Transcript Lecture 12 Community Ecology 2

Slide 1

In this lecture we are going to be talking about succession.

Slide 2

The learning outcomes for this session.

We aim to understand the difference between primary and secondary succession.

We will use many examples of primary and secondary succession, we will be able to describe pioneer and climax communities and species and we will be able to describe how disturbance affects succession.

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If all environmental conditions, (including biotic) were to remain stable then eventually we might expect communities to settle into an equilibrium state where interactions are balanced. This would result in a community of static or stable composition. Environments are not static, however, both physically and biotically. Climate is variable, catastrophic events such as floods storms and volcanoes occur, species migrate and/or evolve and change their interactions in response to environmental changes. Change in community structure and composition in response to change in the environment is usually directional and is known as succession.

Understanding succession is important to allow prediction of community changes after disturbance, such as pollution or land reclamation.

So succession refers to a change in a community that is not random. It occurs in a certain direction on a site, usually from very small, short lived plants to mature forest. It is a very important part of community ecology, because it considers the effect of time on an ecosystem. We are not talking about days or seasons. The concept of succession considers how an ecosystem changes over many years because of the changing opportunities for different species.

And here in this image, we can see that over time we go from short lived, small plants and over time they get longer lived and larger until you end up with a stable mature forest.

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We know ecosystems are not the same in space, and they do not stay the same over time. So we need to account for these changes. When we think about ecosystems succession has three types: primary, secondary and cyclic. Succession is directional, it tends to go from small annuals to large perennial trees, but sometimes disturbance happens. And this can return the ecosystem to an earlier state.

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Primary succession is the change in community composition after a new substrate is exposed. Examples of this are bare rock or lava flow. Abiotic factors are very important in allowing species to colonize. The exposure of the substrate and how much water and sunlight it will receive are key factors that will determine how quickly primary succession occurs.

The first colonizers on bare rock tend to be lichens and mosses. These break down some of the rock to create a very simple early soil. Dead material may allow small annual plants to grow. Over time the conditions become more hospitable for plants, the site will begin to accumulate dead material and plants will start to break apart the rock using roots.

When a stable community occurs that is no longer changing, this is known as the “climatic climax”. Only very small and slow changes are observed at this point, we may consider a rain forest to be at a climax stage. But in reality, it is difficult to identify a true climax in the field because there will always be factors that cause change.

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Primary succession can occur on a range of newly revealed substrates or parent material. The type of substrate will define the community. So if there was an avalanche, for example, and bare rock was exposed, the community that started to grow on that rock would be called a lithosere because litho- means rock. We can also get psammoseres, which form on sand making sand dune grasslands and later forest. A halosere refers to a very salty substrate. It might form a salt marsh ecosystem. Each of these will have typical plant and animal species for that particular sere.

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In the UK radio carbon dating was carried out on pollen from forests to look at the succession of trees over the last 10,000 years. They studied the spread of different tree species using these pollen data from all over the UK and they showed the shift in range of some very common species, since the last ice age. We can see from this graph, which has area of the tree species covered just here. And years before the present from 10,000 years to 1000 years along the x axis so 10,000 years to 1000 years. We can see the tree cover is constantly changing.

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Here is one of the maps from the Birks paper, and it just illustrates really nicely how pollen can be a useful tool and finding how long a species has been present in an area. So in this map *Quercus robur* which is one of our most common and beloved trees was found far in the southwest 9500 years ago.

As the climate warmed the oak was able to move further north until it was found all over the UK.

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As primary succession continues, there are certain directional changes to ecosystem properties. The first is that biomass will increase over time before flattening off in what looks like a logistic curve. This is because as organisms live and die, there are more nutrients and resources in the system. This enables larger organisms to colonize and establish. However, productivity, which is the amount of biomass created at a given time point, steadily increases until mid-succession and then decreases again. This is because as succession continues the lifetimes of organisms increases. And so they do not need to keep growing once they have reached a certain size. A forest of mature trees would have a very low growth rate, but a very high standing biomass.

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The effect of succession on biodiversity is that new species keep arriving until the community reaches a stable equilibrium or climax. It is thought that after the peak community productivity and biomass are achieved some species might leave the area because they cannot establish, and negative species interactions such as competition or predation will remove them while the stabilizing phase occurs.

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In this example, from our course textbook, the Begon book, we can see how animals and the soil community follow plant succession trajectories. This is often the not always the case.

Here we see how birds in the USA have preferences for different stages of succession in old fields.

The width of the bar denotes their presence and the darkness of the bar shows the relative abundance of each bird species. If it is dark, there are many individuals at that particular point in the community succession.

We can also see under the community type three species of arbuscular mycorrhizal fungi. These show a clear pattern of replacement over successional time.

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Secondary succession is when all vegetation is removed and plants colonize using existing biological material. For example, if you plough up a piece of grassland there will still be soil nutrients and seeds to start from. Unlike in primary succession, where the growth begins from virtually nothing The result of this is very similar to primary succession, but it starts from the midway point of primary succession.

In the UK we usually get small shrubs that include and move into grasslands. These then give away to small trees like birch and finally oak.

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Some examples of secondary succession are chalk grassland, which is quite common in Europe that moves to forest later on. We also have heathland so heathers. They have very acidic soils and they will turn to forest later on and then Oldfield succession, which is a classic example by David Tilman who we looked at a few weeks ago.

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Allogenic succession is succession that is initiated by external factors like storms or some kind of geophysicochemical force. For example, in this figure we can see the way the salt marsh is increasing in size due to sediment deposited at the mouth of the River Fal. Over time, this has allowed the size of the forest, which is the darker red, to increase. Succession is therefore occurring as a result of this sediment increase.

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Autogenic succession is succession driven by the biotic factors of an ecosystem. The role of organisms in the progression of succession is recognized to be very important, as it can determine the community composition of later succession or communities. At a very early stage of succession, the species that are already present can have all sorts of microclimate effects or produce nutrients or make some kind of change in their surroundings that help or hinder other species.

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This slide is a bit of a reminder of our species interactions lectures. Succession can result in help or hindrance for newly establishing species. Facilitation is where the first species to arrive aids colonisation or establishment of the second. It is seen in primary succession, because the starting conditions are usually very severe. This means that it is difficult for any species to colonize so the one that does will immediately make things easier for the next. It also means that the first species is unlikely to be able to fill the entire area so competition will not be strong.

Inhibition is where the first species to arrive will reduce the ability of the second species to colonize or establish. This is often called a priority effect and is seen in secondary succession, where there are already resources for the species to use.

There is a lot of work on community assembly and the impact of the order of arrival on community dynamics.

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Fukami in the paper that is on the reading list suggested that priority effects can result in differences in the way the community assembles and the composition that results.

The first outcome is alternative stable states. This means that the final outcome community could be different based on the sequence of species arriving in the area. Once a community enters an alternative stable state, it cannot move to another stable state unless there is a strong disturbance.

Stability here is defined by the locally coexisting species to be permanent members of the community and they are resistant to colonization by other species in the species pool.

Alternative transient states occur when communities are undergoing multiple pathways of succession.

This occurs when they have not reached a stable state and have lots of population or function changes over several generations.

Compositional cycles occur through interactions such as multiple species predator-prey interactions. There is no stable state, just cycles of community change.

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One example where succession can be seen is in gaps that appear when an organism dies or is removed. It is important to note that succession can occur at a range of scales. In this example, a tree has died in a forest and left a gap. And this is a really nice case study of succession, because it shows how the first species that arrive is ash, which is a very fast growing species and it will grow quite tall. The seeds are small and easily carried on the wind. So they will quickly move into the gap and colonize it.

Later oak seedlings will appear. They have large, heavy seeds that are carried by animals. And so, only a few will be present in the gap. You can see very small letter Q where they are present.

Finally, there will be a lot of beech seedlings, which are all these small F's. These are shade tolerant, so can grow underneath the canopy of the other trees.

Competition is very intense in these gaps. As you can see, there are many seedlings, and probably only one will survive. Having a lot of seedlings is useful, though, because many seeds and seedlings will be eaten by animals. Watt also noticed that the small forbs present prevent a lot of tree seedlings from growing. And so these priority effects mean the seedlings at the edge of the gap, like the beech is here, are more likely to grow to trees than the ones in the middle of the gap. Patch dynamics is a large subject of study in ecology with many people building models to predict successional dynamics.

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So we have a gap with many different tree species or trying to be the next big tree. Which one will it be?

There are a lot of variables which we have talked about over the weeks.

Mast is the fruit of forest trees like oak and beech. These fruits are big and use a lot of resources to create. So some years they make hardly any, and some years they create an enormous amount of fruit. The year with a lot of fruit is called a mast year. This can take place in Asia, any frequency between two and 12 years. In a mast year, it is more likely that a tree species will succeed and getting a new tree to grow in a gap due to sheer numbers of fruit.

Replacement does come down to chance. But once a tree reaches a certain size, it will probably win the competition.

Now we'll talk about strategies.

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Plant strategy is very important in succession and we can characterize species approximately in to pioneer and climax species. The pioneer species are quite robust and grow rapidly. They are tolerant of extreme conditions like bare rock or sand and they do not live long. The climax species come later and are slow growing with fewer seeds and slower growth.

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We can return to the r and K selection strategy as a comparison. Pioneer species we would say are more likely to be r-selected. This means that they are reproduction selected so in unstable or harsh environments they can reproduce quickly. They are not designed to compete with others.

By contrast, the K-selected or carrying capacity selected species are more likely to be climax species. They are strong competitors in crowded areas which means they tend to do better later in succession.

Pioneer or r-selected species are often found in disturbed habitats. They can quickly colonize when the new gaps appear. K selected climax species are associated with more stable environments. So, for example, a forest cannot grow on a ploughed field.

In our Watt paper example, we can see that the ash seedlings were more likely to be r selected with lots of small seeds, while the oak, which have large, heavy seeds brought in by animals was more likely to be K selected.

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A ploughed field is an example of cyclical secondary succession. It will take the land back to a state where the vegetation needs to re-establish from existing biological material.

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This is a table of characteristics of ecosystems that early and late stages of succession. Now I'm not suggesting that you look too closely at this now, but it is a potentially useful resource that will be made available.

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This is a conceptual diagram from the Begon textbook showing how we arrived at the community composition that we see in an area. We have various species pools that are filtered by either environmental conditions or the ability to disperse and arrive at a location.

The species that can survive both of these filters become part of the ecological species pool and they are subject to internal dynamics, or species interactions. This will lead to competition, predation and so on, which will reduce the species pool further

In theory, we are left with the realized community which is species that can cope with the abiotic conditions, disperse to the area and then survive the species interactions. All of these factors are subject to changes in space and time.

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So in summary, primary succession occurs from bare substrate and it requires r-selected pioneer species to begin growing.

Secondary succession occurs from existing biological material, it can be thought of as beginning at the middle of primary succession.

Stable K selected climax communities are thought to be the end point of succession.

But there may be many alternate stable states or cycles that mean a true climax is never reached.

Reading

Chapter 16 Begon

Fukami paper

Birks tree pollen

Discussion topics

1. What is alpha and beta diversity?
2. Why is diversity important?
3. What are the benefits of high diversity (to people or for ecosystems?)