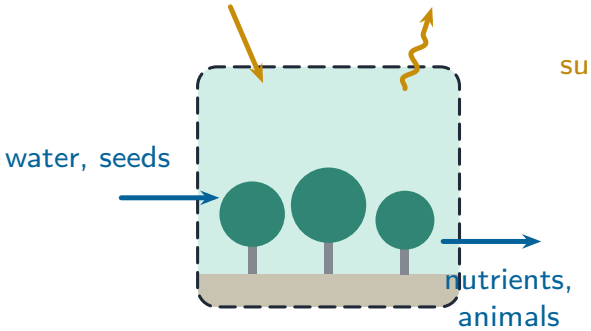
Exercise walk-through

1.2
Systems, feedback and models

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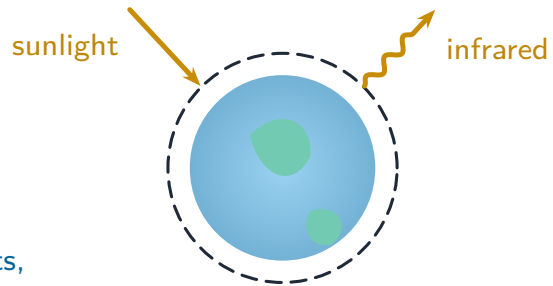
Types of system

open



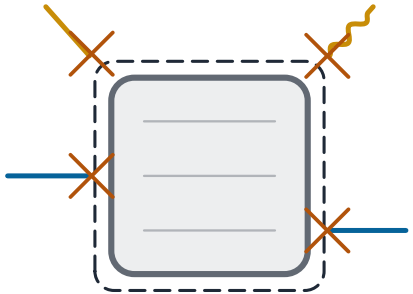
a forest
energy and matter
cross the boundary

closed



Earth (almost)
energy crosses;
matter does not

isolated

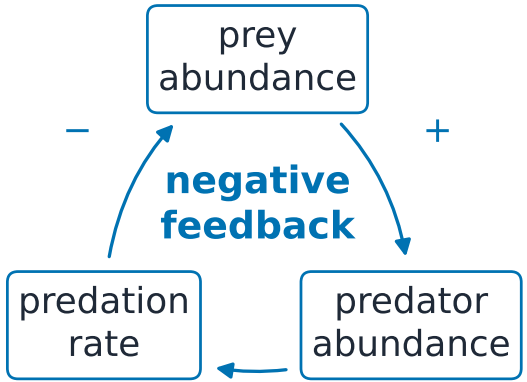


an ideal model
neither energy
nor matter crosses

energy matter system boundary

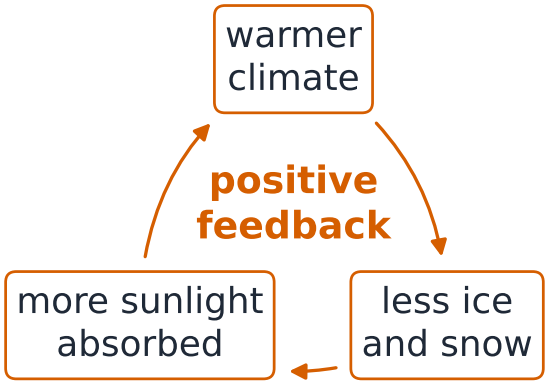
Energy and matter crossing the **boundary** determine the **system** type.

Feedback



\+

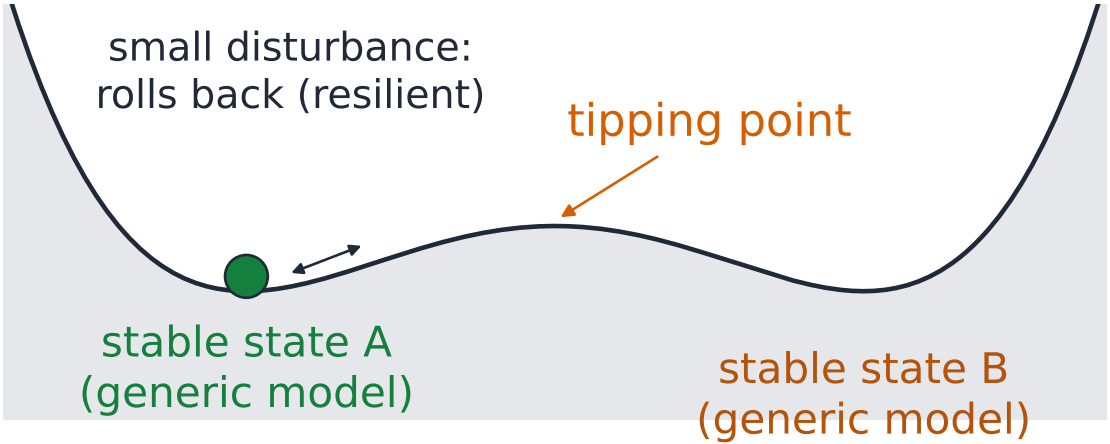
opposes the change;
delays can cause cycles



reinforces the change;
not a value judgement

> Trace the complete loop; its sign does not judge whether the outcome is good.

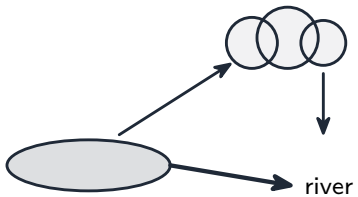
Tipping points and resilience



- Generic **model** of alternative states, not an exact Amazon clearing threshold.
- Functional diversity and suitable recovery traits can help; context matters.

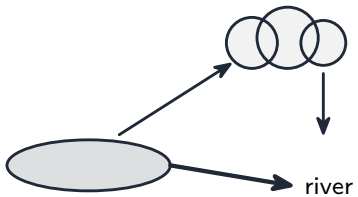
Exercise 2.1

2.1 Distinguish between a transfer and a transformation, with **one** example of each from the water cycle. [2]



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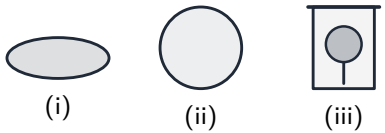


2.1

transfer: matter moves place without changing form, e.g. runoff or a river flow; transformation: matter or energy changes form or state, e.g. evaporation or condensation

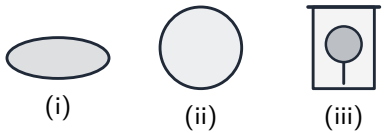
Exercise 2.2

2.2 Classify each as an open, closed or isolated system, with a reason: (i) a pond; (ii) planet Earth; (iii) a sealed jar of pond water with plants, kept in the light. [3]



Exercise 2.2

2.2 Classify each as an open, closed or isolated system, with a reason: (i) a pond; (ii) planet Earth; (iii) a sealed jar of pond water with plants, kept in the light. [3]



2.2

(i) open: energy and matter (water, animals, nutrients) enter and leave; (ii) closed: energy enters and leaves, but almost no matter; (iii) closed: light enters and heat leaves, but no matter

Exercise 2.3

2.3 For each loop, state whether it is negative or positive feedback, and explain. (i) A deer population grows, so food runs short. (ii) Permafrost thaws and releases methane, which warms the climate further. [3]



Exercise 2.3

2.3 For each loop, state whether it is negative or positive feedback, and explain. (i) A deer population grows, so food runs short. (ii) Permafrost thaws and releases methane, which warms the climate further. [3]



2.3

(i) negative: less food raises deaths and lowers births, so the population falls back; (ii) positive: methane is a greenhouse gas, so warming causes more thawing and more warming

Exercise 3.1 (a)

3.1 The diagram shows a simple lake system.

(a) Identify **one** transformation in the diagram. [1]

Exercise 3.1 (a)

3.1 The diagram shows a simple lake system.

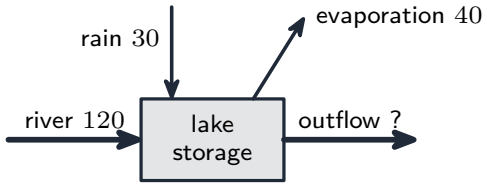
(a) Identify **one** transformation in the diagram. [1]

(a) evaporation (liquid to gas)

Exercise 3.1 (b)

3.1 The diagram shows a simple lake system.

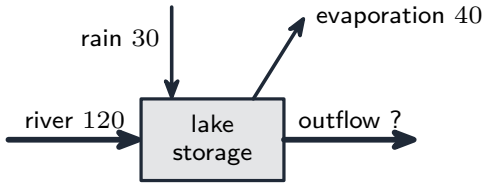
(b) The inflows are 120 and 30 units a day; evaporation is 40 units a day. The lake level is steady. Calculate the river outflow. [2]



Exercise 3.1 (b)

3.1 The diagram shows a simple lake system.

(b) The inflows are 120 and 30 units a day; evaporation is 40 units a day. The lake level is steady. Calculate the river outflow. [2]



(b) inputs = outputs at steady state: $120 + 30 = 40 + x$; $x = \mathbf{110}$ units a day

Exercise 3.1 (c)

3.1 The diagram shows a simple lake system.

(c) State what would happen to the storage if the outflow fell to 80 units a day. [1]

Exercise 3.1 (c)

3.1 The diagram shows a simple lake system.

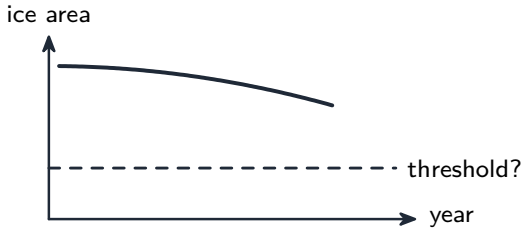
(c) State what would happen to the storage if the outflow fell to 80 units a day. [1]

(c) inputs exceed outputs by 30 units a day, so the lake storage rises

Exercise 3.2 (a)

3.2 Arctic sea ice reflects most of the sunlight that reaches it; open sea absorbs most of it.

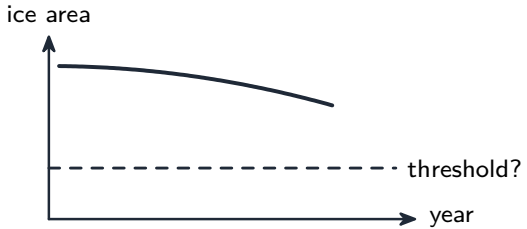
(a) Explain how the loss of sea ice is an example of positive feedback. [3]



Exercise 3.2 (a)

3.2 Arctic sea ice reflects most of the sunlight that reaches it; open sea absorbs most of it.

(a) Explain how the loss of sea ice is an example of positive feedback. [3]



(a) warming melts sea ice, exposing darker water; albedo falls, so more solar energy is absorbed; the water warms and more ice melts, so the change grows

Exercise 3.2 (b)

3.2 Arctic sea ice reflects most of the sunlight that reaches it; open sea absorbs most of it.

(b) Explain what is meant by a tipping point, using the sea ice as an example. [2]

Exercise 3.2 (b)

3.2 Arctic sea ice reflects most of the sunlight that reaches it; open sea absorbs most of it.

(b) Explain what is meant by a tipping point, using the sea ice as an example. [2]

(b) a threshold beyond which the system changes to a new state; e.g. once summer ice is lost, warm open water may stop it re-forming, and the change is hard to reverse

Exercise 3.2 (c)

3.2 Arctic sea ice reflects most of the sunlight that reaches it; open sea absorbs most of it.

(c) State **one** limitation of a climate model used to predict when the Arctic will be ice-free in summer. [1]

Exercise 3.2 (c)

3.2 Arctic sea ice reflects most of the sunlight that reaches it; open sea absorbs most of it.

(c) State **one** limitation of a climate model used to predict when the Arctic will be ice-free in summer. [1]

(c) any one: simplifies processes such as clouds or ocean currents; depends on future emissions, which are unknown; limited past data