1.3 Energy and Equilibria

1.3.1 The nature of equilibria

Equilibrium is the tendency of a system to return to its original state following a disturbance (eg. fire, agriculture).

a) Steady - state equilibrium is a characteristic of open systems where there is a continuous input and output of energy and matter, but the system itself remains in a constant state (eg. a climax ecosystem like a rainforest).

In a steady – state equilibrium there are no long-term changes, although there may be small fluctuations in the short term (eg. in response to weather changes), but the system will return to its original equilibrium condition after the disturbance passes. During a succession the system might undergo long-term changes, but again it will return to its original state.

b) Static equilibrium refers to an ecosystem where there is no change over time. If a static equilibrium is disturbed, it will adapt a new equilibrium as a result of the disturbance. This kind of equilibrium refers mostly to non-living systems like a pile of rocks. This means that they will not change position or state and they remain like this for long periods of time. Therefore, static equilibrium cannot occur in living sytems!

Systems can be stable or unstable:

c) Stable equilibrium refers to those systems that will return to the same equilibrium after a disturbance.

d) Unstable equilibrium refers to a system that will return to a new equilibrium after a disturbance (eg. new climatic conditions, hence the new state will be hotter).

1.3.2 Positive and negative feedback

Feedback mechanisms either change a system to a new state or return it to its original state. Feedback loops can be positive or negative.

For example if we feel hungry we have the option of eating and return to our original state (negative feedback) or not eating and feel more hungry changing to a new state (positive feedback).

When we feel cold, we can wear clothes (negative feedback) or stay with less clothing and feel even colder (positive feedback).

Natural systems act exactly the same way. The information starts a reaction, which in turn may input more information which may start another reaction. This is called a "feedback loop".

Negative feedback tends to bring back, neutralize any deviation from an equilibrium, and it stabilizes systems or results in a steady-state equilibrium. Therefore, it results in a self-regulation of a system.

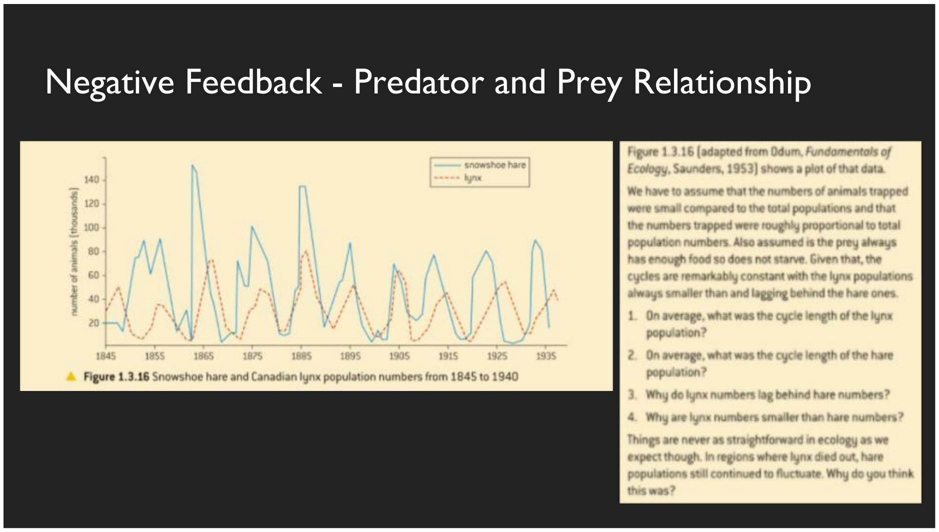
An example involves body temperature when it starts rising above 37 C during a very hot summer day.

→ Sensors in the skin detect that the surface temperature is rising, therefore we start sweating in an effort to lose heat.

Predator-prey interactions: The **Lotka-Voltera model (1925),** also known as the predator-prey model, shows the effect of changing numbers of prey on predator numbers.

→ If prey populations increase, there is more food for the predator, so they eat more and breed more, resulting to more predators which eat more prey, hence prey numbers decrease.

→ If there is less prey, there is less food for predators which in turn decrease in numbers (negative feedback, self regulation).



Positive feedback leads to an increasing change in a system, which is destabilized and pushed to a new state of equilibrium. The process may speed up, taking ever-increasing amounts of input until the system collapses.

Global warming: Higher temperatures may cause more evaporation so lead to more water vapour in the atmosphere. Water vapour is a greenhouse gas so will trap more heat so the atmosphere will warm more (positive feedback).

1.3.3 Resilience

Resilience is the ability of a system to return to its original state after a disturbance. It is a measure of how his system response to a disturbance, such as food, fire, pollution, new climate, disease, extinction etc.

A system is more resilient:

- The more complex it is
- With higher biodiversity
- With a larger ecosystem
- When species have foster reproductive rights and wider geographical ranges
- The more negative feedback loops in place

In a nutshell:

1. Most natural systems are open systems
2. They mostly remain in steady-state equilibrium
3. After a disturbance, a stable system is more likely to return back to its original state

1.3.4 Tipping points in keystone species

Tipping points or care when there is a dramatic change in the ecological state, away from equilibrium. They represent points beyond which irreversible change or damage occurs usually due to human population growth.

Tipping points:

- Involve positive feedback for example deforestation = less rainfall = more forest fires = less trees
- Threshold is reached which means the ecology / biodiversity changed a lot
- Cannot precisely predict when tipping point is reached
- Changes are long lasting and hard to reverse

Examples of tipping points:

Tipping points are often reached on a local / regional level but not on a global level such as lake eutrophication, coral reef death, extinction of a keystone species

Keystone species:

This is the place in essential Road and the structure, functioning or productivity of a habitat or ecosystem.

Examples:

Elephants from the savanna (they play in important role in a balancing natural ecosystem)

Pine Forest (pine tree provides food, shelter and if they are lost then the forest would be irreversible)

So having keystone species, reduces resilience!