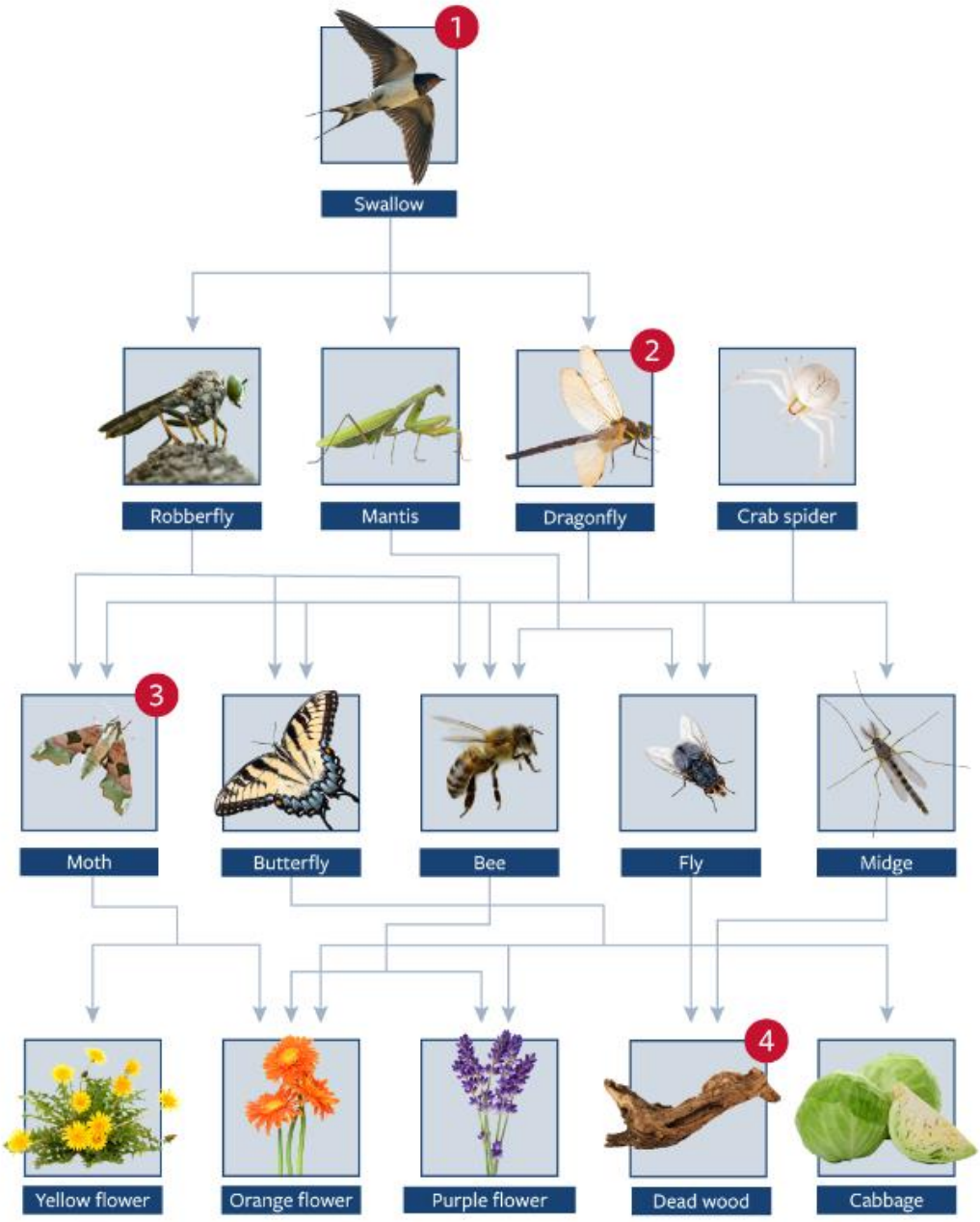
UNIVERSITY OF LEEDS

Full text description

Lesson 2 – How does an ecosystem collapse?



Introduction text

Conservation biologists think about the interactions between predators and prey, parasites and hosts, and herbivores and plants as an ecological network.

Here, you can see a simplified version of a terrestrial ecological network (real networks would have thousands of species and tens of thousands of connections!). The species names are not important for this exercise, but hopefully you can see their respective roles in the network. The purpose is to show you what happens when different species are lost from ecosystems.

Graphic description

An example food web depicting simple terrestrial ecosystem. At the top there is a swallow as the top predator. In the middle there are two layers of insects and at the bottom there are plants and other vegetation.

Level 1

- **Swallow**
  - Robberfly
  - Mantis
  - Dragonfly

Level 2

- **Robberfly**
  - Moth
  - Butterfly
  - Bee
- **Mantis**
  - Bee
  - Fly
- **Dragonfly**
  - Moth
  - Butterfly
  - Bee
  - Fly
  - Midge

- **Crab spider**
    - Moth
    - Butterfly
    - Bee
    - Fly
    - Midge

Level 3

- **Moth**
    - Yellow flower
    - Orange flower
- **Butterfly**
    - Orange flower
    - Purple flower
    - Cabbage
- **Bee**
    - Orange flower
    - Purple flower
- **Fly**
    - Orange flower
    - Purple flower
    - Dead wood
    - Cabbage
- **Midge**
    - Dead wood

Level 4

- **Yellow flower**
- **Orange flower**
- **Purple flower**
- **Dead wood**
- **Cabbage**

Text boxes

Level 1 - Species 1 is lost

What would happen if this first species is lost?

The species at the top of the ecological network – a swallow – is a “top predator”. This means that the swallow eats other animals but, in this case, is not eaten by anything else. When you remove top predators, the species that would have been consumed by that predator can increase in number.

However, this does not mean that the whole community of species will increase in number. The swallow had been eating dragonflies, praying mantises and robberflies and each of those species are also predators. If the three insect predators now increase in number, they will eat more of the insects on which they feed. That increased “predation pressure” will, in turn, reduce the abundances of the insects in the lower levels of the ecological network.

Finally, the plants and dead wood at the bottom of the ecological network will increase in abundance because there are fewer animals left to eat them. We call this a “trophic cascade”, when a big change in one part of the ecological network causes ripples through the network.

The key aspects to note here are that:

1. The loss of the top predator has caused a cascade of changes in abundance through the network.
2. Cascades of this type can lead to reductions in the stability of the network, such that subsequent changes cause much larger (and sometimes irreversible) ecosystem shifts.

Level 2 - Species 2 is lost

What would happen if this second species is lost?

The species in the second level of the ecological network – a dragonfly – is a voracious predator, but not a top predator because it is eaten, in turn, by the swallow. This means that the dragonfly plays an important role connecting the lower parts of the ecological network (the prey that it eats) with the higher parts of the ecological network (the predators that eat it). In this way, the dragonfly acts as a transport for nutrients from the plants and wood at the bottom of the ecological network to the larger animals at the top.

When you remove these intermediate predators, the species that would have been consumed by that predator (here, moths, butterflies, bees and flies) can increase in number but the species that may have consumed them (the swallow) may decrease.

Note, however, that the response of the rest of the ecological network is different here to the loss of the swallow. The dragonfly is a generalist predator that will eat any insects smaller than itself. That means it does not have any single strong relationship that might lead to a strong response to its loss. Instead, there are several insect predators that can "buffer" the loss of the dragonfly by consuming the prey that the dragonfly no longer eats. This buffering effect is one of the most important reasons why we want to conserve many similar species in an ecosystem.

The key aspects to note here are that:

1. The loss of an intermediate predator may have an effect on higher and lower parts of the ecological network.
2. Having many species with similar roles in an ecosystem can buffer against the loss of any one species improving "resilience".

Level 3 - Species 3 is lost

What would happen if this third species is lost?

The species in the third level of the ecological network – a moth – is an important pollinator that is vital to plants and also important as a food source for predators. Pollination is essential for many plants to reproduce, and moths play a vital (though often underappreciated) role in transferring pollen among flowers at night.

The relationships between plants and their pollinators are very similar to the relationships between predators and their prey: losing one of a pair of interacting species results in changes to the other species. Here, however, there are quite different effects for the plant than there were when we removed species 1 (the swallow) and species 2 (the dragonfly).

There is one plant that is solely dependent upon the moth for its pollination (the yellow flower in the bottom level of the network). We call these species with small numbers of interacting species or narrow preferences for environmental conditions "specialists". Since the only pollinator of that plant has now been lost, that plant is also going to be lost from the network. We call this a "secondary extinction", where a species is lost because a species on which it is dependent has gone extinct.

The key aspects to note here are that:

1. The losses of some species may result in losses of other species if there are strong relationships between the two: called a "secondary extinction".
2. Specialist species are much more at risk of loss than generalist species.

Level 4 - Species 4 is lost

What would happen if this fourth group is lost?

The species in the fourth level of the ecological network – a dead wood – is not a species of animal or plant, but it is a vital resource for many other organisms. It has been included to illustrate that these ecological networks are as much about nutrients as they are about species. The dead wood contains a lot of valuable compounds that are consumed by beetle and fly larvae, and act as a home for many more.

If you follow the logic that we used when considering the consequences of losing species 3 (the moth), you will see that the dead wood is an essential resource for the fly and the midge. Those species will, therefore, be lost from the network as secondary extinctions. Sadly, this kind of effect is all too common when we try to “tidy” natural spaces by removing dead wood that is considered unsightly or unsafe.

The loss of these two species (fly and midge) is likely to be greater in impact than the loss of species 2 (the dragonfly) as they represent a far larger proportion of the species in the third level of the ecological network. The loss of two species may increase competition for food among the insect-eating animals in the second level of the ecological network. That competition may lead to population declines that lead to less food being available for the top predator, our swallow. In this way, you can see that a trophic cascade (like the cascade seen when we lost the swallow) can also arise from a change at the bottom of the ecological network.

The key aspects to note here are that:

1. Trophic cascades can result from changes at the bottom of the ecological network, as the overall nutrient inputs into the system change.
2. Ecological networks are often shown based solely on species, but other sources of nutrients are essential for ecosystem function.