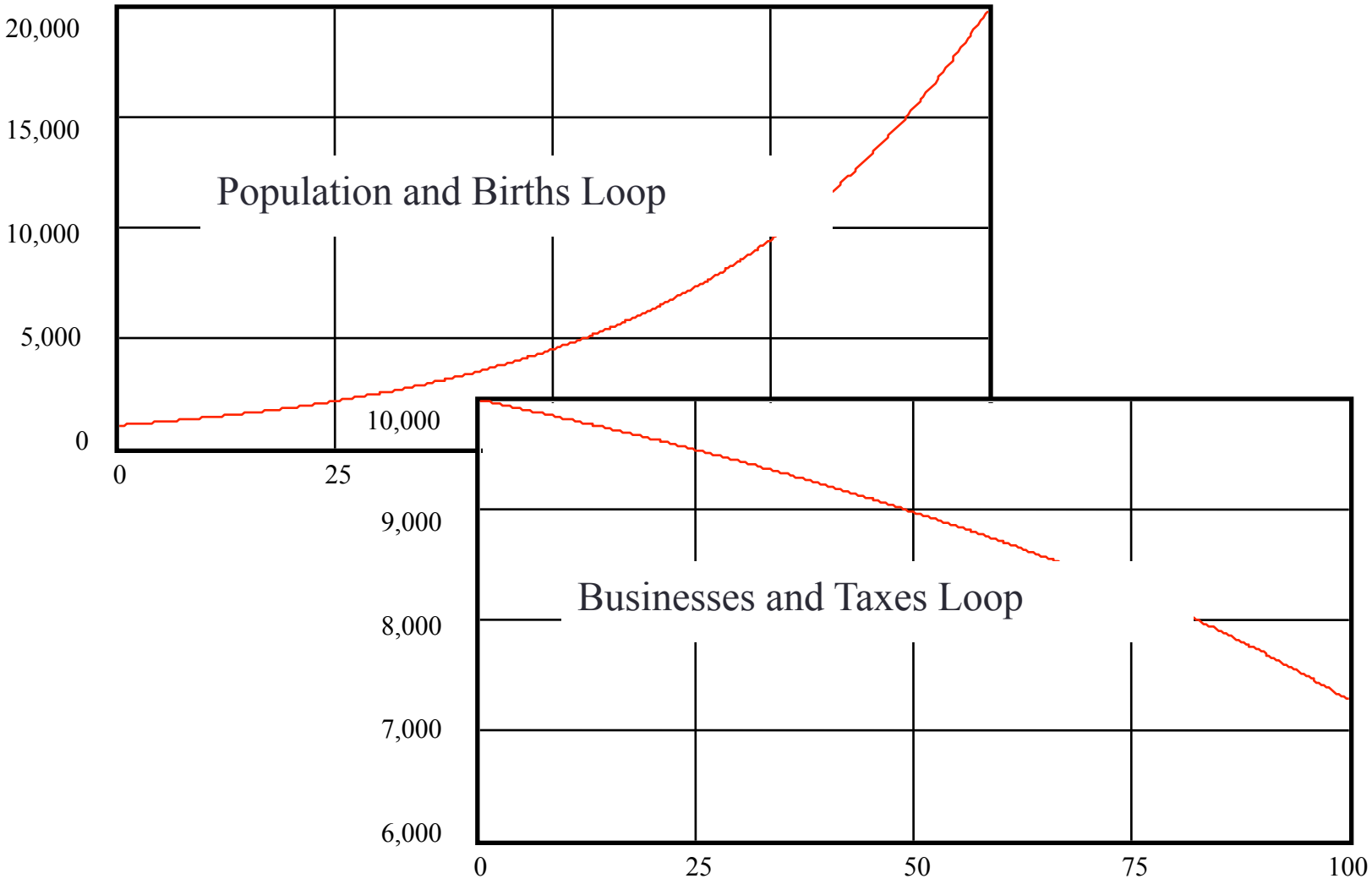
- **Balancing loops**
  - counteracting
  - goal seeking
  - stabilizing
  - odd number of –'s
  - "negative" loops
- **Symbolized by**



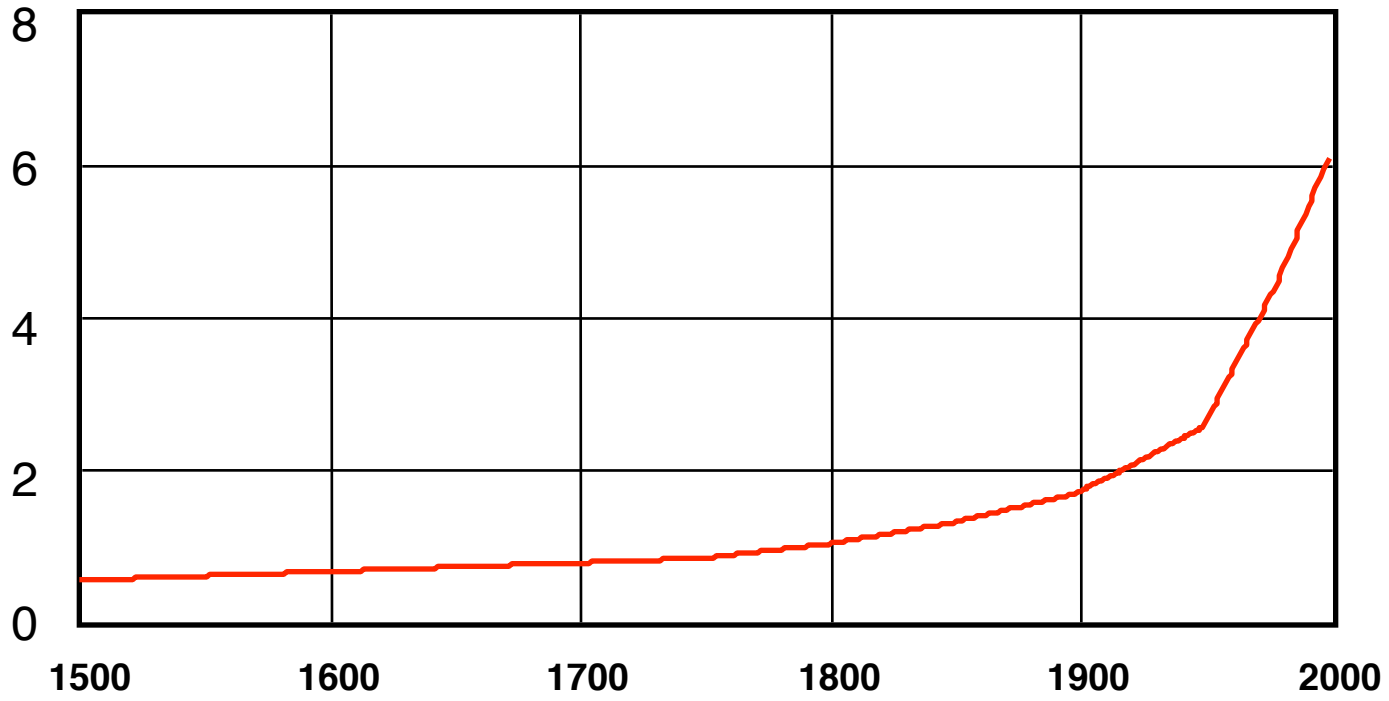
Examples of Reinforcing Loops



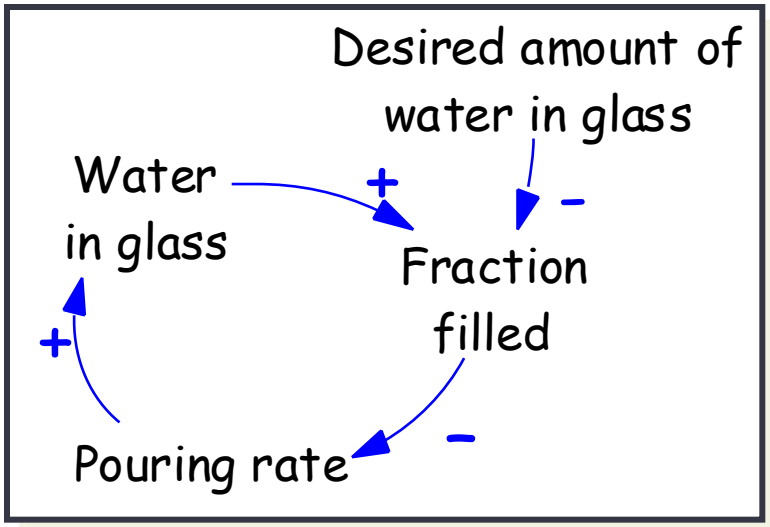
Typical Reinforcing Loop Behaviors

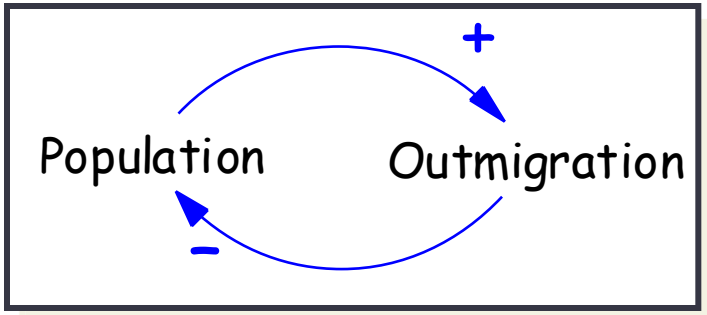


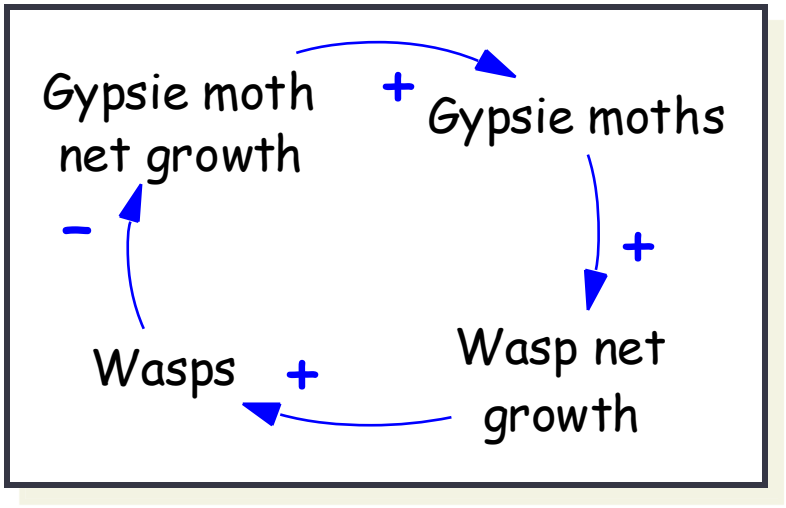
World Population (billions)



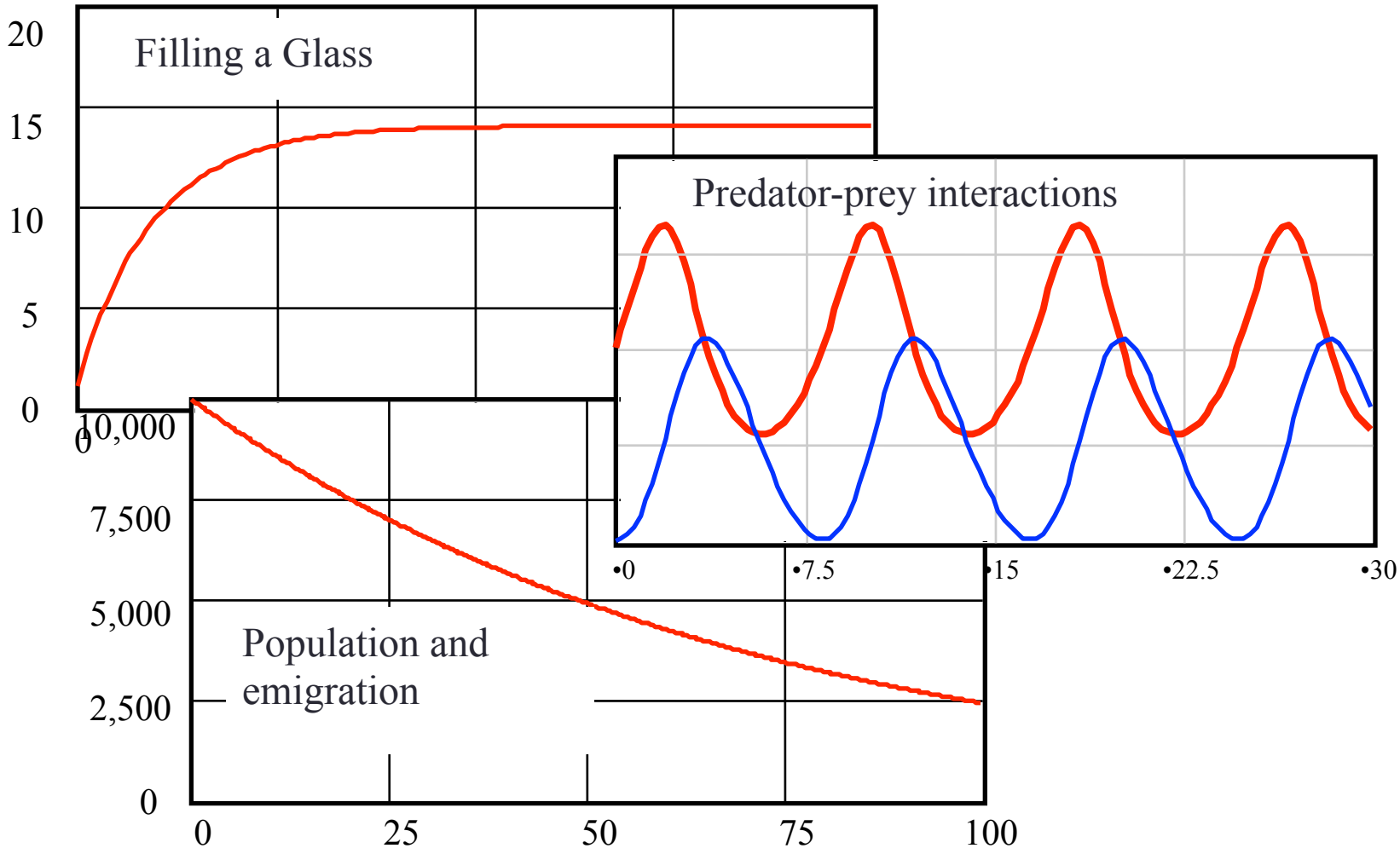
Examples of Balancing Loops







Typical Balancing Loop Behaviors



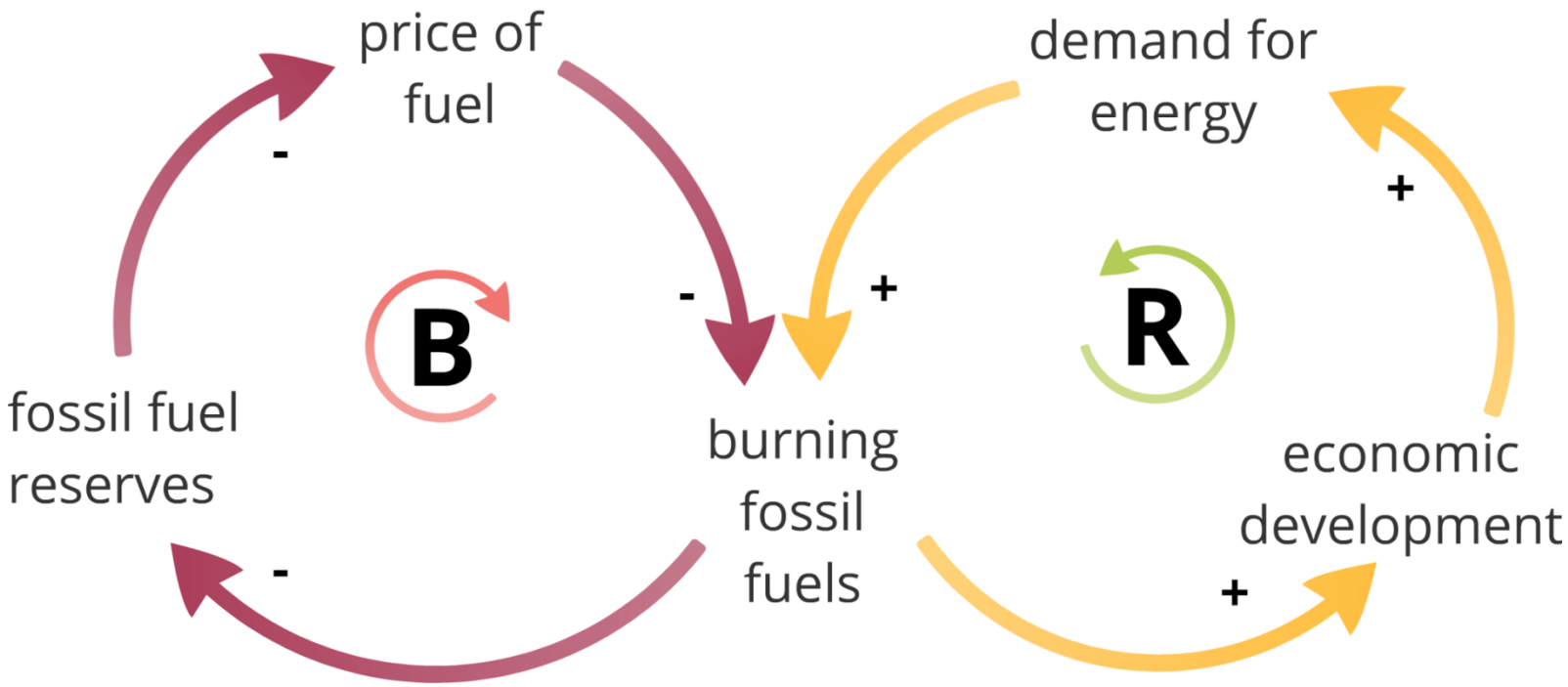
Tips for Determining Link and Loop Polarities

- For each link, determine the effect of an **increase** in the variable at the tail of the arrow:
  - If the variable at the head **increases**, assign a **plus**.
  - If the variable at the head **decreases**, assign a **minus**.

- For each loop, count the number of negative signs:
  - An **even** number of negative links is a **reinforcing** (R) loop.
  - An **odd** number of negative links is a **balancing** (B) loop.

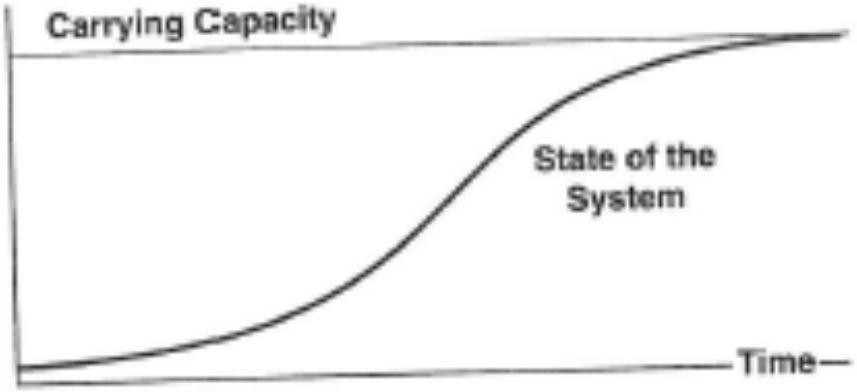
- **Most important: For each loop, tell a story, and check that the story matches the loop polarity.**

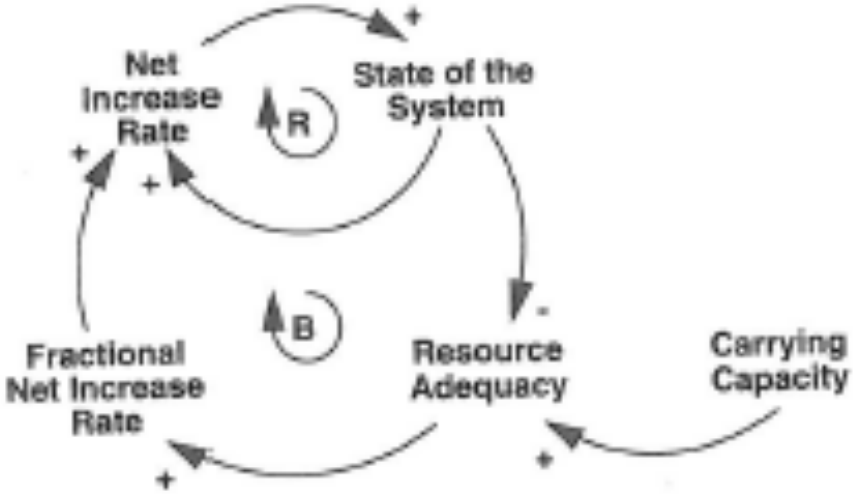
Example


price of fuel
demand for energy
fossil fuel reserves
burning fossil fuels
economic development
B
R
-
-
+
+
-
+

S-shaped growth

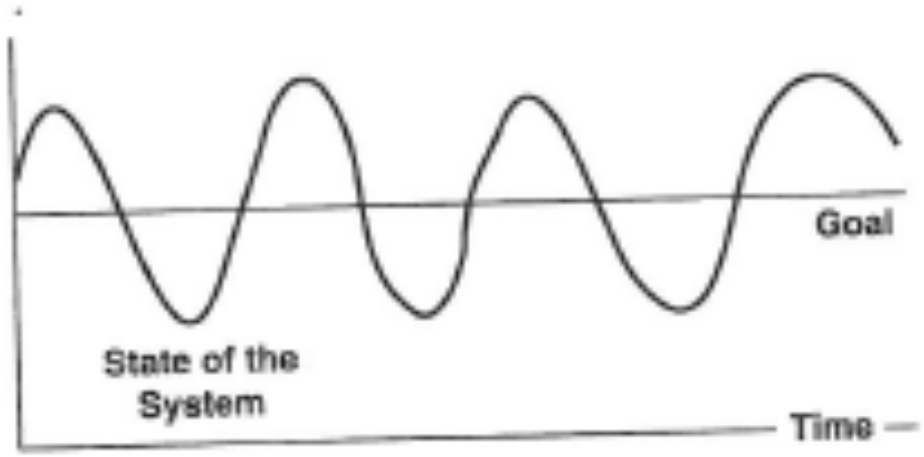
FIGURE 4-8
S-shaped growth: structure and behavior

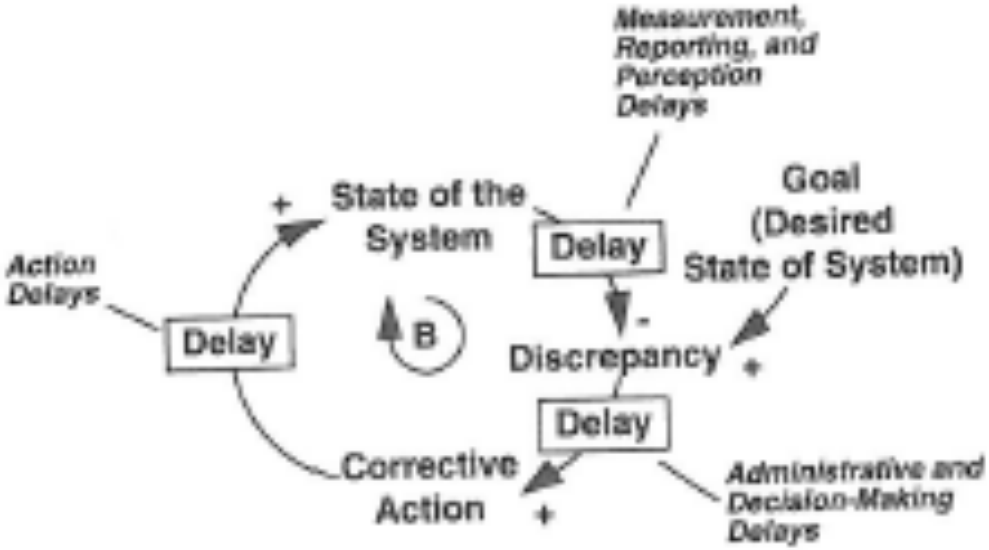




Sterman *Business Dynamics 2000*

Oscillation

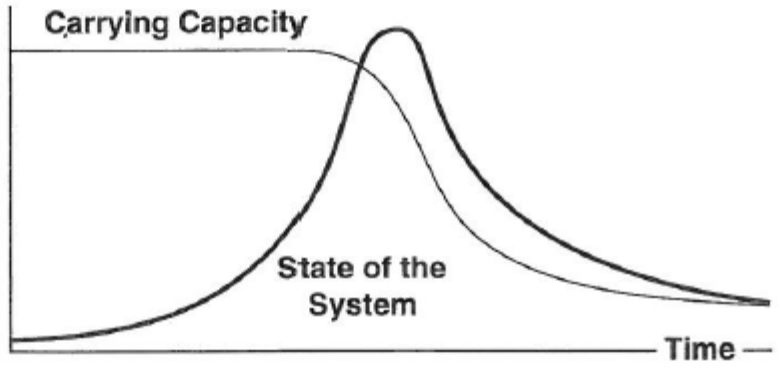


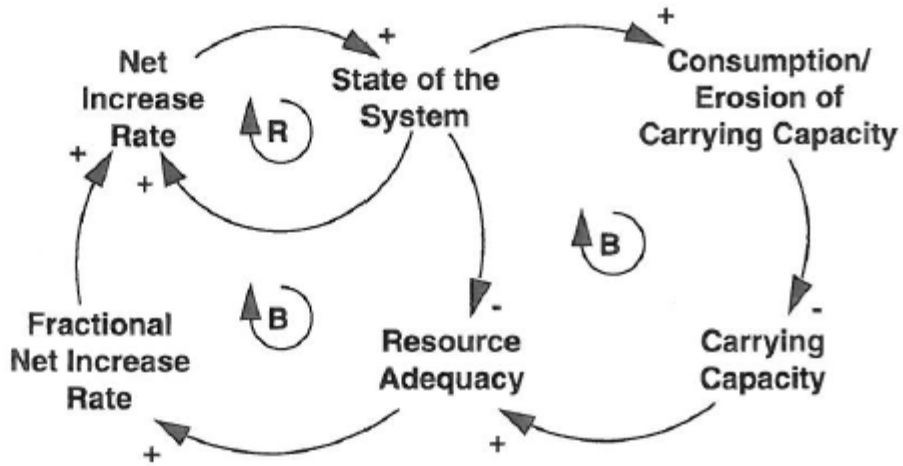


Sterman *Business Dynamics 2000*

Overshoot and collapse

FIGURE 4-12
Overshoot and collapse: structure and behavior



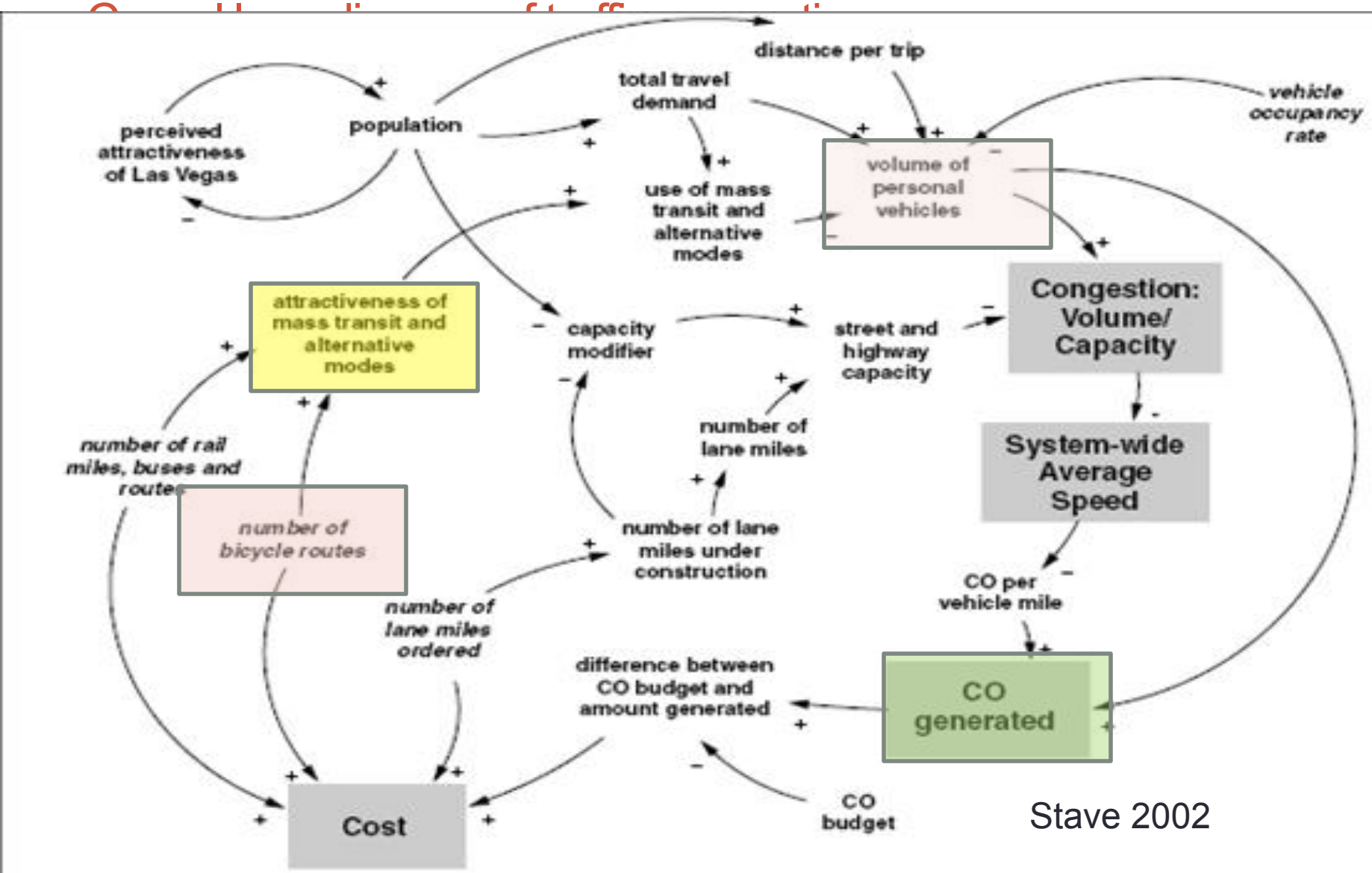


Sterman *Business Dynamics 2000*

Disadvantages

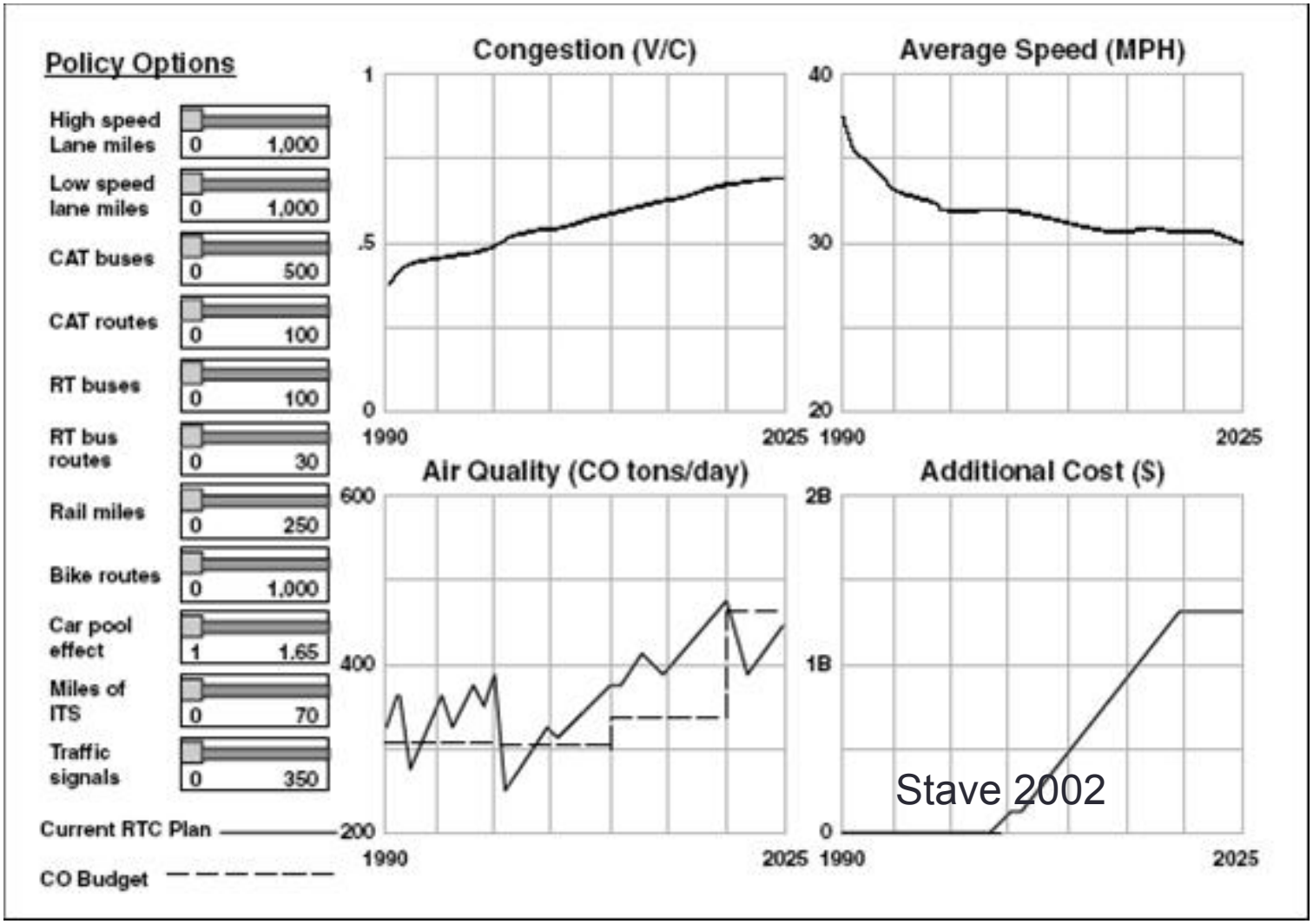
- Untraditional approach to policy analysis (not linear)
- Models can become complex fairly quickly
- Scoping of problem and determining model boundaries challenging
- Difficult to link up natural, social, behavior parameters with data or information

SD for public participation in environmental decisions



Stave 2002

Policy lever interface



Collaborative Modeling

- “any method that brings together a multidisciplinary group and employs a ‘model’ to better understand key relationships in the system being studied”

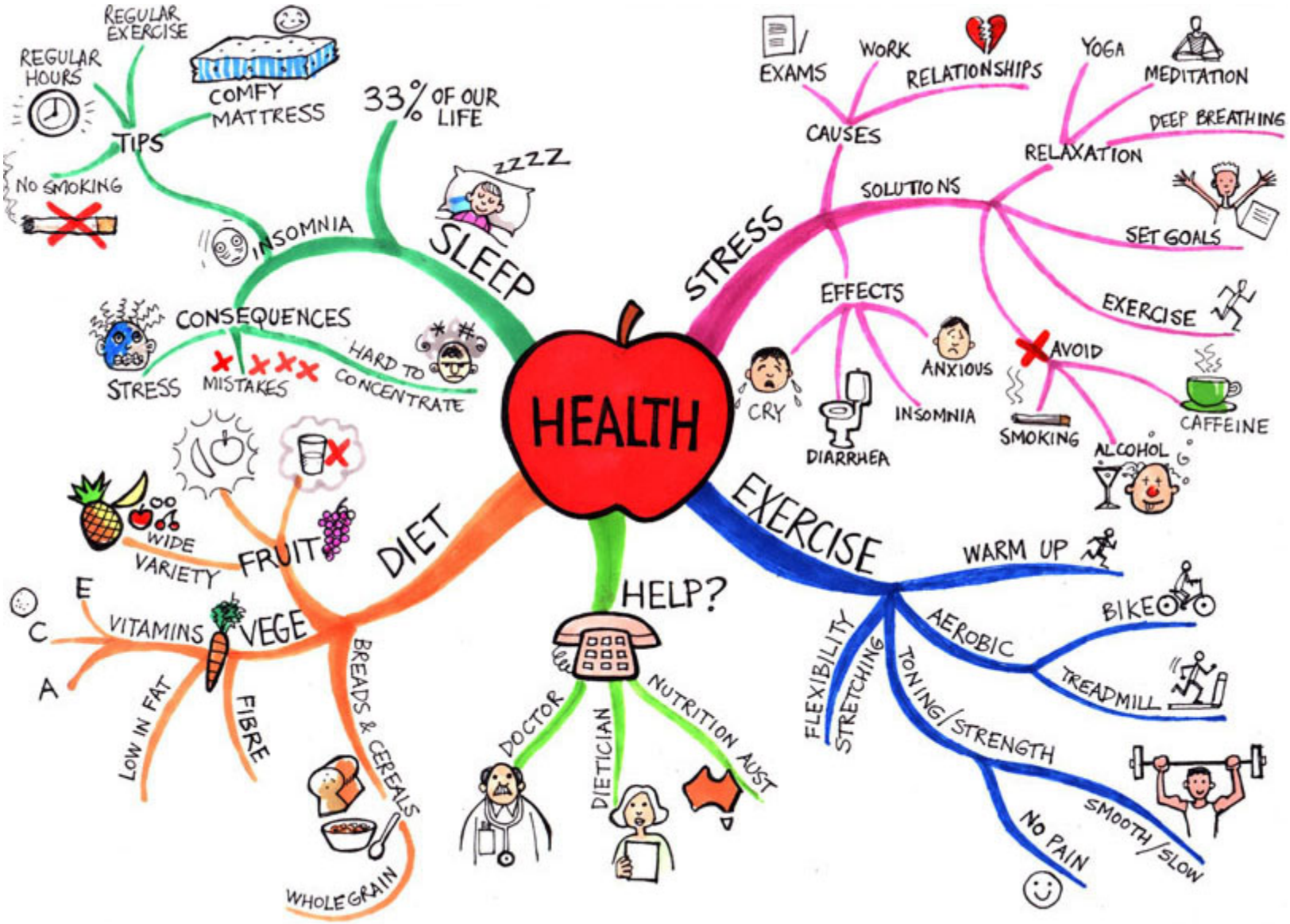
- “models can range from simple diagrams of causal behavior to complicated computer-based simulations”

MAPPING TOOLS WITH FEWER “RULES”

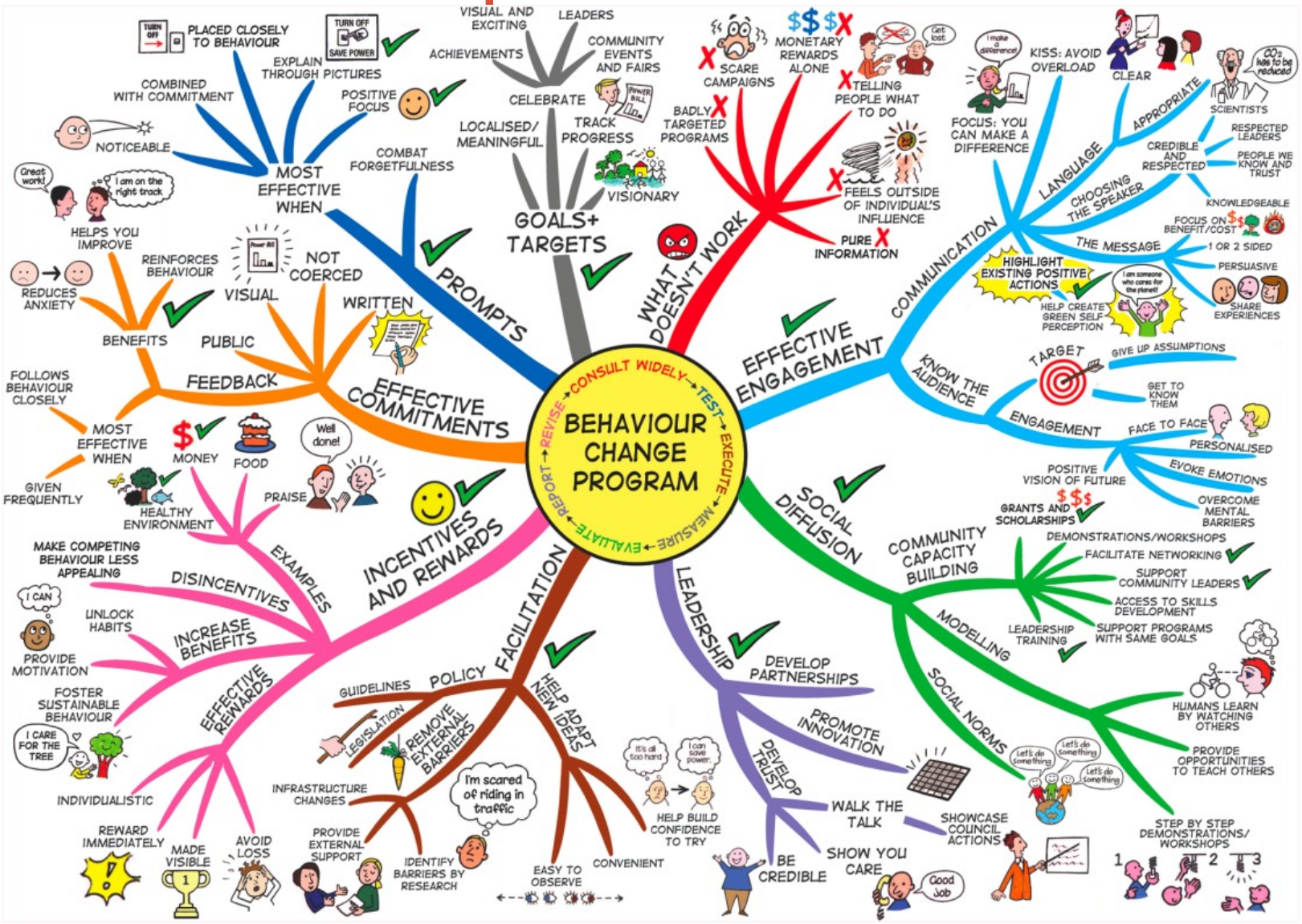
Mind-mapping Guidance

adapted from Davies 2011

- Focus on topic
- Think of key elements and connect to central idea.
  - Do not judge or filter, or focus on accuracy at this stage
- Use images, colors, upper or lower case, etc. to develop your Mind Map
- Once most ideas on table—circle most important, move things if group desires, etc.
- Tell the story of your mind map in words


HEALTH
SLEEP
33% OF OUR LIFE
TIPS
REGULAR EXERCISE
REGULAR HOURS
COMFY MATTRESS
NO SMOKING
INSOMNIA
CONSEQUENCES
STRESS
MISTAKES
HARD TO CONCENTRATE
DIET
FRUIT
WIDE VARIETY
VEGE
VITAMINS
E
C
A
LOW IN FAT
FIBRE
BREADS & CEREALS
WHOLEGRAIN
HELP?
DOCTOR
DIETICIAN
NUTRITION AUST
STRESS
CAUSES
EXAMS
WORK
RELATIONSHIPS
SOLUTIONS
RELAXATION
YOGA
MEDITATION
DEEP BREATHING
SET GOALS
EXERCISE
AVOID
CAFFEINE
ALCOHOL
SMOKING
EFFECTS
CRY
DIARRHEA
INSOMNIA
ANXIOUS
EXERCISE
WARM UP
AEROBIC
BIKE
TREADMILL
TONING/STRENGTH
SMOOTH/SLOW
NO PAIN
FLEXIBILITY
STRETCHING

Another example



For today…

- Start with the things your group cares most about for the type of variable (health or eco risk/benefit, policy, economics, social/cultural) and the case study (human health, conservation, agriculture)
- Put that variable down as a starting point
- Think of any type of variable (influences) and the connections to your key variable (what you care about)

Mapping

- If your group wants, try causal mapping
  - Tell stories with your loops
  - Identify competing loops
  - Identify places where more information or data would be needed
  - Identify potential places for social mitigation of undesirable effects
  - Even identifying a couple of loops is great progress in two hours!
- If not, mental modeling is great too!

Example for gene drives

- Pests and agriculture, sociocultural