Lecture 15 Habitat Fragmentation

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This week we are moving into talking about the main threats to the natural world. This session will be based on habitat fragmentation and the next session we will talk about invasive species.

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So the learning outcomes for this session, we will learn what habitat fragmentation is we will understand what an edge effect is and the impact of edge effects on microclimates. We will finally be able to understand the impacts of fragmenting a landscape.

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Habitat fragmentation is where a large area of habitat is broken up into smaller fragments, or patches that are isolated from each other. It can occur naturally, such as when a lava flow from a volcano moves through part of a habitat. But we are particularly interested in human activity or anthropogenic fragmentation.

Once the initial disturbance or incision has occurred, loss of the habitat might increase. This is particularly true of road building through tropical rainforests. Remember our look at metapopulations?

Habitat fragmentation is a way of creating metapopulations artificially, and this is a cause for concern among ecologists because it will substantially alter population sizes of organisms that need to live in the core of the habitat, (the middle) and also those that live on the edge.

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When a disturbance removes some habitat and causes fragments, you create an edge along the divide between the two new habitats. So if you put a road into a forest, you would create an edge where the forest met the road. The effect of this edge is very important in ecology.

Edges can be described in terms of contrast. A high contrast edge means that there is a sharp change in environments. So, for example, a field or a road. They are often more linear in appearance and the sharp edges mean that it is difficult to penetrate either way. This is called reduced permeability.

By contrast, you could have a more gradual change from one habitat to another, and the intermediate section where you're halfway between each is called an ecotone. These are less linear and more irregular with greater permeability.

The habitat will have a large range of species, and some will be adapted to only live in the heart of it.

They will not be able to survive at the edges. The edge effect, which is a term that includes all aspects of the changes, means that there will be reduced space for the species inside the fragment. It also means that predators and parasites increase along forest edges. So it is not safe for prey species to cross out of the fragment into other fragments. There will be less cover for the prey species to hide in.

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The microclimate is the climate in the small areas, and it can be affected by elevation vegetation, the presence of water bodies and so on. So when we were talking about nurse plants. For example, a plant in the desert could create a shadow where it is cooler underneath and this could be a microclimate that helps other species to grow. So if you create a gap or a fragment in a forest, the forest fragment will have a different microclimate to outside of the fragment. It will be more windy, hotter and less humid outside the fragment. This effect will also be felt in the edges of the fragments up to 300 meters into the fragment. Some species will increase along the edge because it makes foraging for food or prey easier. There is more visibility. Others will stay away. In forests edge effects can result in increased fires, because they are more dry. These local scale microclimate effects can shape the plant, animal and microbial community.

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In this study of vertebrate animals by Marion Pfeifer and colleagues, they looked at species density, that is the number of species in an area of land, and tested to see if density was different in the middle of a fragment or along the edge. They looked at 1600 species across the world and showed that 85% of the species were affected by forest edges. Birds and small reptiles increase along the edges of the forests. Birds are easily able to move and choose their habitats. Reptiles tend to be predators. So would be using the edges to forage. In the middle of the fragment, you get more mammals and amphibians. These may be herbivores. They may have small home ranges. Amphibians in particular are very sensitive to abiotic conditions and may have difficulty adapting or dispersing to new areas.

Pfeifer’s work shows that the species that live in the core of the fragments are more likely to be listed as threatened on the IUCN red list. These reach peak abundance (maximum abundance) at distances 200 to 400 meters away from the edge. So this means that the more fragmented the environment, the fewer species will be able to survive.

So what we're looking at in this graph on the left we have the density of the species. At the forest edge in these light bars, and the forest core in the darker bars. What you see is that at the edge you have more birds and reptiles and in the core you have more amphibians and mammals. The graph on the right shows the sensitivity to the edge. The sensitivity means the amount of effect the edge has. So we can measure how affected a species is by an edge. And this can be positive or negative. So some species like the edge, as we've seen, and some do not like the edge.

The top of the bar shows the top 75%. The middle of the bar with the notch shows mean, and the bottom of the bar shows bottom 25% of species here. These are just a scatter. So all the species that are not clustered. This line shows all of these means are approximately in the same place. There is not a very big difference between the mean or the average of each of these groups. They are all approximately in the same place. The top of edge sensitivity is also quite similar. But what we see is that there were more species that are less sensitive to the edge.

So the amphibians and the mammals have larger bars than the reptiles and the birds. So these bars are larger than these two. This means a larger range of values of edge sensitivity. This means that some are not very sensitive at all and show no response. Reptiles and birds have low variation, which means they all respond in a similar way.

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One place we can test habitat fragmentation is in the Amazon rainforest. When people create roads into pristine, that is, untouched forests, they create incisions that separate populations of organisms and create opportunities for other organisms to move up and down the road into new habitat patches.

In this set of figures we see the road network of the Amazon rainforest in 2000 these three on the left.

And 2008 in these three on the right. The result of increasing road building is a loss of biodiversity and there are many reasons for this, including roadkill disturbance and creating barriers to dispersal of some organisms. In the bottom diagrams we can see that species richness of birds is lower in areas that have many roads. So we can see here that low species richness is pale and high species richness is very dark. And if you compare the location of the roads, the most roads with the species richness, we can see that where you have no roads, you have the highest species richness and when you have a lot of words and an area you have low species richness. This middle graph shows the extent of the forest in the grey and you can see that it's very much broken up and destroyed where the roads are very dense.

In this paper, which I will share, Dr. Ahmed highlights bird species has been very highly affected by the increasing road building. Birds are particularly important in tropical deforestation, and many studies have looked at the effect of building roads. Negative effects have been observed on reproductive success, mortality, site occupancy of nesting areas, movement patterns and vocal activity.

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Fragmentation of a habitat therefore has very significant effects on the individual species survival and behaviour and also on ecosystem functions and services. In summary, if a habitat has very little disturbance or fragmentation, there is high connectivity between patches which means the species can disperse and are less likely to go extinct. A complete area of a habitat also has lower risk of being invaded by other organisms and ecosystem functions will be more stable. For example, nutrient cycling will occur at a stable rate and will not be lost from the system through leaching nutrients into the groundwater or exporting nutrients out of the system.

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We know that when habitat is lost, we also see biodiversity decline. In a recent paper Professor Chase discussed two ways this might happen. The first is the species area relationship. Fewer species can persist in smaller habitats. Rare species will therefore go extinct faster. We see that species are lost in proportion to their abundance and distribution in the natural habitat.

In this graph, conducted using data on a range of organisms across the world, Chase looks at how the size of the fragment is related to the number of individuals, the number of species and the evenness of the organisms. So that's B, C and D. Number of individuals, species richness, species evenness. Evenness talks about the relative abundance of a species. If you have low evenness you have a community with some species that have many individuals and some species with only one or a few. If smaller habitat fragments have a low evenness, this means more very rare species that are at risk of going extinct. Chase says that this is evidence of ecosystem decay, which is the second potential way of losing biodiversity.

Ecosystem decay is where biological processes in small fragments are different to those in large fragments, and increase extinction risk. This could be due to edge effects, lower dispersal or the range size needing to be bigger to avoid conflict between individuals.

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I'm going to talk briefly about the SAFE project taking place in Borneo. The experiment is designed to look at the effect of converting tropical rainforest into oil palm through progressively more intensive logging. It is one of the world's largest ecological experiments.

The project aims to discover how the species and ecosystem functions can survive in a forest as it is fragmented. One part of this study looks at all the ecological concepts we've looked at in this lecture.

So are the spatial structure of a landscape and the connectedness of the fragments kind of alter the effects of logging. Another very important part of the project is looking at waterways. So the findings from this project will give people working in the tropics all over the world insight into the effects of habitat fragmentation.

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This is a map of the experimental design of the SAFE site in Borneo. The map shows the four different types of land use, which are 1) rainforest fragments, 2) the forest that has had some logging of individual species 3) forest that has experienced more intensive logging, and finally, 4) the land that was planned for oil palm.

So in this map we can see the different colours correspond to the different types of logging. The black dots are the points where the researchers take samples and they will take samples regularly at the same points to show the changes in animal and plant life and ecosystem function.

I invite you to take a look at the website as there is a lot of information and all of the findings from the experiment so far.

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So some key findings of the study showed that for freshwater fish in streams diversity decreased in all logged areas. So it didn't matter if only one tree species was taken in an area and the rest of the forest left intact, or if the entire forest was cut down and converted to oil palm. The effect on fish diversity was always the same. The authors thought that this could be because trees provide shade, which is good for fish trying to reproduce. When the shade is gone, the water warms up. And also it is likely that the loggers are taking the tallest oldest, most mature trees with the largest canopy, so that is reducing overall shade from the area. The water warms up because the shade is reduced. Trees also provide dead leaf material. This is a food source for many invertebrates that are prey for fish. So overall, this has a negative effect of just removing one plant one tree species that is enough.

A second finding of interest is that moths prefer to move along a riparian strip. A riparian strip is the section of vegetation along a riverbank. The moths would prefer this over going into the continuous forest (the pristine forest), or the oil palm. This means they can use the riparian strip as a movement corridor which means a line of uninterrupted habitat that a species can use to move between habitat fragments. These corridors are very important for keeping metapopulations operating.

The last finding I want to show on here is the effect of logging on animal behaviour. Animal behaviour is very important in ecology. Unfortunately, it is beyond the scope of the course to go into too much detail but behaviour can make all the difference to the ability of a species to survive in a habitat.

The size of an animal's home range, how far it will travel in one day or over its lifetime, and if it will create territories that it will defend against others, are critically important in understanding the impacts of habitat fragmentation. So in this study, the researchers found that in forests that have been logged, 10 species of mammals reduced the distance they travelled in a day and the speed they travelled. This could have consequences for the populations. They could become stressed and reduce their reproduction or come into conflict with each other more often. They might also not be able to find as much food because they cannot forage as far, which could lead to starvation.

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So in summary, after an initial incision into a habitat, for example, a road or farming, loss of the habitat will speed up.

Edge Effects can impact organisms hundreds of meters into a habitat and therefore our understanding of the size of the fragment must take edge effects into account. And this is equally important when we are designing ecological experiments, we have to include an edge effect where we do not sample, because it will not give us a true indication of the effects of our treatment.

And finally, we need to be aware that effects can affect different organisms positively or negatively and so, some will increase and some will decrease.

Reading

Begon Chapter 7

Ahmed- roads in Amazon rainforest

Pfeifer- edge effects on vertebrates

Chase biodiversity loss

SAFE project papers