Introduction to Systems Thinking and Causal Loop Diagrams
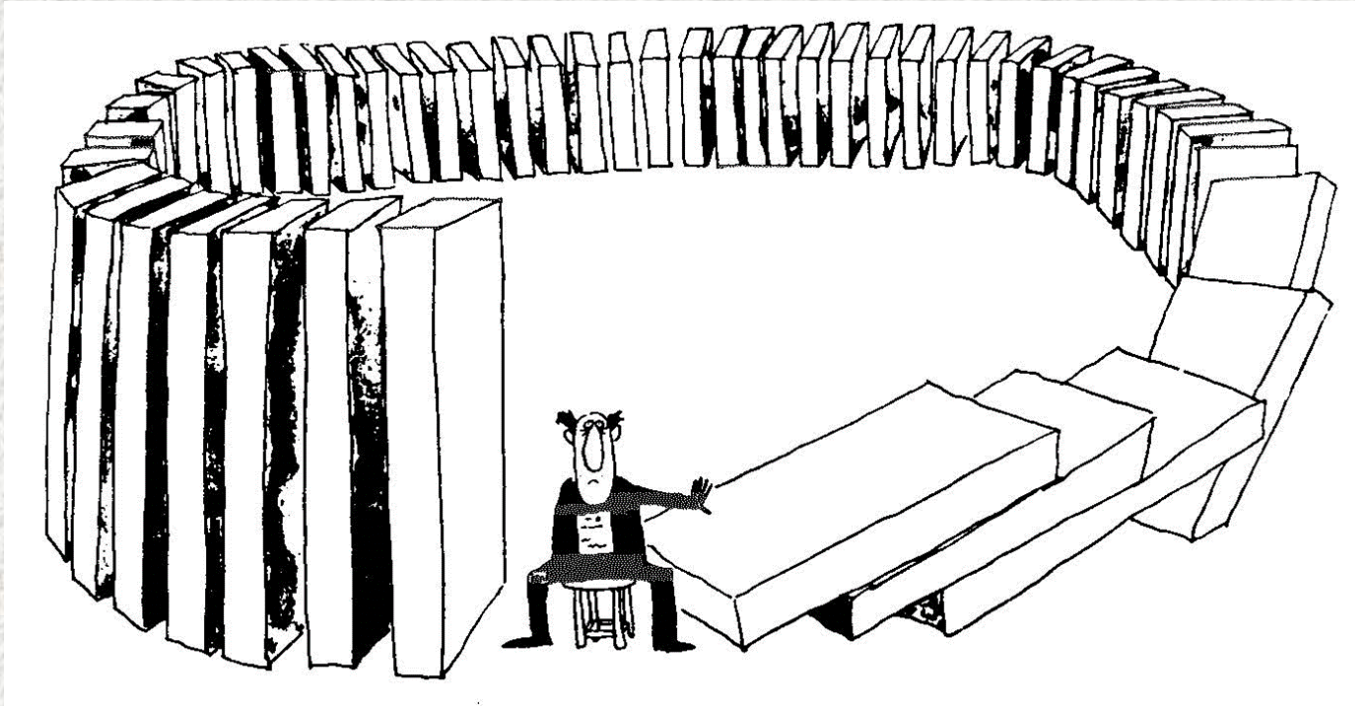
BAE 815 (Fall 2017)

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- Emphasize the relationships among a system's parts, rather than the parts themselves.

- Understand dynamic complexity of systems and find the leverage points for sustainable change.

Systems thinking

- See the big picture
- Recognize that structure influence performance
- Examine how we may create our own problem

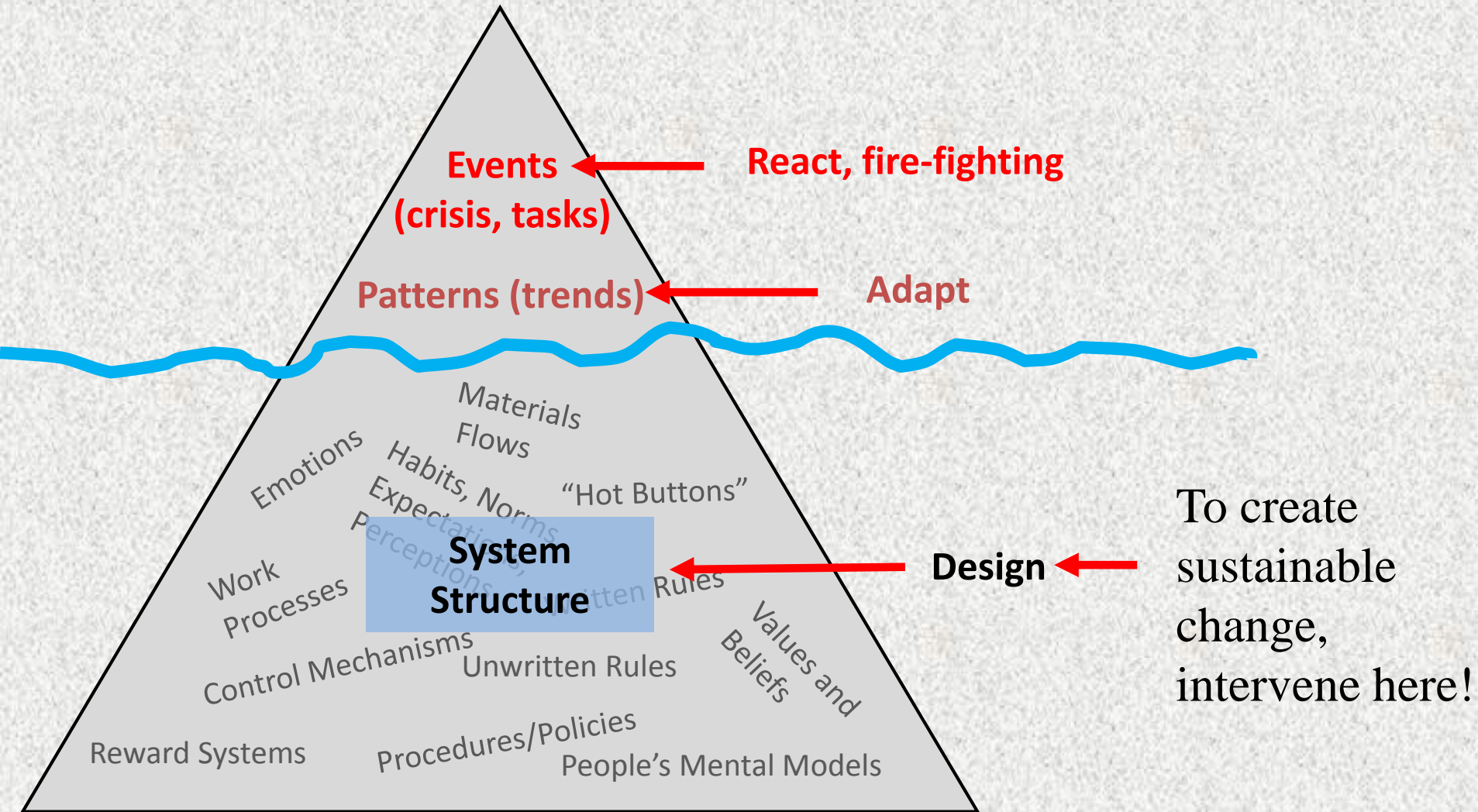In complex systems, cause and effect are distant in time and space.

Why systems thinking ?

- Increasing use of antibiotics

  → More resistant strains of bacteria

- Adding more roads to reduce congestion

  →Increased development and ultimately more congestion

Some system stories

- Today's problem may come from yesterday's "solution".

- The cure can be worse than the disease.

- The easy way out usually leads back in.

- Long term behavior is often different from short term behavior.

- Cause and effect are not closely related in time and space.

- Small changes can produce big results, but the leverage points are not obvious.

Some "truth" on complex systems

Events (crisis, tasks) ← **React, fire-fighting**

Patterns (trends) ← **Adapt**

Materials Flows

Emotions

Habits, Norms

"Hot Buttons"

Expectations, Perceptions

Work Processes

System Structure

Written Rules

Values and Beliefs

Control Mechanisms

Unwritten Rules

Reward Systems

Procedures/Policies

People's Mental Models

Design ← To create sustainable change, intervene here!

90% of an iceberg's volume is not visible

- A useful tool to provide a visual representation of dynamic interrelationships
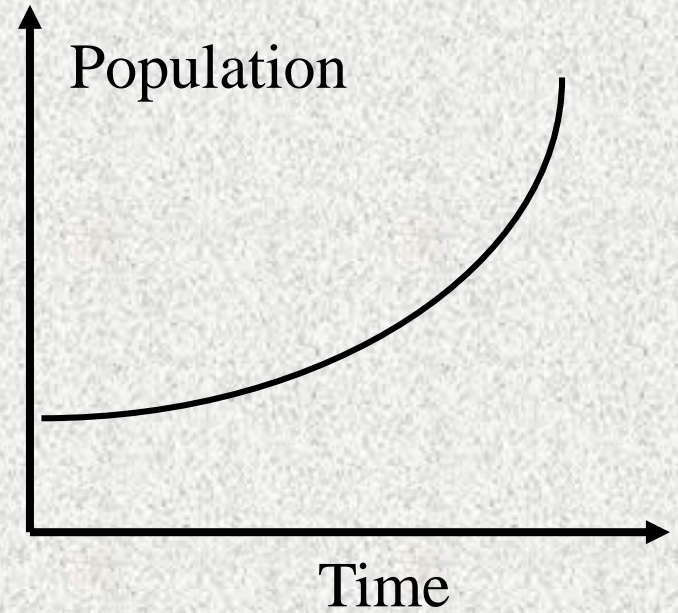
- Test and clarify your thinking

Causal loop diagrams

- Variables: up or down over time

- Arrows: the direction of influence between variables

  Causality: A ⟶ B

- Polarity:

  + or s, if A and B change in the same direction

  - or o, if A and B change in the opposite directions

- Feedback loops: Balancing (B) or Reinforcing (R)

- Delay (||): The effect is delayed.

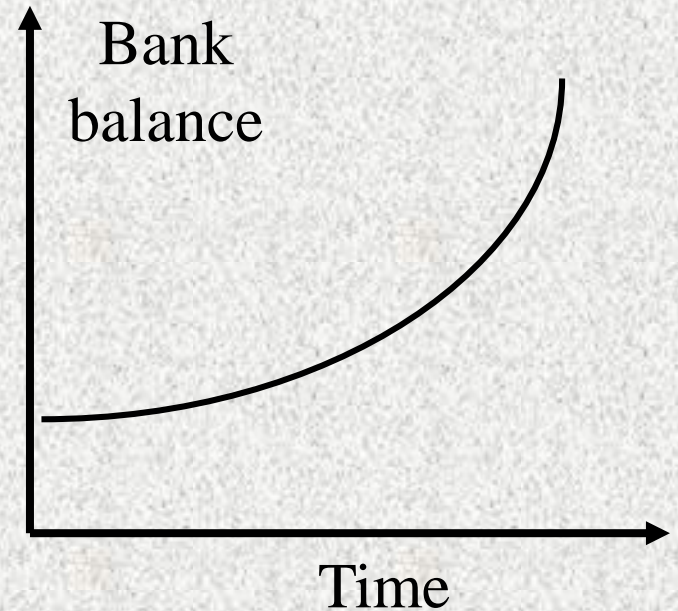# Component of a causal loop diagrams
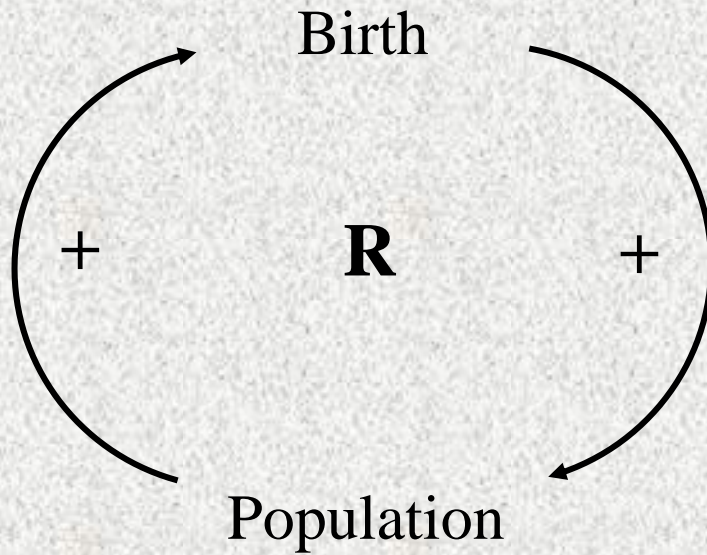
Structure

Dynamic behavior

Birth

R

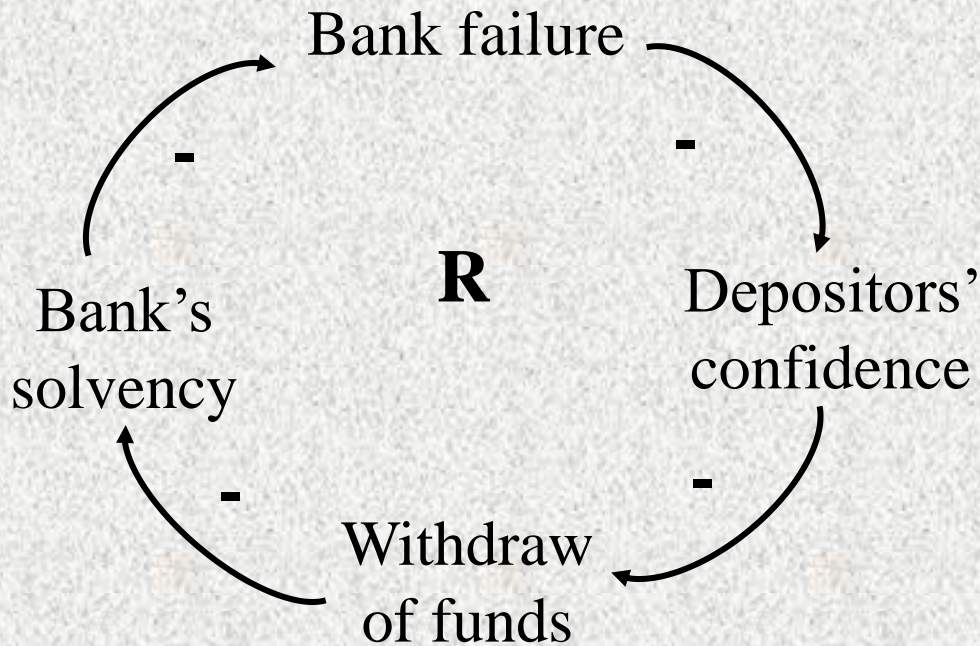+   +

Population

Population

Time

Reinforcing loop

Structure

Interest
paid

R

+   +

Bank
balance

Dynamic behavior

Bank
balance

Time

Reinforcing loop

Structure

Bank failure

\-   \-

R

Bank's solvency   Depositors' confidence

\-   \-

Withdraw of funds

Dynamic behavior

Bank failure

Time
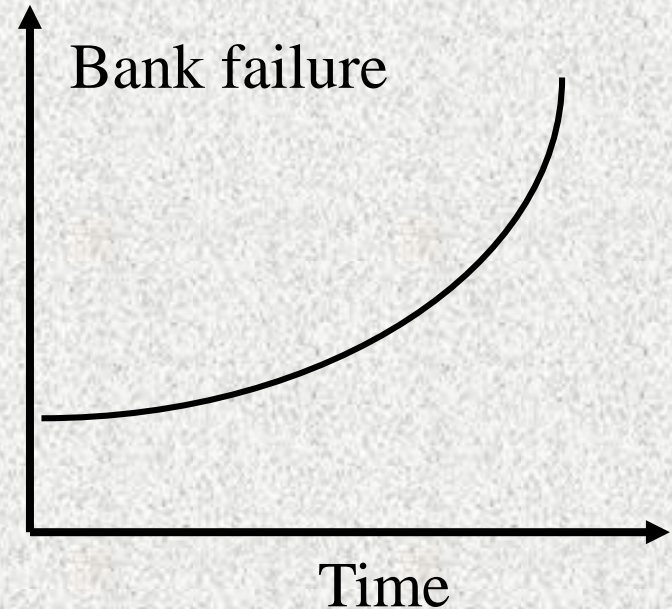
Reinforcing loops can be vicious cycles!

Reinforcing loop

Structure

Food ingested

+   **B**   -

Hunger

Dynamic behavior

Hunger

Time
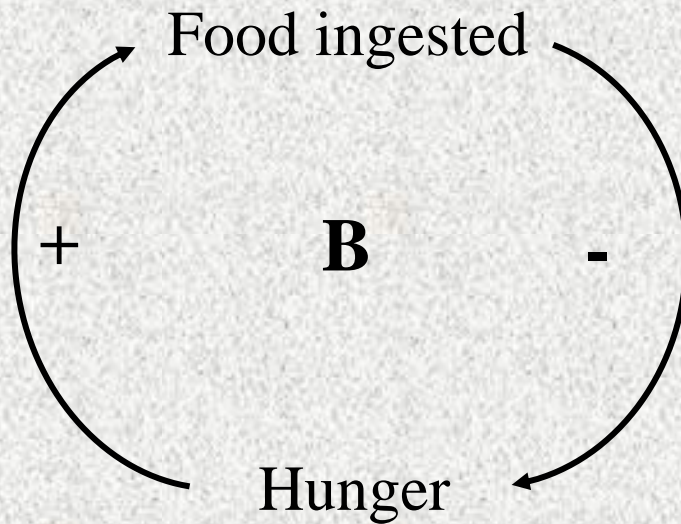
Balancing loops create stability

Balancing loop

Structure

People moving
into town

B

+   -

Job openings

Job openings

Time
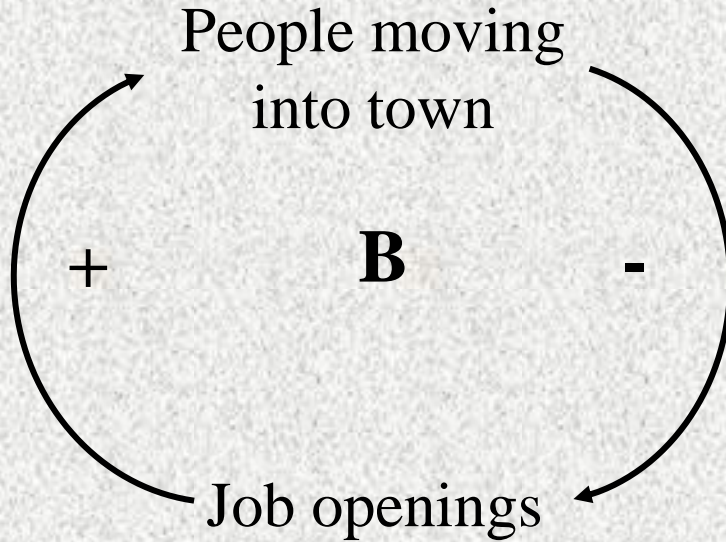
Balancing loops can be automatic, or intentional policy.

Balancing loop

13

Births

+ **R** +

Deer
population

+ **B** -

Available
food

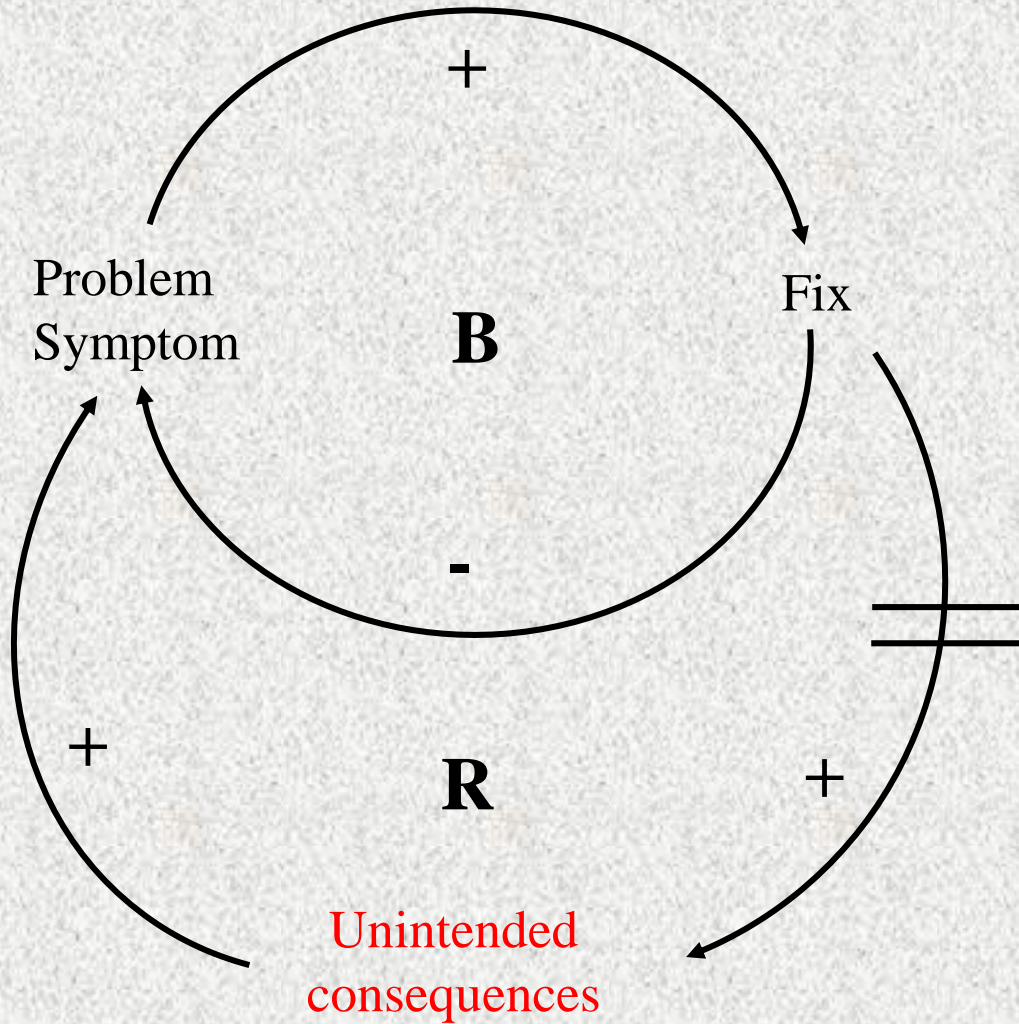**Dynamic behavior**

Deer
population

B

R

Time
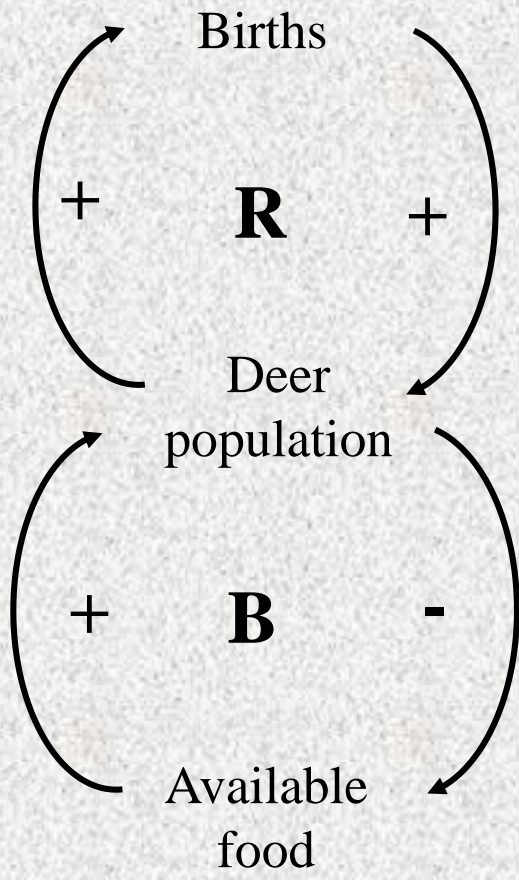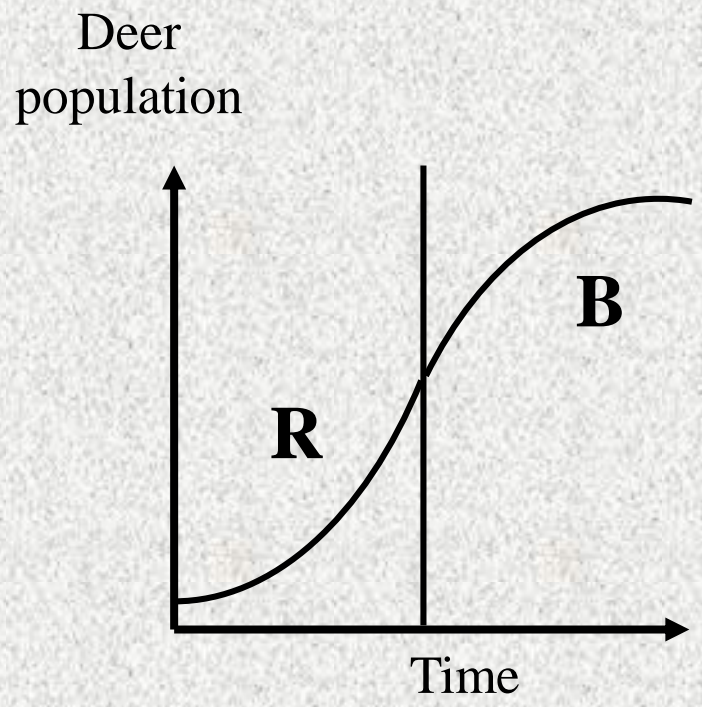
Combination loops

A class of tools that capture the "common stories"

1.1. Fixes that fail / Backfire

1.2. Shifting the burden / Addiction

2.1. Limits to success

2.2. Growth and underinvestment

3.1. Success to the successful

3.2. Tragedy of the commons

4.1. Drifting goals

4.2. Escalation

Systems archetypes

Dynamic behavior

Problem Symptom

+

B

Fix

-

+

R

+

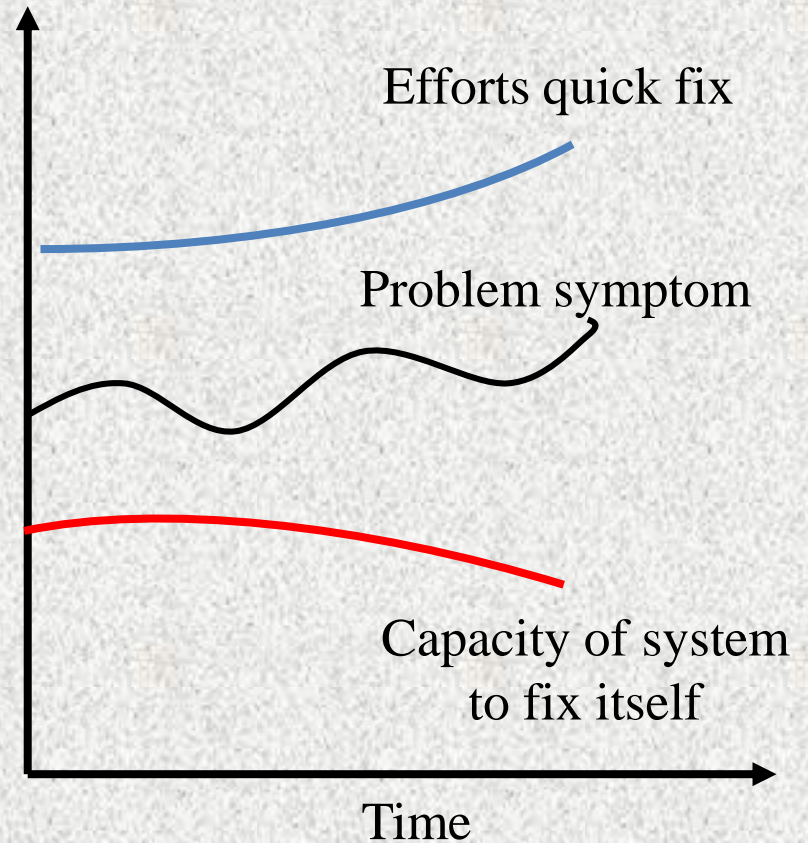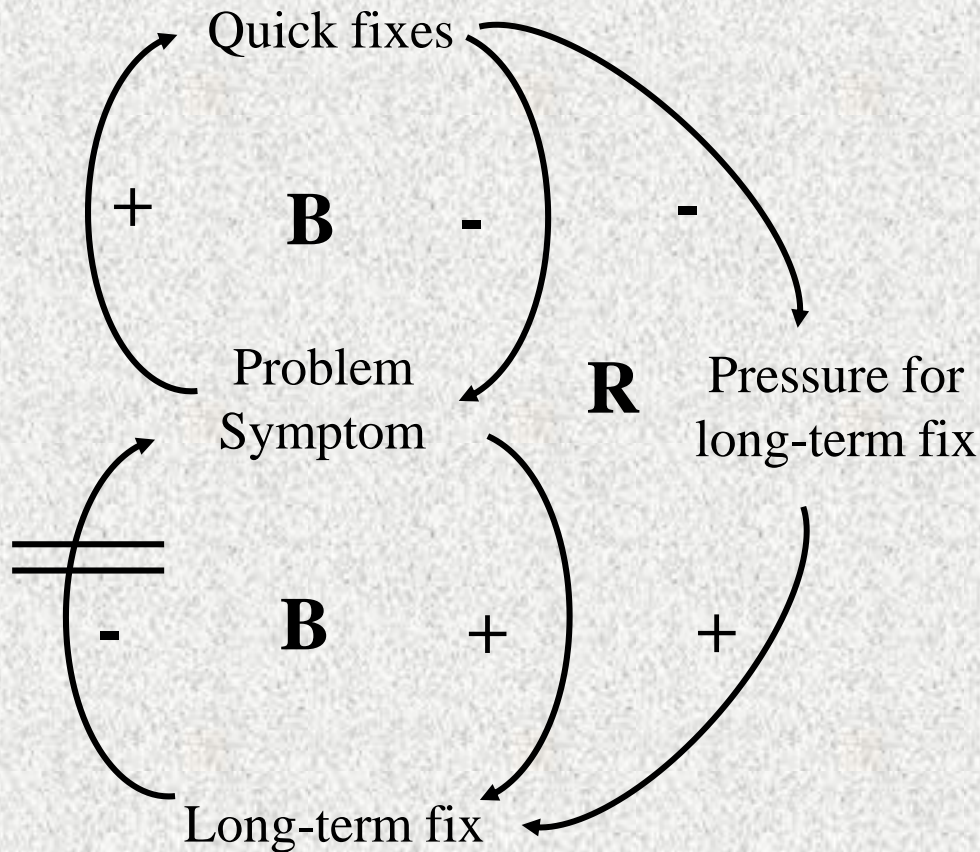Unintended consequences

Problem Symptom

R

B

Time
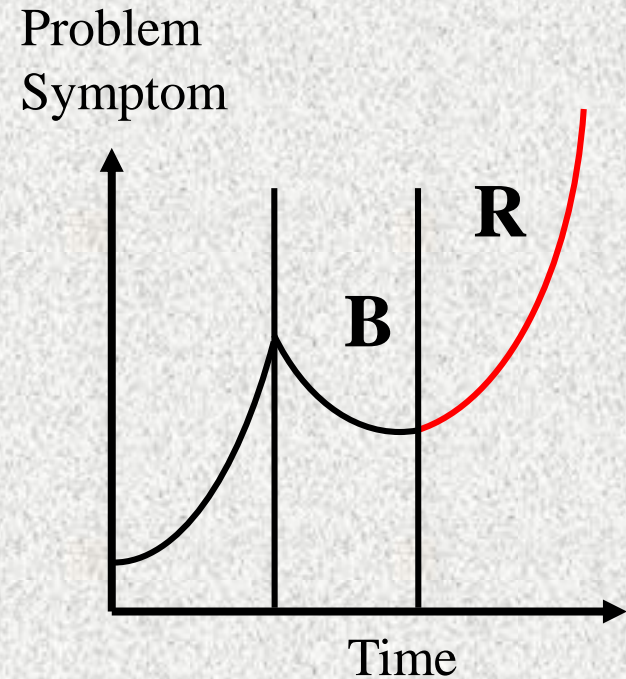
1.1 Fixes that fail

Prescriptive actions:
- Increase awareness of the unintended consequences
- Reframe and address the root problem, give up the fix that works only on the symptom

1.1 Fixes that fail

Quick fixes

+ **B** - -

Problem
Symptom **R** Pressure for
long-term fix

- **B** + +

Long-term fix

Efforts quick fix

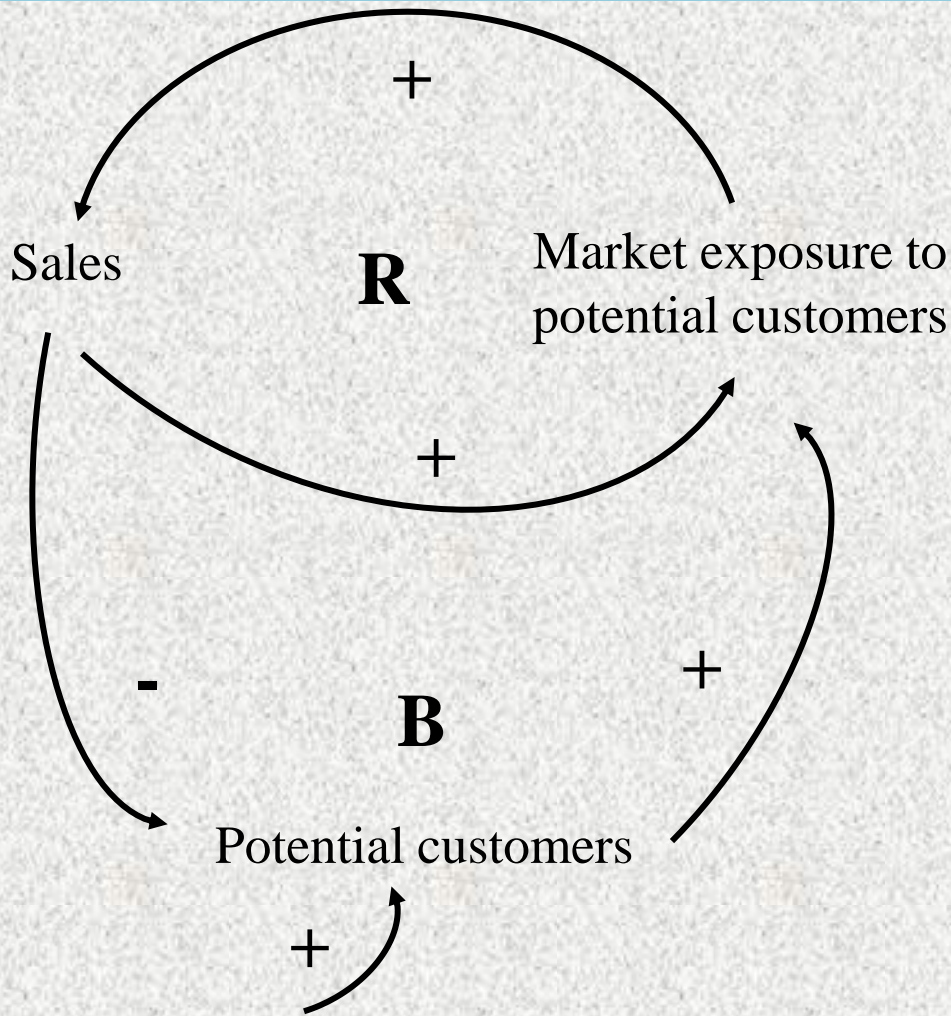Problem symptom

Capacity of system
to fix itself

Time

1.2 Shifting the burden

Prescriptive actions:

- If possible, support only long-term solution. If you must address the symptoms right away, do so with restraint.

- As you strengthen long-term capability, do what you can to reduce dependency on the short-term fix.
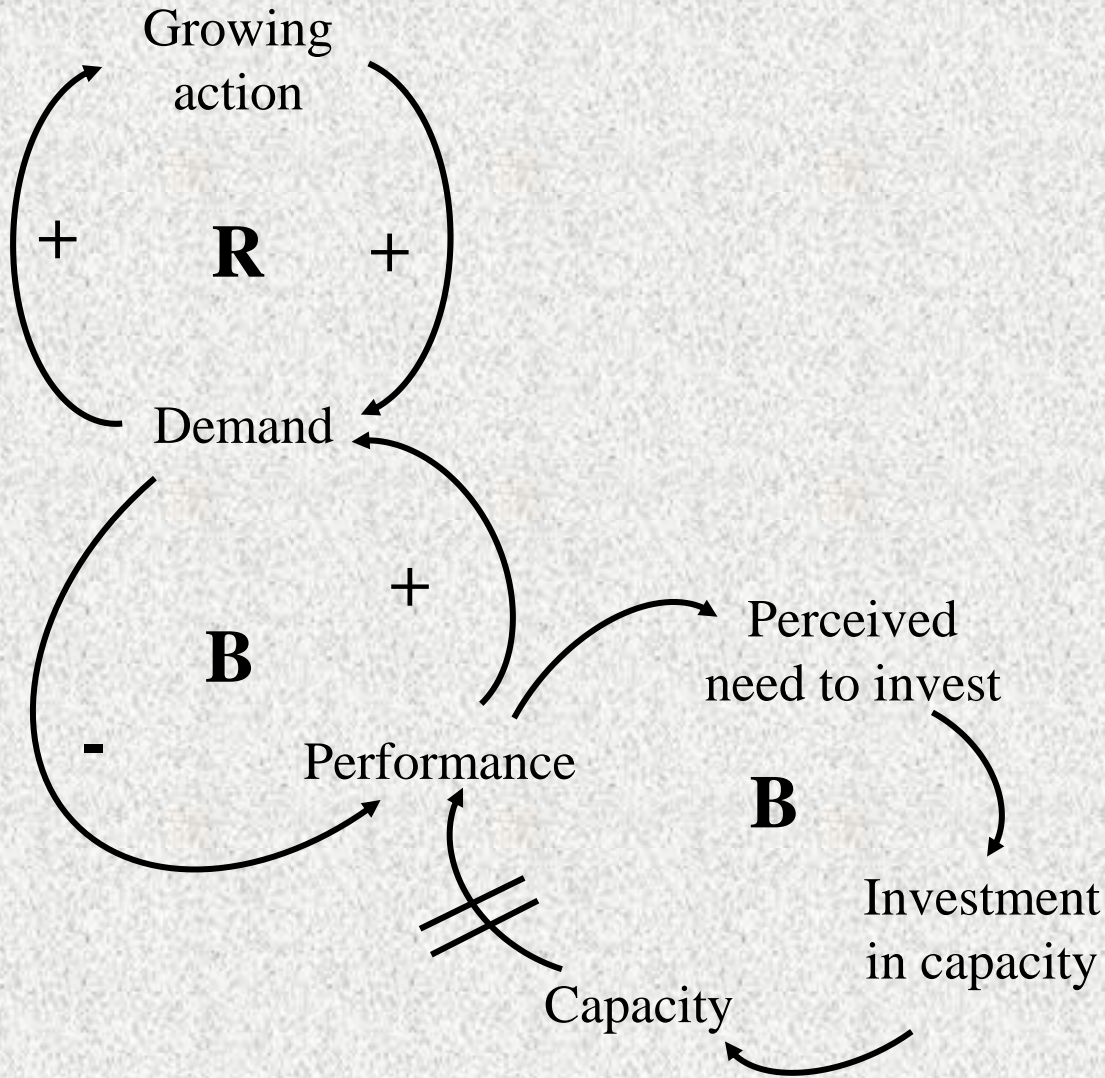
1.2 Shifting the burden

Dynamic behavior

Sales   **R**   Market exposure to potential customers

+

+

-    **B**   +

Potential customers

+
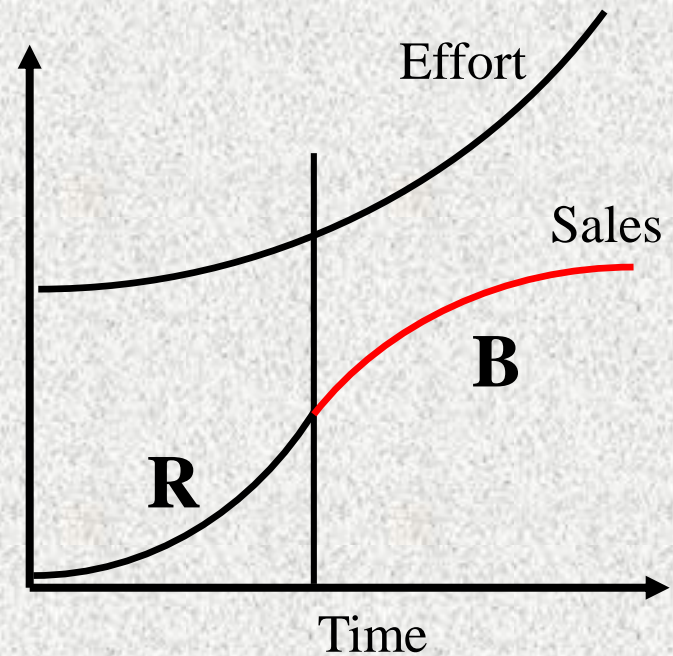
Market size (Limiting variable)

Effort

Sales
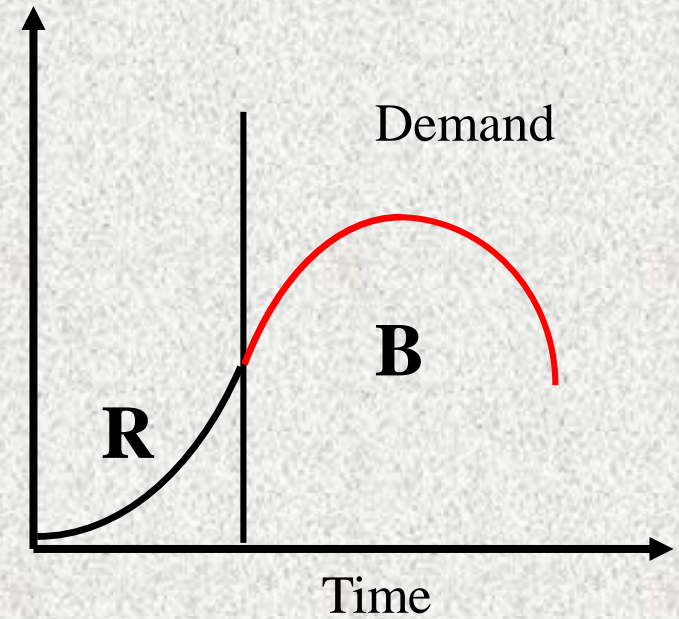
B

R

Time

2.1 Limits to success

Prescriptive actions:
- Determine timeline of the growth engine (R loops).
- Identify potential limits (B loops).
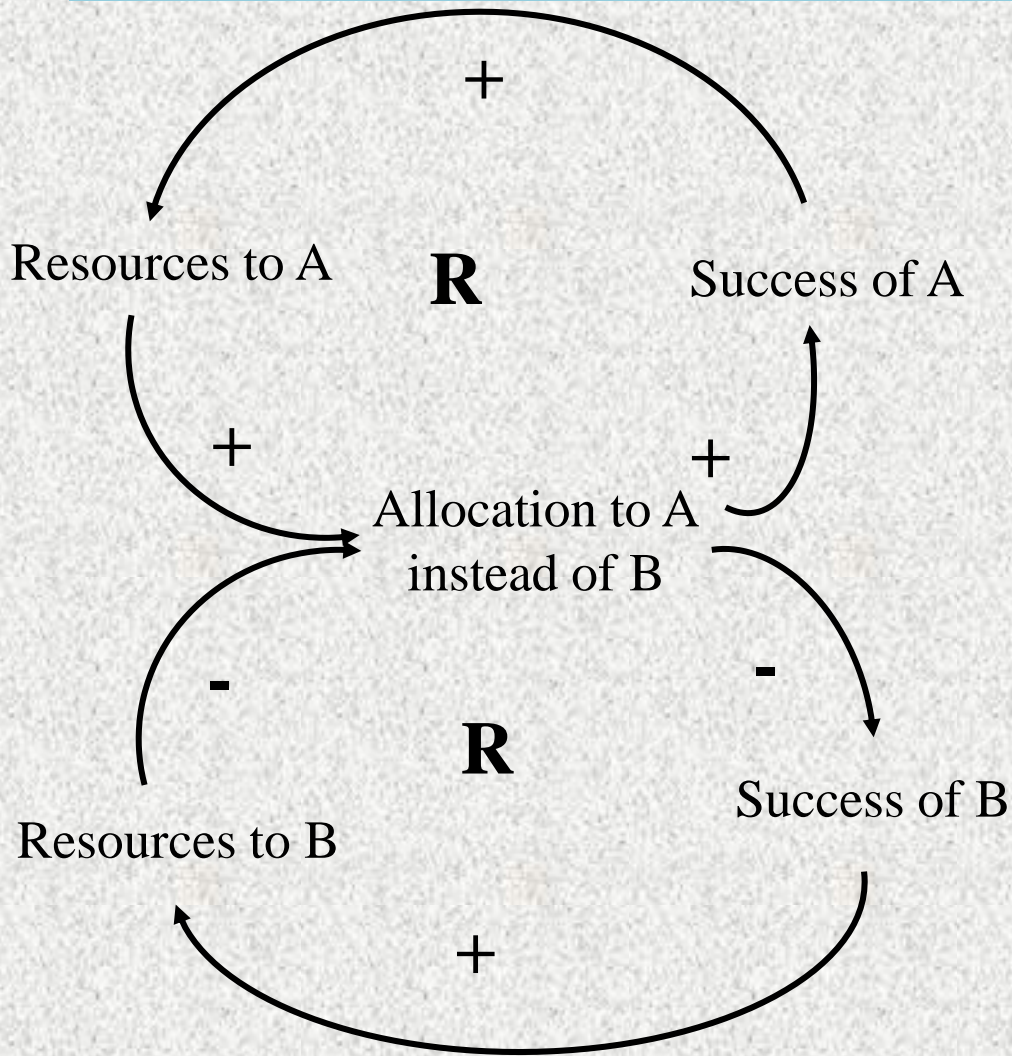- Look for other potential engines of growth.
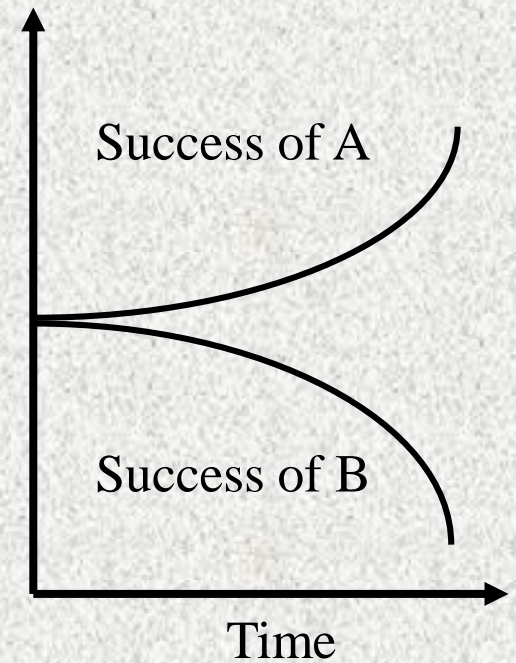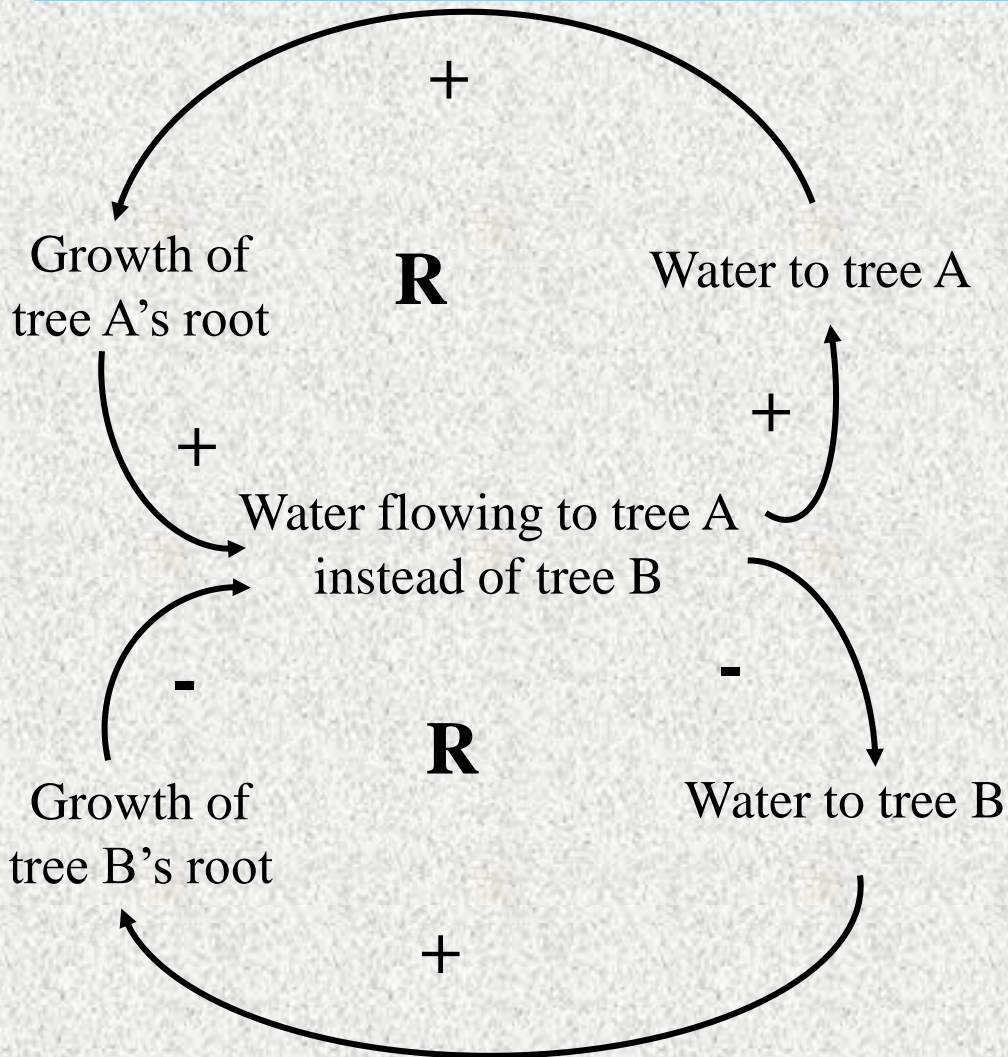
2.1 Limits to success

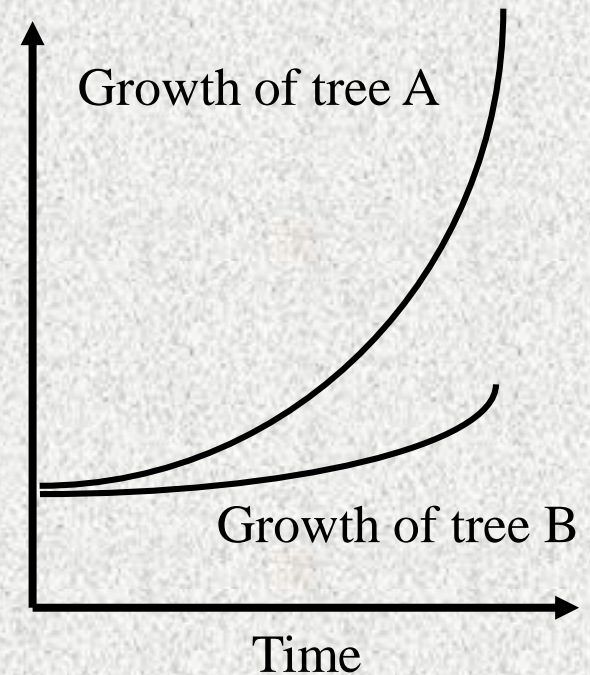**Dynamic behavior**

2.2 Growth and underinvestment

Dynamic behavior

Resources to A **R** Success of A

+

+ Allocation to A instead of B +

- -

R

Resources to B Success of B

+

Success of A

Success of B

Time

3.1 Success to the successful

Dynamic behavior

Growth of
tree A's root **R** Water to tree A

+

+

Water flowing to tree A
instead of tree B

- -

R

Growth of
tree B's root Water to tree B
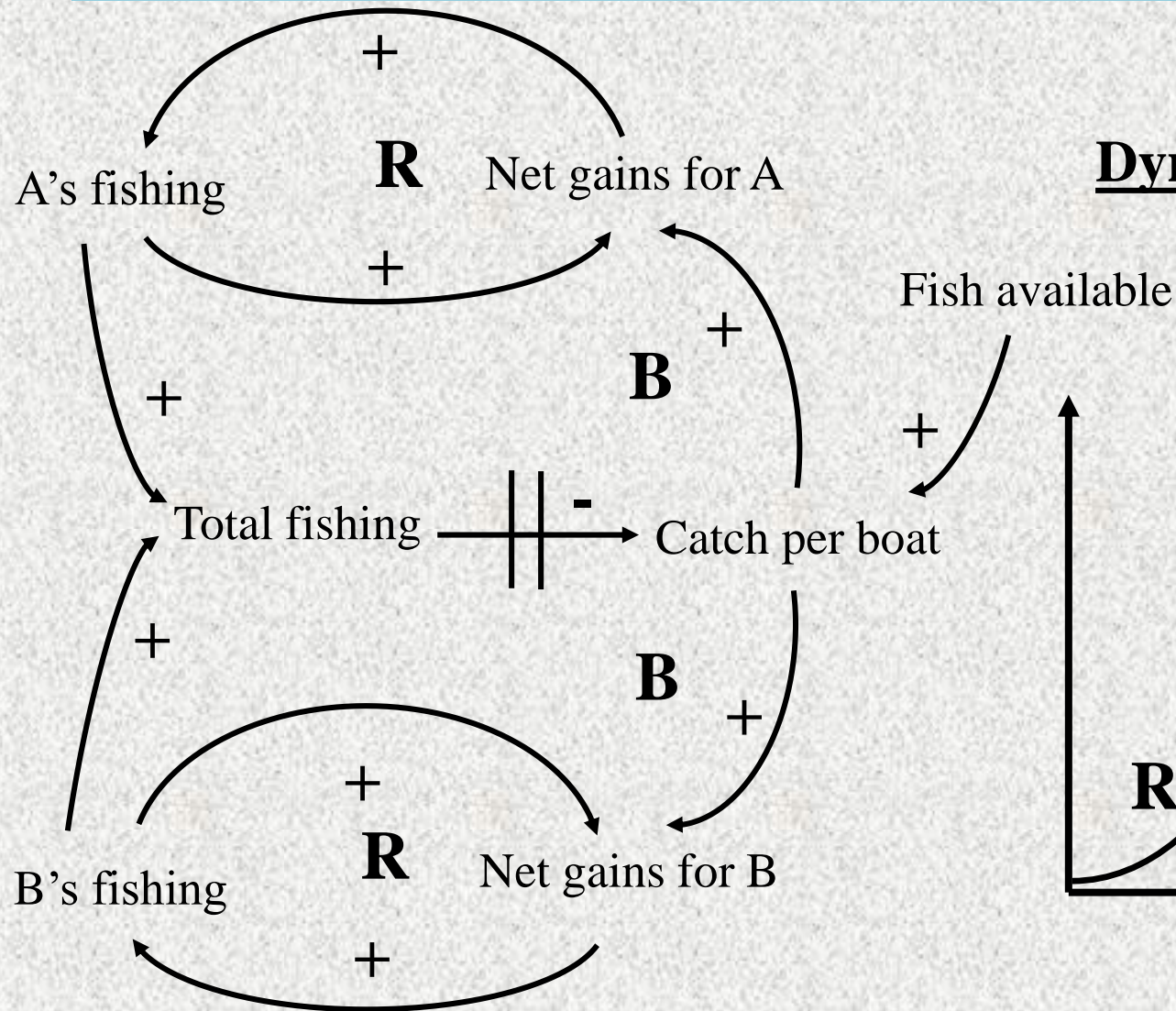
+

Growth of tree A

Growth of tree B

Time

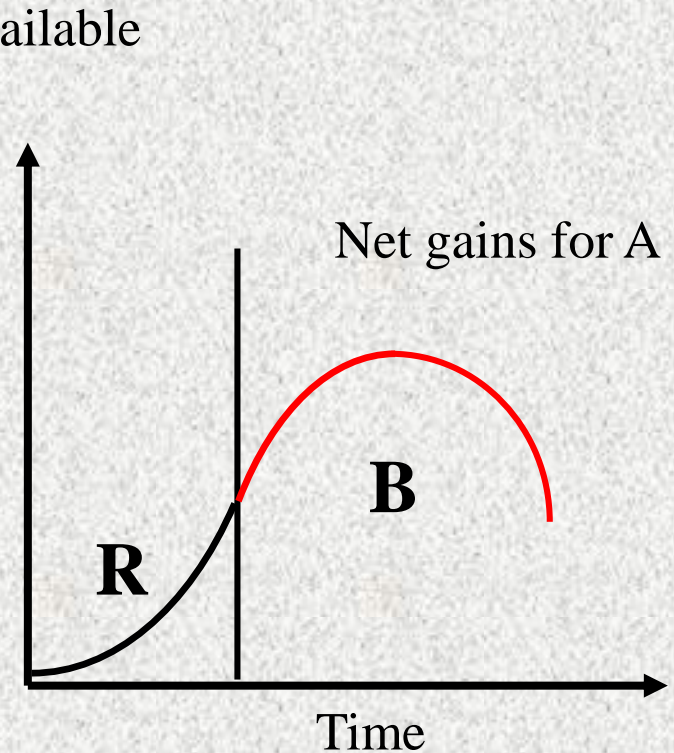# 3.1 Success to the successful (Darwinism)

Prescriptive actions:
- Look for reasons why the system was set up to create just one "winner"
- Find ways to make teams collaborators rather than competitors

3.1 Success to the successful
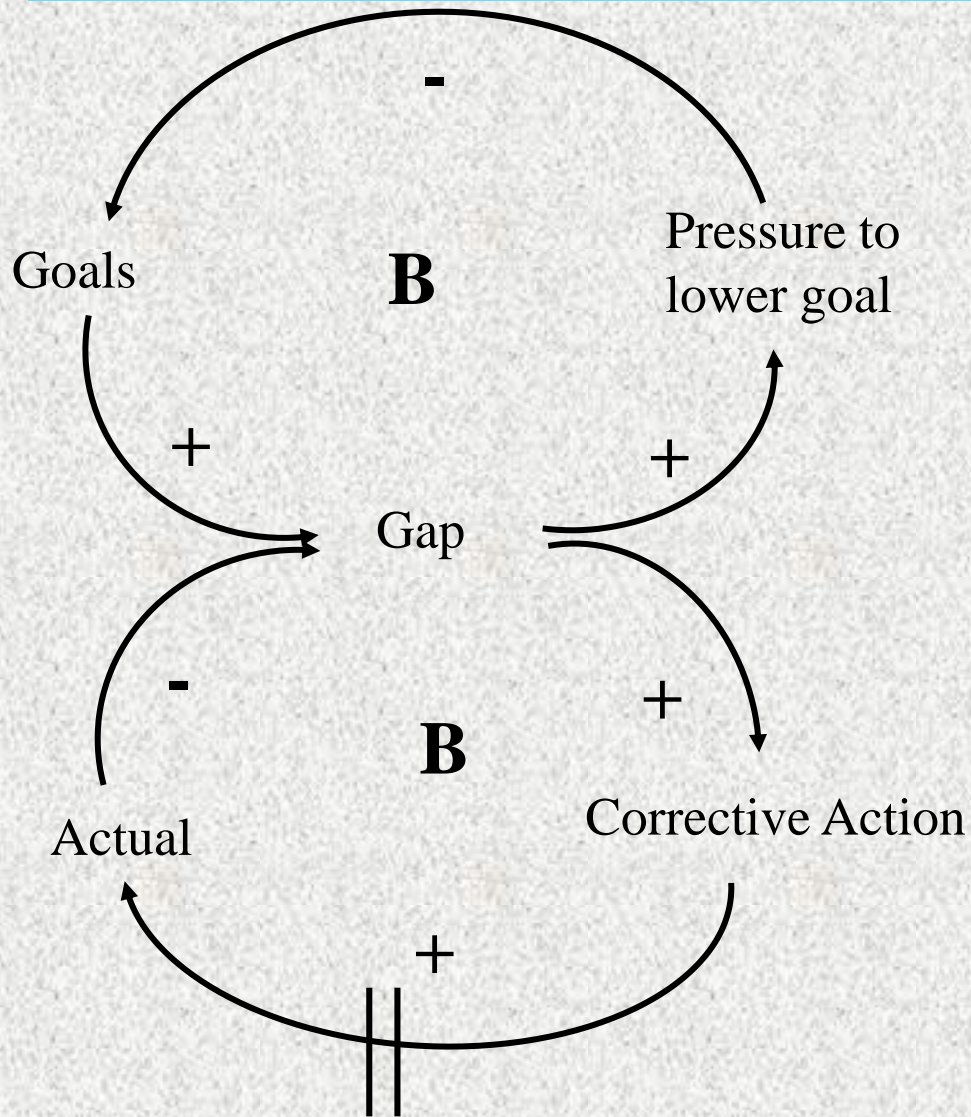
Dynamic behavior

3.2 Tragedy of the commons

Prescriptive actions:
- In any of the 'tragedy' situations, there must be an overriding legislation for common good.
- To protect common resources some form of regulation should be introduced.
- Re-evaluate the nature of the commons to determine if there are ways to replace, renew or substitute the resources before it becomes depleted.

# 3.2 Tragedy of the commons

**Dynamic behavior**
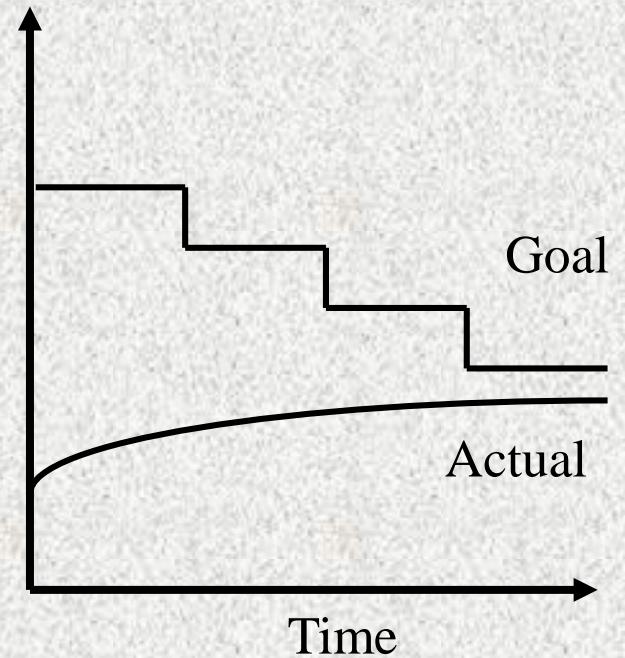
4.1 Drifting goals

Prescriptive actions:
- Establish a clear transition plan from current reality to the goal including realistic timeframe to achieve the goal.
- Determine whether the drift in performance is the result of conflicts between the stated goal and implicit goals in the system.
- Anchor the goal to an external frame of reference (benchmarking).

4.1 Drifting goals
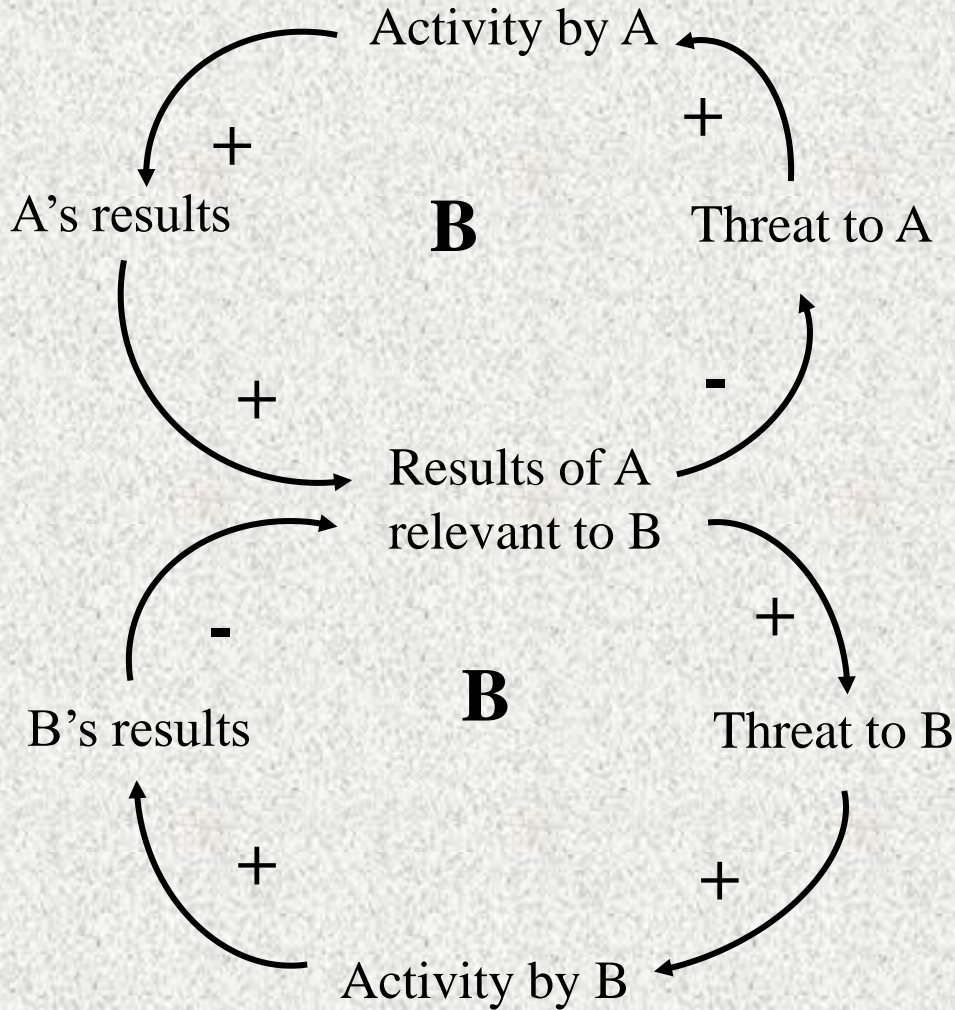
Dynamic behavior
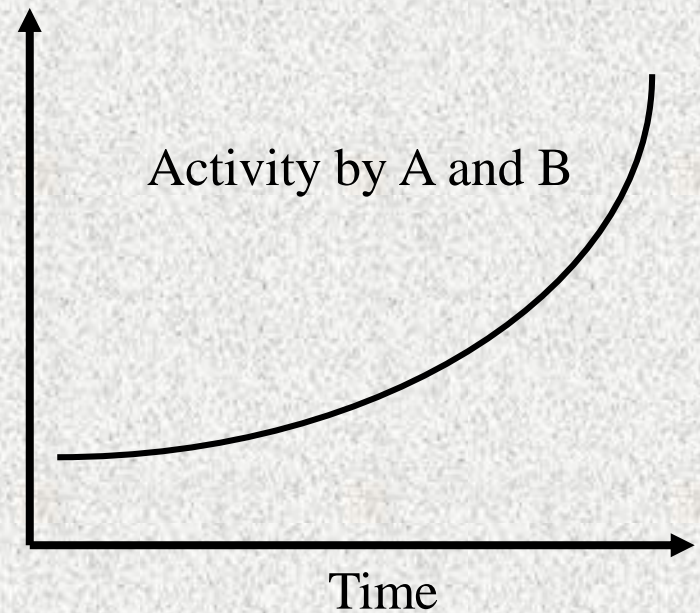
4.2 Escalation

1.1. Fixes that fail / Backfire

1.2. Shifting the burden / Addiction

Capture side effect, find fundamental solution

2.1. Limits to success

2.2. Growth and underinvestment

Manage your limit, evaluate alternatives

3.1. Success to the successful

3.2. Tragedy of the commons

Collaborate and protect commons

4.1. Drifting goals

4.2. Escalation

Careful goal setting

Systems archetypes