Conservation Economics
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Module 4
Threats to wildlife
Lecture 2
Threats to species

Namaste!
In today's lecture, we will have a look at the Threats to Species. The threat factors can be discerned from ecology and in the last lecture, we had seen that there are a number of push and pull factors that decide whether an organism will be found in a particular place or not.
Pull factors as you will remember are those factors that attract organisms to them. So, they could include things like a good climate, a good soil, ample amount of food and so on.
Whereas push factors are those factors that push the organisms away from them and they include things like a climate that is very hot or very cold or very dry, so areas that do not have good amounts of food available for them or areas that have predators or diseases.
These are the areas where these factors would be pushing the species away from these areas. So, any organism that is found in these areas, there is a very good chance that either this organism will be killed or this organism will shift to some other place.
There are certain push factors and certain pull factors. Now, when we talk about the threat factors, then if an organism is a threat, what does it mean? It means that the organism is facing push factors everywhere and it does not have a pull factor anymore, which means that from all the areas, this organism is being pushed out and there is no place where this organism is finding a habitat that is suitable for itself.
The threat factors discened from ecology are that you have push factors everywhere and pull factors nowhere and that would be a major threat to any wildlife species. And if you look at these push factors, we can divide them into certain categories. So, the first one has no suitable habitat.
You have an area which does not provide a suitable habitat for the species. It is either too hot or too cold or there are no trees. So, there is no shelter that is available for the organism, there is no food, there are no nutrients in this area or an area that is completely burnt out. So, probably there was a forest fire and this forest fire burnt away all the habitats of a particular species.
In that case, this organism will not be having any other suitable habitat in which to live - areas are rich in noxious factors or are too polluted. For instance, there is a species that is found in a particular lake and this lake is now being used as a dump site for industrial accruals.
When that happens, the organisms will lose out their habitat or areas that are not suited behaviorally because of habitat selection. Probably an organism could have thrived in an area,

but then, this place is all full of such trees that its habitat selection does not permit to use or to prefer as a habitat.

These are push factors that are related to the habitat. Then, there are certain other push factors that are related to competition. Probably, the habitat of the organism is now full of invasive species.

Invasive species are those species that when they come into a habitat, they grow so profusely and they out-compete the native species to such an extent that in a very short period of time, you will only find these invasive species that are predominating these areas.

If an area has invasive species, then probably the habitat will go back or areas that have too many predators or diseases. So, the organism could have lived there, but now there are so many predators in that area that any organism that remains in this area might get killed off or there are a number of diseases in those areas.

There could be competition because of invasive species, because of predators and so on. So, these are other push factors or you could have the push factors of being killed out, specially to by human beings; say due to heavy poaching.

So, for organisms such as tigers, this is a major threat. Then, we also have other push factors in the form of small population dynamics. Now, small population dynamics act when the population has already become very small and these include things such as Allee effect or stochastic difference.

Allee effect is an effect that occurs when the population size has gone down. Now, in the case of a number of species, the size of the population plays a very important role in how efficient this population and the individuals of the population are.

For instance, if we consider a pack of wolves. If there is a single wolf, it might not be able to kill the prey. So, it requires a certain small number of wolves that should be there so that the prey is killed effectively and all the individuals in the pack are able to get their food.

Now, if the pack size reduces to such an extent, that you only have a few wolves. So, these wolves will not be able to hunt in an efficient manner and in that case this would start acting as a push factor for this small pack of wolves. So, this is known as the Allee effect or you could have stochastic deaths.

Stochastic deaths means that you have a random death that is occurring in this area and it is just possible that you already have a very small population, say around 4 individuals and these 4 individuals die off or 3 out of these 4 individuals die off.

Now, this would not have had a big impact if the population size was large. In a pack of say 40 wolves, if 3 individuals died, it could not have mattered much. But in a pack of 4 wolves, if 3 individuals die off, the lone individual will not be able to breed any further and this pack will be as good as gone.

These are the impacts that occur when the population sizes vary and these are known as small population dynamics. So, these are all different threat factors that we can discern from the ecology of different species.

There could be the push factor of an unsuitable habitat everywhere or there could be a biological factor that these individuals are getting completed out because of a invasive species, because of

predators or humans could be involved in killing out the individuals of the population or there could be the small population dynamics because of which there is a big threat to the small populations.

When we talk about these push factors, these push factors can be divided into two categories. There are factors that push a population towards smaller numbers. So, here the population is currently large in size and these are the factors that are pushing the population towards a smaller number.

And these are known as Declining population paradigm. So, the declining population paradigm is the study of those factors that push a large size population towards the smaller numbers and this occurs through population dynamics.

On the other hand, we also have the Small population paradigm which occurs due to factors that push a small population towards extinction. So, in the case of the declining population paradigm, you have a large population and the declining population paradigm is converting a large population to a smaller population.

Whereas, in the case of a small population paradigm, we are talking about a small population that is now being eliminated. So, the small population paradigm comprises factors that push a small population towards extinction.

We can categorize our push factors into the declining population paradigm because of smallness such as things like no suitable habitat. So, if the habitat is becoming unsuitable it is, say, because of climate change. If climate change is occurring in an area, then it is possible that the habitats become too hot or they become too dry or too wet and when such a scenario occurs, then it is possible that the large size populations will now be pushed towards smallness.

Because they are now not getting sufficient food, they are not getting sufficient suitable habitats in which to thrive or we can have this competition. So, competition also pushes a large population towards small size populations.

Or poaching. Now, poaching or heavy poaching, generally reduces a large population into a smaller one. And in the case of the small factor paradigm, we can consider these small population dynamics such as the Allee effect and the stochastic deaths.

Now, when we talk about any population, a population is composed of individuals of the same species that are living in the same area and can potentially interbreed amongst each other. So, basically, we are talking about the small cohesive group of individuals.

Now, if you consider any population, there are two factors that are occurring at all times. Now, these factors are the deterministic factors and they are the stochastic factors. Now, deterministic factors act at large population sizes and stochastic factors are more important when the population sizes are smaller.

What are these factors? The deterministic factors are the factors that act at large population sizes. So, these include things like birth rate, death rate, population structure and so on. So, basically if you have a population, a large size population and the birth rate has gone down or say the death rate has gone up.

Now, why could such a thing happen? Probably, there is some pathogen that is affecting the the breeding females because of which a spontaneous abortion occurs. So, that would reduce the

birth rate in this population or probably, there is an infection that is killing off the individuals because of which the death rate has increased.

Now, these sorts of factors, the changes in birth rate and the changes in death rate, are important even when your population is large in size and so, these are deterministic factors. So, things like birth rate, death rate, population structure; suppose, your population is now composed of individuals that are very old.

It is just a matter of time that the population will collapse because these very old individuals will not be able to breed. So, at all points of time, you need to have a population structure that comprises certain young individuals, a number of mature individuals and some old individuals.

And the population structure should also be such that you have roughly equal numbers of males and females. Now, if you do not have a suitable population structure, then even if you have a small a large size population, it is possible that the population might be pushed towards smallness and so, this is a deterministic factor.

On the other hand, the stochastic factors which are more important when the population sizes are small comprise things like demographic stochasticity. Now, demography's demographic stochasticity includes occurrence of probabilistic events such as reproduction, litter size, sex determination, and death.

What do we mean by demographic stochasticity? Suppose, you have a large population; suppose, you have 1000 individuals and, in this population, you have 500 new young ones that have been born in this particular year.

Generally, the sex ratio is close to 1 is to 1. So, out of these 500 500 young ones, you have 250 males and 250 females. Now, what happens if by chance it happens that more males are born?

In place of having 250 males, suppose you have 300 males and you only have 200 females, will that make a very big difference to this population? Probably not. What about if you had say 400 males and 100 females?

Well, it might have a certain influence; but again, this is just a chance factor. It is possible that in the next letter, you will have more females. So, it does not matter much when we consider a large population.

But now consider a small population. So, you have a small population that is composed of only 3 individuals and these and you have 1 breeding pair and these 3 individuals which have given rise to a litter and it so turns out that the litter comprises say 2 males.

In the parent generation, you had 2 males and 1 female and in the next generation, you again came up with 2 males. Now, this is a random phenomenon. It can occur in any population. But in the case of larger size populations, some deviation would have been quite acceptable.

But in this small population, it so happens that the females have gone down in numbers so fast that now you do not have sufficient females for this population to continue. So, demographic stochasticity plays a very important role in the case of small populations and so, this is a stochastic fact.

Another stochastic factor is environmental variation and fluctuations. Now, the environment and the weather of any place is variable and it might so happen that in a particular year, it turns out to be a droughts like situation. Now, in a drought like situation, if you have a large population, a

number of individuals would die off.
Probably you started with say 1000 individuals and out of those 1000 individuals, 500 individuals perished in the drought. So, this could happen. But the 500 individuals that remain will be quite sufficient to take this population back to its original state.
Probably in the next year, when it rains better, then the population will be able to jump back to its original state. But now, consider a very small size population, suppose you only started with a population that comprised say 5 individuals. Now, in these 5 individuals. suppose 3 or 4 individuals perished in the drought.
The 1 or 2 that remain might not be sufficient to take this population back to the normal state, which is why the environmental variation and fluctuations are also stochastic factors that are very important when the population sizes are smaller. Then, we have catastrophic factors such as forest fires and diseases.
These are also much more important when we talk about smaller populations because we are talking about the perishing of a large number of individuals from the smaller populations. So, this would push these small populations to such small states that probably the population will not be able to come back to its original state.
Other stochastic factors include genetic processes such as loss of heterogeneity and inbreeding depression. Now, what we mean here is that in the case of a small population, it is possible that all the individuals that are there in the population are related to each other and in that case, when a breeding happens between these individuals.
It is possible that you have breeding between brothers and sisters or you have breeding between parents and children. When that happens, the recessive alleles that are there in the individuals, they get a chance to express themselves and in such scenarios, we will find a number of recessive disorders that come up into these populations.
You will start seeing diseases, which are recessive diseases, which would not have expressed themselves had this population size being larger and had these breeding's occurred between individuals that were not related to each other.
But now because the population size is small, there is a much greater chance that inbreeding depression occurs and that would be a genetic process that is leading to extinction because of the stochasticity.
Or we have things like deterministic processes such as density dependent mortality on exceeding the carrying capacity of the habitat. Now these processes, what we are talking about here is the density dependent mortality.
Now, in a number of indi in a number of species it has been observed that as the population density increases, the rate of mortality increases. Because you have a large number of individuals that are there in a very small area and there are very continuous contacts between individuals.
There is much greater aggression, much greater competition and diseases can also spread in a much quicker manner. Now, if we talk about a small population which comprises a small area.
Then, even though your population size is small, the population density is very large. Because of which, we will start seeing density dependent mortality. And this is again a stochastic factor that becomes much more important when the population sizes are smaller.

When the population sizes are larger, then the density dependent mortality is a mechanism by which the population size is getting controlled. So, when the population increases very much, then a number of individuals die off and the population comes back to the level of carrying capacity of the habitat.

That is ok when the population sizes are large. But when the population sizes are small, then it becomes a very important factor that can push the population towards extremes. Then, we also have the factor of migration among the populations.

Now, we have seen in an earlier lecture what migration is. So, migration is the movement of individuals from one place to another. Typically, it is a seasonal movement and typically, it occurs along fixed groups.

Now, if it so happens that in a population you have say 4 individuals and out of these 4 individuals, there is 1 female and this female migrates out. So, the 3 males that remain in this area will not find a partner to breed and in that case, this small population will turn towards extinction.

It is a very similar manner, if you have 3 females and 1 male and the male goes off. So, such factors become very important, when the population sizes are small. If the population sizes were large, say in a group of 1000 individuals, say 10 or 20 or 100 individuals move out during a migration period, it's fine. It does not make much of a difference.

But in the case of smaller populations, if it so happens that members of a particular sex move out, then it is possible that the remaining members may not find partners and the population will be pushed towards extinction.

Now, the factors that drive a species towards extinction can very easily be remembered using this acronym HIPPO. Now, the first H refers to habitat loss. The habitat is getting lost and if a particular species does not have suitable habitat.

It will not have a place to live and this factor will lead or push the species towards extinction. I refers to invasive species; so, invasive species if they come to the habitat of your species of interest and they can lead to the degradation or loss of the habitat.

Next is pollution; so, pollution reduces the quality of the habitat because of which it is unable to support a large number of individuals. The next P is human overpopulation. Now, these days' humans are the most important factor when we consider the extinction of species.

More the number of humans in an area, more is the impact of these humans. Because more number of humans, more amount of affluence it would mean that more amount of pollutants are being released into the environment, more and more amount of resources are being taken from the environment.

In a number of cases, we have seen that in a forest if there is a small pond and this pond would have met the requirements of the wild animals. Now, if a village comes up in the vicinity, then these humans start competing with these wild animals for water and in most of the cases, the wild animals will be out-competed by the humans and slowly, their population sizes will go down.

The next O is over harvesting; over harvesting is harvesting beyond the capacity of a system. So, in a number of cases, we have seen that in a forest if you have a species that is commercially

important, say you have a shrub or a herb that has medicinal properties.
If humans were to extract this herb or shrub in a sustainable manner, what they would have done is that they would take out some individuals and let others remain so that the next generation comes up.
But then in the case of over harvesting, what happens is there would be a few greedy people, who would get inside, remove all the individuals of this herb or shrub species and then, not a single individual is left in that area and the population declines or collapses.
The factors that drive a species towards extinction are these five factors; the loss of habitat, invasive species that have come into the habitat, pollution, human over-population and over-harvesting. Now, the impact of humans on different species is different. So, the sensitivity of a species to human impacts is dependent upon a number of factors such as the adaptability and resilience of the species.
There are certain species that produce a large number of offspring. So, even if humans are taking out individuals from this species, the individuals that remain, they breed so profusely that it hardly matters. Good examples are things like mosquitoes or things like rats and mice.
Now, humans have been trying to exterminate mosquitoes for quite a long period of time. But what happens is that every female mosquito lays hundreds of eggs. And so, even if a few individuals survive, they are sufficient to bring the mosquito population back to its original state.
This is an example of a resilient species. On the other hand, there are certain species such as elephants. Now, elephants have a very long gestation period. Elephants do not produce a large number of offspring; typically, in a birth you will only have a single calf that is produced and they also have a very long period of sexual maturity.
Now if humans remove a few elephants from the population, the population will not be able to come back. So, the impact of humans on a species would depend on how resilient the species is. Rats and mosquitoes that are very resilient; earlier the species like elephants that are not resilient.
Adaptability and resilience of the species has a very important bearing on the impact of humans on that species. Next, we have human attention. So, there are certain charismatic species such as tigers which are more sensitive. Because humans have a high demand for their skin, for their bones and their other body parts.
If humans pay a lot of attention, if humans find that a certain species is beautiful or charismatic or it is majestic, then that species will have a much greater impact of human beings.
So, there is a much greater danger, if the species is beautiful like peacocks, if it is majestic like tigers and humans are giving attention to that species. So, that is a big problem. Next, we have ecological overlap between humans and the species. The greater the overlap, the greater the impact.
Now, a good example is those species that live in the plain areas. Now and especially, the grasslands. Now, humans have converted a large number of grasslands into agricultural fields.
Those species that lived in those grasslands were much more affected than those species that lived in, say the deserts, because there is a very less ecological overlap between the activities of humans in the desert and the activities of those wild animals in the desert.
Because humans typically avoid going to the desert. That is not a very good place for humans;

whereas, in the case of grasslands humans find so many uses because it is a flat land, it has soil and the land is also rich in nutrients.

It is very easy to convert these grasslands into agricultural crops. So, the impact of humans because of this ecological overlap on the species that live in the grasslands will be very high.

Next, we have the home range requirements of the species. The species that have larger home ranges are more sensitive to human impacts right. To take an example, let us consider elephants. Now elephants require hundreds of square kilometers of area for a small population.

If humans say dissect this area into two small parcels; parcel a will not be able to hold an elephant population and parcel b will also not be able to hold the elephant population. And the elephant population will slowly get wiped off; whereas, if you had a species that requires a very small area.

Again, to take an example let us consider rats. Now, rats require a few square meters of area or say a few hundreds of square meters of area. Now, even in these two patches, this patch can support a rat population, this patch can support a rat population.

So, the rat population will be able to thrive; but the elephant population will go into a decline because elephants have the larger home range requirements, they cannot live in smaller areas. But then is this threat real or is this threat imaginary and what is the rate at which we are losing out this species?

We can make an estimate by using the principles of biogeography and especially, the Island biogeography model. Now, the island biogeography model says that the species richness is dependent on the area.

If you consider an island and if you have a small sized island, it will have a smaller number of species; if you have a larger sized island, it will probably support a larger number of species. Now, the richness of the species in this island will be dependent on the area of the island.

But it is not directly proportional, it is proportional to some power of the area and we call that as z. So, we can write it as S is equal to C into A to the power of z; where, C and z are constants.

Now, it has been found that z varies between 0.15 and 0.35. Now, taking a middle value 0.3 for an area A 1, you will have S 1 is equal to C into A 1 to the power of z which is 0.3, which is telling us that the species richness in this area of size A 1 is this much.

Now, even if the area decreases by as much as 90 percent. So, you only have one-tenth of the area left. Let us say that 90 percent of this island has been cleared off by human beings and only 10 percent of the area remains.

Now, how many individuals or how many species will be able to survive on this island with 90 percent of the area gone? So, if we write A 2 as 0.1 into A 1, we will have the species richness now is C into A 2 which is 0.1 into A 1 to the power of 0.3.

Which means that if we take a ratio, we will find that S 2 by S 1 is approximately 50 percent which is telling us that even when the area has been reduced by 90 percent, the species richness has only become half, which means that out of the complete area of the island, you have removed 10 percent only 10 percent remains.

But even in this 10 percent, 50 percent of the species that were earlier there in the island, they will find a representation; only some species that have larger home range requirements would be

extinct. But now, this is just an example. If we consider what is the amount at which or what is the rate at which the areas are actually going down.

Let us consider the tropical forest. Now, tropical forests are actually decreasing at the rate of 1.8 percent per annum. So, the rate is very small. We are not putting the area down by 90 percent, we are only reducing it by 1.8 percent every year and let us consider the lowest value of z which is 0.15.

Now, if you put both of these values into the equation, you will find that there is an annual loss of 0.27 percent. Now, an annual loss of 0.27 percent would look like a very small figure. But then the estimated number of species in the tropical forest is as high as 10 million.

So, we are having an annual loss of 0.27 percent of 10 million which is 27,000 species in a year. So, taking a very conservative estimate of the lowest value of z, we are finding that we are losing as many as 27,000 species from the tropical forest every year and this is only talking about the tropical forest.

Because the impact of human beings is there on all different kinds of habitats. We are also seeing loss of habitats, when we talk about temperate forest, when we talk about subarctic forest, when we talk about grasslands, when we talk about the wetlands, when we talk about lake strain areas,. When we talk about even the oceans because the oceans are also being dumped with so much of chemicals and waste materials, then they are also degrading in their habitat quality. So, just from the tropical forest, we are getting a figure of 27,000 species every year.

Just consider how many species we are losing when we consider all the habitats together and this figure is every year. So, we are losing 27000 species every year and the sad part here is that we will not even know what species we are losing because we have not yet documented all the species that are found in the tropical forest.

We do not know how many species of frogs are there, we do not know how many species of snakes are there, we do not know how many species of lizards are there, we do not know how many species of plants are there and this estimate is telling us that even before documentation they are losing out a number of these species.

So, the threat to these individuals is actually very large and the susceptibility of species to extinction varies. As we saw that when we are reducing the area of an island by 90 percent, 50 percent of the species remain.

What are the 50 percent that get exterminated in priority and what are those 50 percent that remain in that area? So, some species have a much greater chance of extinction, primarily because they are rare. Rarity is a function of the ecology and the and the evolutionary characteristics of the species.

And the rarer a species is, it means that you already have a very small population. Probably, it is localized in a very small area and this rarity would mean that the small population paradigm would act very fast and those small habitats, where these organisms are found, if those habitats are lost, we will lose out these species.

Now, why are certain species rare? There are three reasons. One, there is a habitat selection and evolutionary characteristics because of which a species is restricted to an uncommon habitat. Example is species that are found in desert springs. Now, in the deserts, we already have a very

small number of springs.
So, a species that is localized to a spring that is found in the desert will automatically be a very rare species or species with limited geographical range such as those species that are found in a single lake. Now, it is possible that the individuals that or the species that are found in that lake, are unable to move to some other lake.
Because maybe these species cannot fly. So, they have no means of moving to another lake or those species that have low population densities, especially species such as elephants. Because larger animals require more space.
And so, because the individuals are large in size, they require large areas and a mechanism to deal with it is that these species have low population densities. Now, because this species has a low population density, it is a rare species.
Now, the impacts on the habitat or the push factors on the habitat can be accentuated by these four processes. We have the processes of habitat degradation, habitat fragmentation, habitat displacement and habitat loss.
And all four of these are different, but they have a very similar impact in reducing the habitat that is available for the species. So, let us look at these one by one. Habitat degradation is the process by which the habitat quality for a given species is diminished.
So, in the case of degradation, the habitat quality goes down. Now, what do we mean by habitat quality? Suppose, consider a lake and earlier this lake was able to support say 1000 individuals. Now, in this lake, we are dumping municipal waste and because of which the habitat quality has gone down. Now, in place of supporting 1000 individuals, it can only support 800 individuals.
Now, when such a thing happens, we will say that the habitat has become degraded; the quality has gone down, because of which this habitat is unable to support the large number of individuals and the large number of species that it was able to support beforehand.
So, it is the process by which habitat quality for a given species gets diminished. Some causal agents for habitat degradation include things like contamination; air pollution, water pollution, eutrophication, pesticides and accumulative toxins can all degrade the habitat.
Now, eutrophication is the phenomenon in which fertilizers are able to reach into water bodies. Primarily, because these days we are using a large amount of fertilizers in our agricultural fields and when it rains, these fertilizers also get washed down together with the rain and they reach into the water bodies.
Now, what happens when you artificially increase the amount of nutrients that are made available in the water bodies? So, earlier, consider there was a lake and this lake was a very good ecosystem. It was supporting a large number of fishes. Now, fertilizers have entered into this lake together with the rain water; now what happens?
These fertilizers will result in a very profuse and a very rapid growth of plants in this lake and these plants will in turn strangle the fishes and when these plants die off, then when their bodies get get decomposed, then that would also result in lowering of the oxygen levels that are there in the water.
At the same time, when these plants are growing, then they are also taking up space in that water and so, the amount of space that is available to the fishes also goes down. All these processes

eutrophication; eu is good, trophication is the presence of nutrients.
In the process of eutrophication, you are putting a good amount of nutrients into the system which is having a negative impact on the habitat quality. Pesticides and accumulative toxins ah; so, pesticides can also reach into the water bodies together with the rain water and these pesticides can get accumulated in the bodies.
Now, this is an example of a Eutrophied state of a water body. So, this is the Potomac river and here, we can see that there is such profuse algal growth because the amount of nutrients in this water body has gone up.
Now, when we say bioaccumulation, what it means is that suppose we had sprayed an insecticide into the agricultural fields and together with the wind, it has also reached into other areas. It has reached into grasslands; it has reached into the forest areas.
Now, what happens? These grasses now also have a certain amount of pesticide. The insects that live on these grasses or that feed on these grasses will also eat up pesticides when they are eating of the grasses and these pesticides will in turn get accumulated or stored in the bodies of these insects, primarily in the fat tissues.
A number of pesticides are very easily stored in the fat tissues and in the bodies of these organisms, they will get accumulated and this is known as bioaccumulation. Now, what happens? The level of pesticides that was there in these grasses was very low; but now because these insects have fat bodies in their bodies, so now, the pesticide is getting accumulated in the bodies.
Now, when the next organism like frog, when it eats these insects, what happens is that the fat that was there in the bodies of these insects is now entering into the body of this frog. Now, one frog will be eating a large number of insects and all of these pesticides that were there in the bodies of so many insects, a large proportion of it will get stored in the body of the frog.
The concentration of pesticides in the grass was very less. It was higher in the case of the insects because one single insect was feeding on a large number of grasses; it is even more in the case of frogs because one frog is eating up so many insects. Then, a snake eats a large number of frogs.
And so, the pesticides from the bodies of a large number of frogs will get accumulated in the body of the snake and as we move up the food chain, we will find that the concentration of pesticides goes up and up and this is known as biomagnification. So, there is a bioaccumulation in the bodies and this accumulation goes on increasing as we move up the food chain and this is known as magnification.
A good example is the concentration of DDD in a Lake ecosystem. When it was measured, it was found that water had 0.01 parts per million of DDD. The Planktons, which are small plants, had 5 ppm.
So, there is a large increase around 500 times in the concentration of DDD that was present in water to what was present in the planktons. Then, the fishes that eat these planktons had a concentration of 40 to 300 ppm and the fish-eating birds had a concentration of 1600 to 2500 ppm.
Now, this is a very high concentration and it would have a very drastic impact on these birds and it was also found that a number of these birds, their population was declining very fast because

of the presence of these pesticides, they were not able to lay eggs with strong shells.
This is an impact that occurs as we move up the food chain, the concentration of the pesticides increases and it may increase to such an extent that it starts showing up a negative influence. Other causal agents of habitat degradation are trash. So, trash includes things like ghost nets.
Now, a ghost net is a net that was earlier used for fishing; but then probably because of a storm, it just drifted out into the sea or probably it had completed its utility and so, it was dumped into the sea and you have a number of animals that get trapped in these nets.
These ghost nets keep on reducing animal numbers by trapping these animals and killing these animals or we have things like entanglement. So, here you have a seal and this seal is surrounded by this piece of plastic and this plastic is cutting into its body.
Another example is this Tahr. So, we have Mukurthi National Park, where we have Nilgiri Tahrs and if you go to this area, you will also find certain trash that is there alongside the roads. So, this is having an impact of habitat degradation for the Nilgiri Tahr. We also find that plastics have entered into the areas often of a number of other wild animals such as Hyenas.
Other factors of habitat degradation include things like soil erosion. Now, when soil erosion occurs the top layers of the soil get washed away or they get blown away and when that happens the amount of soil that remains in the habitat goes down. When that happens, a number of plants may not be able to thrive in that area. So, this is also an example of habitat degradation. Another is fire regimes.
If you have a forest and there is a fire. Now because of this fire, a large number of plants can die off, a large number of animals will die off, the amount of nutrients that are available in this ecosystem will go down. So, this is another example of habitat degradation.
Another causal factor is over-exploitation of water which makes water less available for the species and deforestation. Now, we have seen this example before. If there is deforestation, then that is also degrading the habitat. And we are seeing deforestation on a large scale. So, this is an area in Balaghat, district of Madhya Pradesh in 2006.
And this is the same area in 2018 and here, we are seeing deforestation for mining operations. This is a region in Umaria district and I would like you to concentrate on this area. So, here we have a road and I I would like you to concentrate on this area.
This is how it looks in 2018. So, all of these forests are now gone and this is deforestation to expand agriculture. Here, we have a region in Bhopal district in 2003. And here is the same region in 2018 to make this dam.
So, deforestation is occurring in a big way. Another causal agent of habitat degradation is desertification, which is conversion of good areas into deserts. Primarily by overgrazing and through cultural practices.
This is an image from Gujarat and when all these goats eat up this vegetation, then this area will slowly and steadily be converted into a desert. Other causal agents include draining, dredging and damming operations; in water bodies, over-exploitation of biota in which case humans go into the forest areas and extract these biotic resources out of these areas and introduction of exotic species.
When habitat degradation occurs to such a large extent that the habitat quality goes down to an

extreme, then we call it a habitat loss. Habitat loss occurs when the quality of the habitat is so low that the habitat is no longer usable by a given species. So, this is the extreme form of habitat degradation.

Then, we also have habitat fragmentation. Fragmentation occurs when a natural habitat landscape is broken up into small parcels of natural ecosystems, isolated from one another in a matrix of lands dominated by human activities. It involves both loss and isolation of ecosystems.

What we are saying here is that in place of a continuous large sized area, we are dividing the area into very small parcels or pockets of land, pockets of habitat and this is known as habitat fragmentation. So, a large sized habitat is fragmented into smaller parcels.

Now, habitat fragmentation is important because larger fragments typically support more species because larger fragments have more diverse environments, more habitats, they are more likely to have both common species and uncommon species.

And also, because these smaller fragments have smaller populations, the chances of them getting extinct are greater. Because if you have smaller populations, then the small population dynamics also start acting on those small populations. So, it is always beneficial that we should have habitats as big contiguous areas and not as small parcels.

Now, how does habitat fragmentation occur? The causal agents include things like roads, railways, dams and other structures and structures such as these linear infrastructures of roads and railways, they not only cause mortality, they act as a physical barrier because of which the animals are not able to cross them, they act as psychological values.

If you consider a road in which there is heavy traffic, the animal, if it wants to cross to the other part of the habitat, will not be able to do that. Because of the fear of getting hit by one of these vehicles. So, either this animal gets hit or in certain cases it is so afraid that it does not cross this area because it acts as a psychological barrier.

Then, these structures such as roads and railways also increase the access to human influence and they increase access to invasive species and exotic species. Other causal agents for habitat fragmentation include diversion of land for agriculture. So, here we are seeing linear infrastructure in the form of pipelines.

If you have such pipelines, animals find it very difficult to cross from this area to this area. If you have a dam an animal will not be able to cross just like this. It will have to either cross a very long stretch or it will just not cross this area. So, dams cause habitat fragmentation.

Now, the process of habitat fragmentation and loss occurs in a series of steps. So, we will understand these steps through these illustrations. Let us consider that this is an original forest and you have a line number of trees here.

Now, the first step that occurs is Dissection. In dissection one or more linear infrastructures, primarily roads are set up and these roads dissect this complete forest into two or more smaller parcels. Now, once this dissection has occurred, it is now easier for humans to come to these areas and so, we will start seeing small settlements.

Now, in these small settlements, people will start farming these areas or raising some certain livestock and to make space for farming and for livestock, they will clear up certain portions of the forest and this is the stage known as Perforation. So, now, they are perforating into the forest.

So, this is how it will look like. These are livestock in the forest near the Mudumalai Tiger Reserve.

Now, after perforation, once you have certain human beings that are living there in the settlements, these settlements slowly grow and why do they grow? Because they are right next to the door and any produce that these farmers or these early settlers produce in the form of milk or say agricultural produce, it finds a ready market because people who are going through these roads will buy their stuff.

Slowly and steadily, the number of livestock will increase, the area under cultivation will increase, more and more buildings will come up and in this process, it is now converting this whole forest into smaller parcels. So, this is one parcel; this is one parcel; this is one parcel and this is one parcel. So, we now have four small parcels. So, this is habitat fragmentation that is happening.

This is an example of habitat fragmentation. So, these early settlers have now converted all of these areas into their agricultural or plantation areas and so, the animals that were there in these forests are now unable to cross these areas and so, this has become a small fragment.

After fragmentation, we will have the process of Attrition. Now, in the process of attrition, these settlements grow to such a large extent that these pockets have now become very small areas and during this process of attrition.

We will also start seeing electricity coming into this area or small industries coming into this area or certain facilities such as schools and hospitals that are being built up. Because now, these settlements are so large that the government is bound to provide them with certain facilities.

And so, with this process of attrition, we have very small parcels that are left. This is an example. So, this was a beautiful hill that was covered with forest, but now through the process of attrition, we only have this small patch of forest that is left in this area.

Now, we can see an example through the deforestation of the Amazon rainforest. So, these are satellite images from 1975 and I would like you to pay attention to this road. So, this is how the dissection occurred in this area. So, this road was constructed in this pristine forest.

Now, this is 1975; this is 1984. So, by 1984, people have started to enter these areas and they have constructed a new road. So, we did not have a road here, but now you see very clearly that this stream has also been converted into a passageway and now, deforestation is occurring in the form of this fish bone pattern.

So, this is 1984, 1985, 1986, 1987 and we see that slowly and steadily the forests are being converted. And the wood is being extracted out. 1996-98, 2002, 2007, 13, 15, 16 and so, what was there in the form of a pristine forest is now completely deforested.

What started with a small amount of habitat degradation and habitat fragmentation, ultimately resulted in the loss of the forest. So, before we have a situation like this a pristine forest. Afterwards, we hardly have any forests that are left in this area.

And this is an example of an extremely fragmented habitat from Mudumalai. So, this area is a part of the elephant corridor. So, elephants traditionally use this area to move from one place to another place. But now, with the settlements, we can see that these hills still have some forest left.

But the rest of the place is now completely converted into a human dominated landscape and in such landscapes, people set up fencing and because of that animals are unable to cross into these landscapes and the hills that are left are so high that the elephant will not be able to cross through this landscape by going through the hills.

Because it is a very massive animal, it has a weight of like 4000 or 5000 kgs and it takes a tremendous amount of energy to lift that huge weight through gravity on top of these hills.

So, animals do not prefer going like that and so, this has resulted in a fragmentation in this area.

Now, apart from habitat fragmentation, we also find another phenomenon which is known as habitat displacement. Now, habitat displacement is the shifting of wildlife to non-prime or subprime habitats such as hills or rocky patches.

Now, what is habitat displacement? Now, typically if you go to any grassland area that is near a forested area and if you find that people are taking their cattle into these grasslands and if you ask these people that- 'oh, your cattle are out competing the wildlife', they would normally say- 'oh, no, this is not the case because our cattle graze in these grasslands; whereas, the wild animals live on top of the hills.

Now, if you think about it logically, the wild animals do not live on top of the hills because the wild animals also require the same resources, they also require access to the same grasses, the same fodder, the same water that is being used by the cattle. But then, because of a tremendous competition with the cattle.

Because together with the cattle, there will be humans who will be going into these areas with their and probably, they will also be taking a few dogs and so, the animals have been displaced out of these grasslands.

These animals do not have any other place to live than the top of the hills. So, the animals have been shifted from their prime habitats to a non-prime or subprime habitat. Now, why are these hill areas non-prime or subprime habitats?

Because they do not have a sufficient amount of fodder, they do not have a sufficient amount of water and so, they are subprime habitats and in this process of habitat displacement.

The the wildlife has been shifted from a prime habitat to a sub-prime habitat such as hilly or rocky patches and because these sub-prime habitats do not have sufficient amount of food and water and other resources for the animals, so slowly and steadily there the the population of the wildlife will go on decreasing because the habitat does not have sufficient canal capacity.

These are all different threats to the species. So, we looked at the large population dynamics, we looked at the small population dynamics and we looked at processes of habitat degradation, habitat loss, habitat fragmentation, habitat displacement and so on. These are all the threats that our wildlife are facing these days.

That is all for today. Thank you for your attention. Jai Hind!