Conservation Geography
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Module - 7
Biosphere
Lecture - 21
Biodiversity

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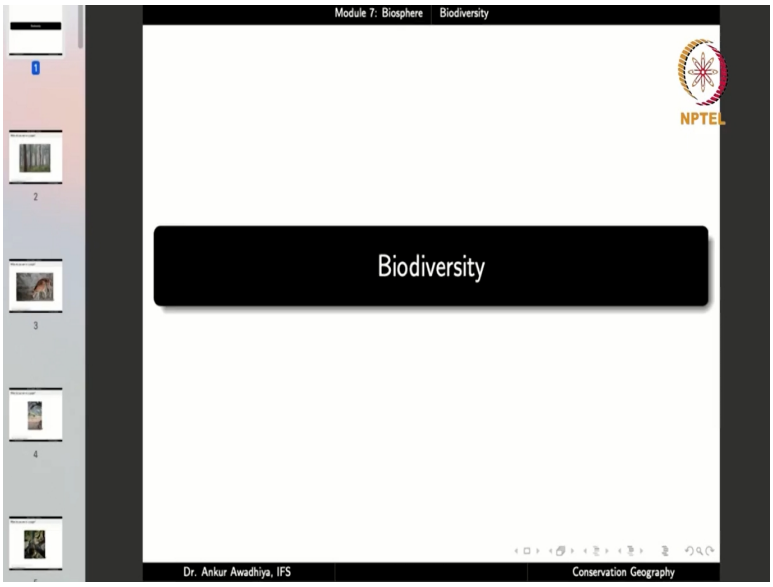

Namaste! Today, we carry forward our discussion on biosphere, and we shall have a look at biodiversity. Now, you'll remember that when we were talking about the geological timescale, we discussed that the earliest forms of life on the planet were very small organisms. Typically, bacteria and cyanobacteria, or the blue green algae.

Now, with time, more and more forms of life evolved. So from the very early organisms, we had the development of multi cellular organisms, followed by different varieties of plants and animals. In the case of animals, we saw that the fishes came before the reptiles, the reptiles came before the mammals, and so on. And finally, we saw that in the very recent phases, we had the evolution of the human beings.

Now similarly, in the last lecture, when we were discussing about ecological succession, we saw that different areas are able to support different forms of organisms. So for instance, an area that is a very primitive area, an area that is just a bare area, such as a rock that is devoid of any soil cover will not be able to support trees. It will not be able to support shrubs, or even herbs.

So in that case, it will only be able to support things like the crustose lichen or the foliose lichen. Whereas, if you have an area that is full of soil, has many meters deep soil, in that case that particular area will be able to support trees. So basically, if you look at the planet, different areas have different conditions and different organisms can survive, or make the best utilization of those conditions.

If you look at a camel, a camel is best suited to a life in the desert, because it has certain adaptations, things such as having a storehouse of water or a storehouse of food, or very thick, padded feet that enable it to walk in the desert, or very long eyelashes that protect it from the sand, and so on. So a camel is very well adapted to a life in the desert.

Whereas, a polar bear is very well adapted to a life in very cold conditions. So it has adaptations such as white colored fur that enable it to be camouflaged, and enable it to hunt. It has a lot of fur that provides a certain amount of insulation. It has a very thick layer of fat that again provides it with insulation. And it has certain behavioral adaptations, such as hibernation, that again, enable it to conserve food when there is a shortage of it.

Now, if you brought a polar bear into a desert, it'll not survive. Similarly, if you take a camel into the polar areas, the camel won't survive. So essentially, different areas have different organisms that are best suited to living in those conditions.

Now, through the several billion years of evolution on our planet, and because the planet has different areas with different conditions, we find a very great amount of diversity in the life forms. So different habitats support different kinds of organisms, and because we have a plethora of habitats, and also, a lot of time, that has been provided for organisms to adapt and evolve to those conditions, so today we have a very great amount of diversity. And that is what we are going to discuss in today's lecture.

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So when we talk about biodiversity, we are talking about the diversity in various life forms. So that is biodiversity, and we can make a good understanding about the biodiversity by discussing what do we observe in a jungle. So forests are natural areas, and in the forest, you can observe a very great number of organisms with a very great amount of diversity.

So for instance, in a normal forest, what do you think about a forest? When you think about a forest, the first thing that comes into your mind is trees. So in the forest, you will find trees. But will these trees be of the same species? Will probably not, unless, say, it is a planted forest, it's a plantation. So in certain areas, what we do is that we plant only one type of trees. Typically, those that have an economic importance for us. They are valuable, they can be sold in the market. So trees such as eucalyptus or trees such as teak.

So we can have certain forests that have only one variety of trees, nothing else. But in, if you go to any natural forest, that is, say, only a bit maintained by the human beings but it has not been planted by the human beings, then you will probably find a great diversity of trees. In central India, a typical forest will be a mixed forest with trees including trees such as mango tree or amla tree or tamarind tree, or mahua tree. And you will find a great diversity of trees.

But not only will you find a diversity in the tree species, but you will also observe that in a large number of forests, you also have a very good amount of ground cover. Now, this ground cover is made up of different types of herbs. So you will find very great diversity of grass species. A lot of medicinal herbs will be found in the forests.

Then in certain areas, you will have shrubs and shrubs, again, are of different species. You'll find things like climbers, creepers, lianas. Now, all of these make for a great amount of plant biodiversity. So this is the variation that we are talking about. So you will find a great amount of variation in the case of plants.

In certain areas, if you observe closely, will find things such as mosses, or you will find things like lichens that will be there on the barks of the trees, or maybe on the stones, on the rocks that are lying there. In the water bodies, you will probably find algae, you will probably find a lot of aquatic plants.

Now, even in the case of a small water body such as a pond, you will find plants that float on the top, you will find plants that remain suspended, you will find plants that grow at the bottom, do not come up. They are completely submerged. You will find plants that have roots that deter them to the bottom, but they have a very long stem that enables the leaves to come to the surface.

So in the case of a small water body, you will find a great amount of diversity of aquatic plants. So this is the diversity that we are talking about. Now, not only that, you will find a great amount of diversity in the case of animals.

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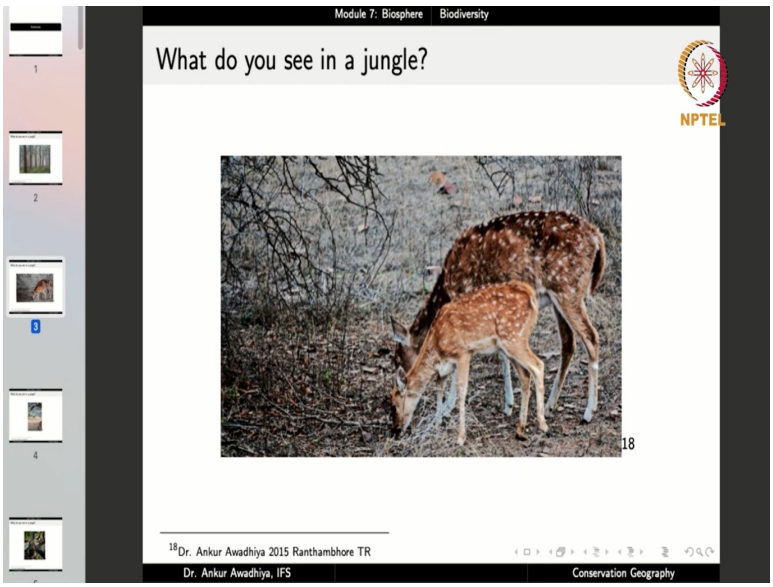

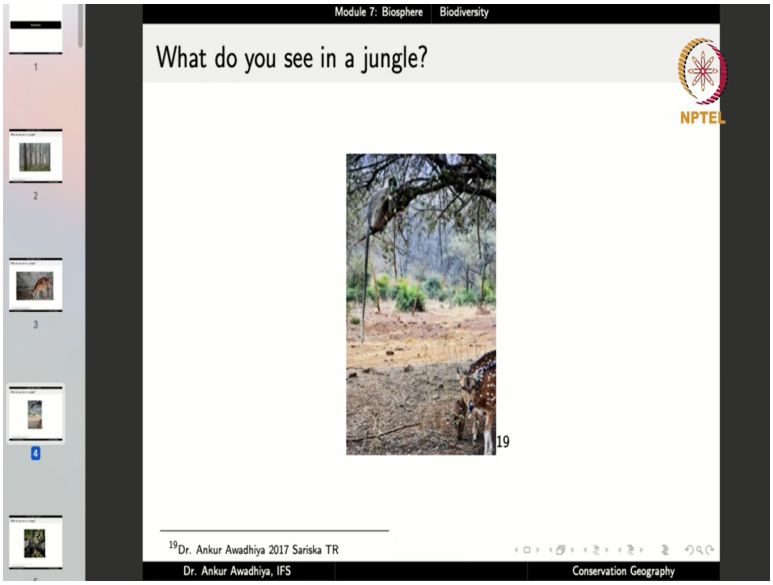

So a very common species that you will find in our forests is the chital or the spotted dear. So in most of our forests, you will find a chital that is, say, grazing somewhere, or it may be interacting with other species. So a very common interaction is that of the chital with the langur.

Now, the langur is a monkey that lives on the trees. And when the langur feeds on the leaves and the fruits and the flowers, what it does is that it is a very destructive feeder, so it will eat certain leaves or certain parts of the leaves, and it will throw down the rest. Now, you will find chital nearby to eat those leaves or to eat those fruits or to eat those flowers.

So in this case, you will be observing interactions amongst the different organisms. Now, this provides both of them with certain other benefits as well. If the langur is able to see a predator, say, a tiger coming towards this particular tree, the langur will give alarm calls to warn members of its own species that will be residing somwhere nearby. So it gives an alarm call essentially to warn the other animals that the tiger is coming.

But when it does that, the chitals also get the message and they start to run away. So it gives them a certain amount of protective mechanism, a protective cover, especially because the langurs are sitting on top of the trees and so they are able to see a very far off distance.

On the other hand, the chitals have a very good sense of sound and a very good sense of smell. And so if the chitals smell that a tiger is coming nearby, they'll probably also give an alarm call to warn their herd, and the langurs will get the message.

So in the case of biodiversity, a lot of biodiversity also exists because it provides certain amounts of advantages to different species, especially when they are living together. So this is also something that you mostly observe in the jungles, or you can find certain animals that are helping each other out.

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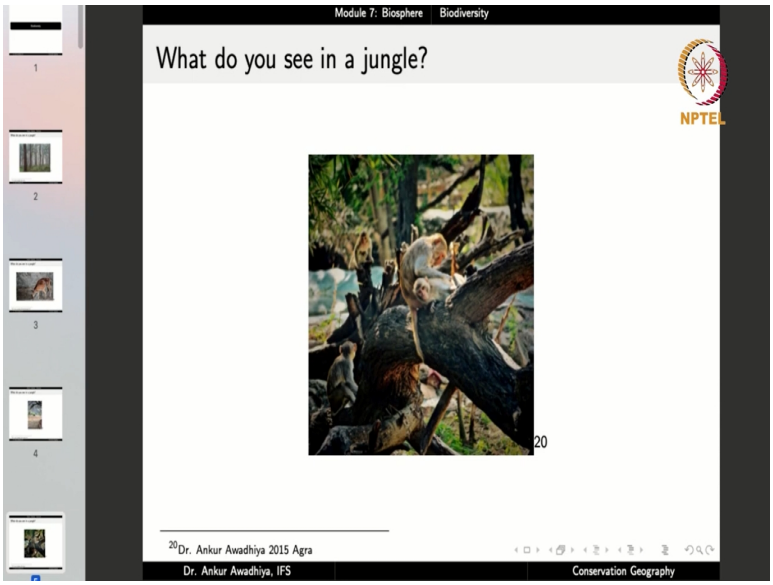

So for instance, in this case, we are observing a phenomenon that is known as allogrooming. So this monkey is taking away the fleas and the lice that are there on the bodies of this monkey. And in this process, this monkey is getting benefited, and probably later on this monkey will help this monkey and remove the fleas of this monkey.

So you all observe that different organisms are doing different kinds of activities. Now, when you observe a group of animals, you will probably also notice that the animals are not all the same. Some individuals are exceptionally big in size, others are smaller than the rest. Some individuals are more aggressive, others are more docile. Some individuals have darker shades, others lighter shades.

Some individuals have longer hairs, others have shorter hairs. Some individuals are very fast. Some individuals are slow. So even in a particular group of animals, you will find that there is a certain amount of diversity because not every individual is the same. They are not clones of each other. Now, a lot of these differences are coming from the genes that these organisms have. So different animals, or different individuals in this group have a different genetic constitution, a different genotype, which, upon interacting with the environment is giving a certain trait to these animals, a phenotype, an expression genes.

So certain animals would be having genes that make them very fast, and you will observe this genetic constitution in the form of a monkey being very fast. So by looking at these differences, we can also make an inference that there is a distinct amount of difference or variety, even at the genetic levels.

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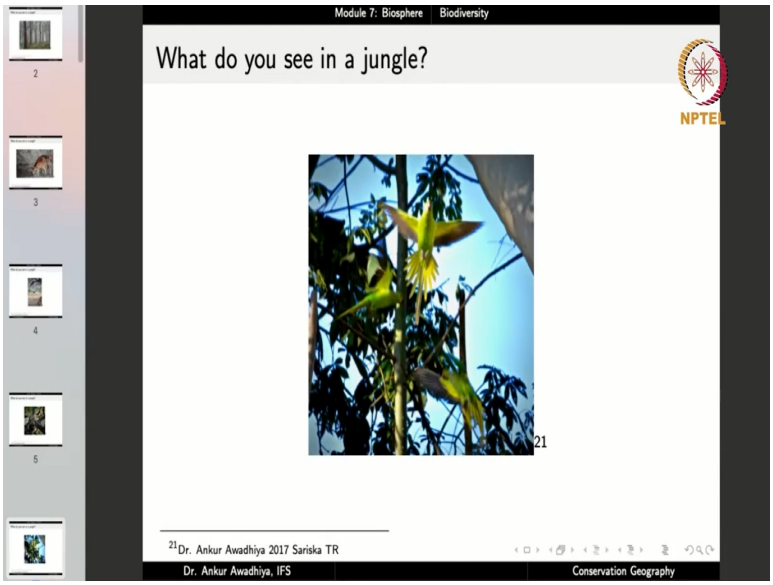

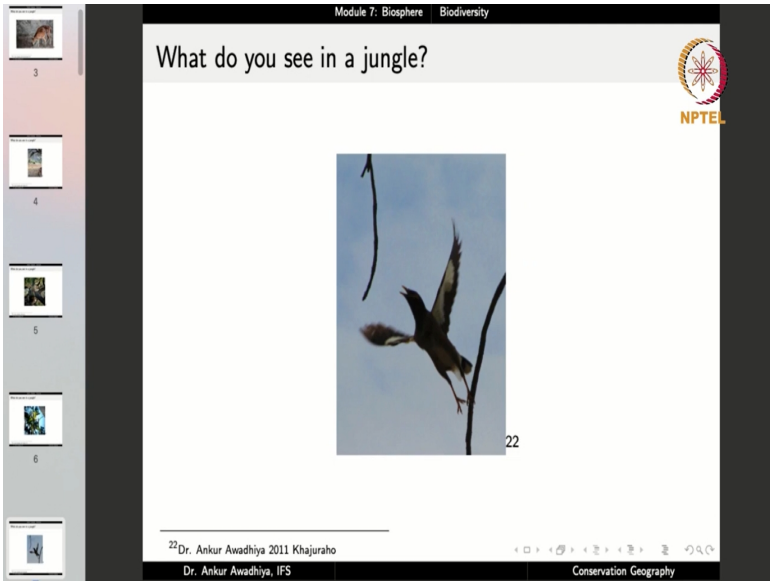

Now, this difference or variety in the genetic level is also a form of biodiversity. So not only are we observing that there are different species, but also that even within a species there is certain amount of diversity. Or you will observe birds in flight. Or you can observe birds such as a myna.

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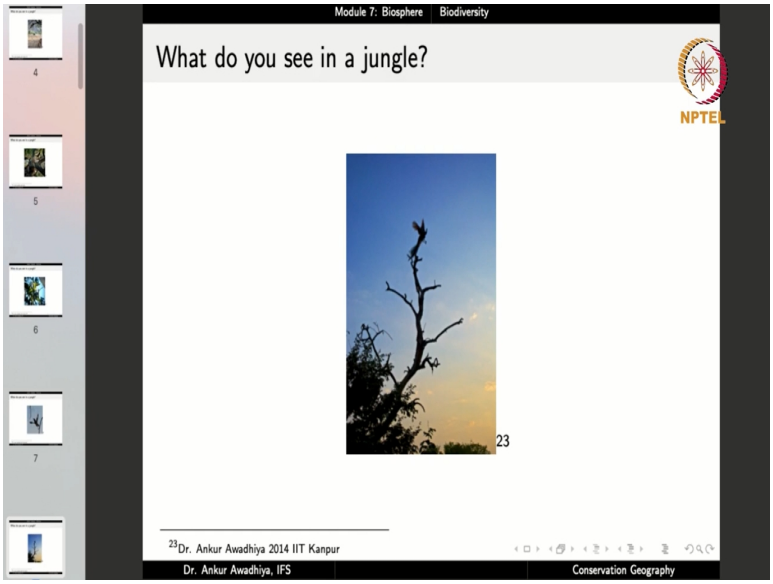

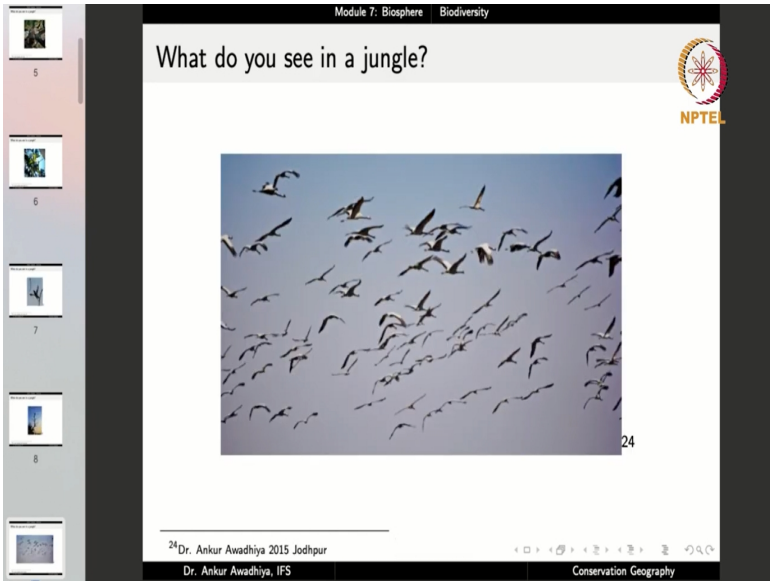

So we have a number of parakeets, we have mynas, we have peacocks in our jungles. We have a large number of migrant species, migratory birds such as the demoiselle cranes. So in certain seasons, you will find these organisms, in certain other seasons, you will not find them. Quite a number of times, you will not actually see the organism, but you will find certain signs of the animal.

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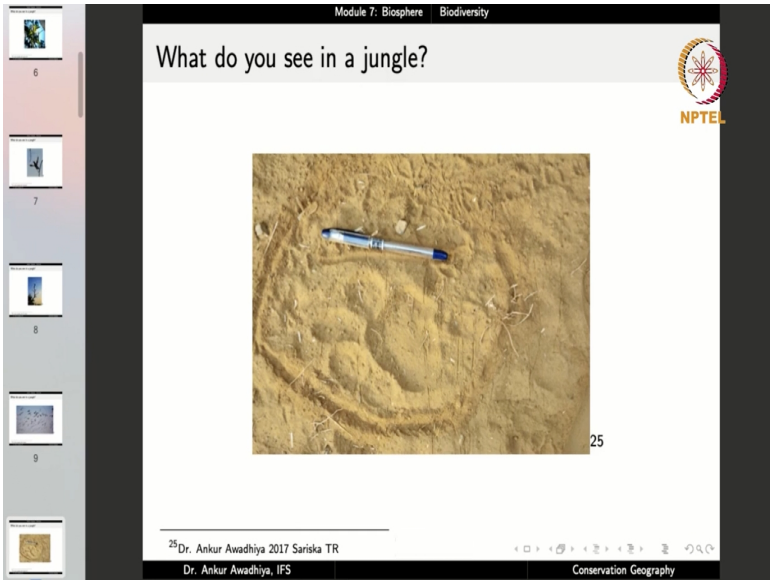

So a very good example of a sign is a pug mark. Now, this is the mark of a tiger. And you can see that it's a fairly big sized pug mark. A pug mark is essentially a foot mark that the animal makes when it is moving on a soft ground. Now, this soft ground may be one that is filled with dust, or it may even be one that is a bit moist, and so the animal leaves an impression when it walks over that moist ground.

Now, in a number of cases you will find that, okay, the animal is not visible, but there are certain signs that are visible. Signs such as the pugmarks, or signs such as scratches that you will find in different trees. So scratches are, again, another way in which the animals give their presence. Large number of animals are territorial animals. So they advertise themselves that okay this is my territory, don't you dare come inside.

Or in a number of cases you will just hear the sound of an animal, you'll just hear a growl. But you won't see the animal, or you will find certain droppings of animals without actually seeing the animal, or you will find that there is a large animal that has been killed and you are carcas, and so you can make an inference that okay this sized animal can only be killed by a tiger. So there should be a tiger nearby.

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So you will not just see animals but you will also see a large number of signs and you will make inference about what animals are nearby. So these signs include pug marks. They include faeces. So different animals have different kinds of faeces, and especially in the case of carnivorous animals, you can observe that the faeces will contain a lot of hairs, a lot of bones that belong to their prey species.

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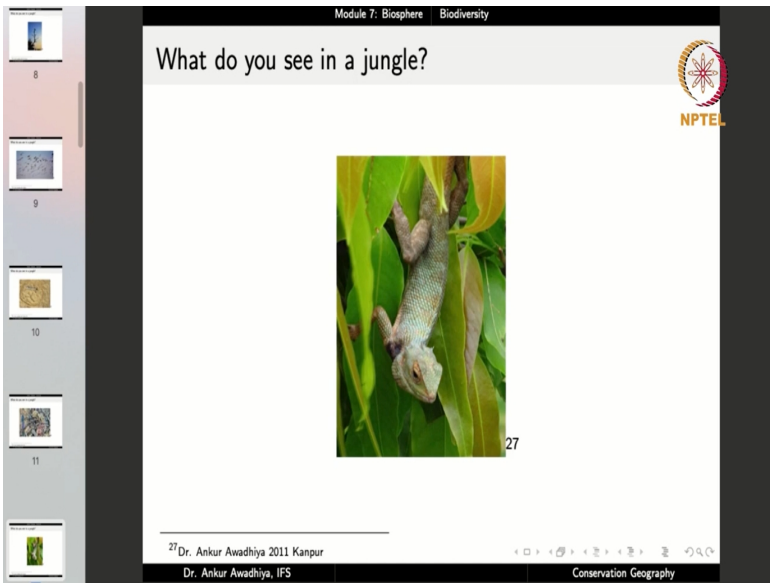

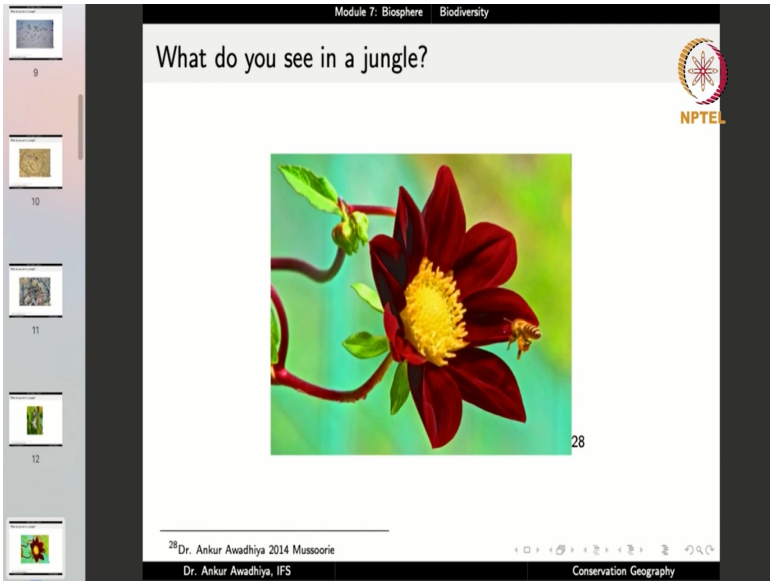

In the case of herbivorous animals, you will find that the faeces have fragments of the plants. So you will typically find certain twigs or certain parts of the leaves, or certain seeds of the fruit that the animal has eaten, and so on. So these are also different signs about what kinds of diversities are there in this particular jungle. Or, if you look closely you will find small animals or insects.

So we have a great amount of insect diversity in our forests. Insects play a very big role as pollinators. So they carry the pollen from one flower to another flower. And in this process, they help the plants in fertilization. Now, if you look at just one category of organisms that is the insects, in one forest you will find a lot number of insects, you will find different kinds of bees, you'll find different kinds of wasps, different kinds of butterflies, different kinds of moths, different kinds of weevils and so on.

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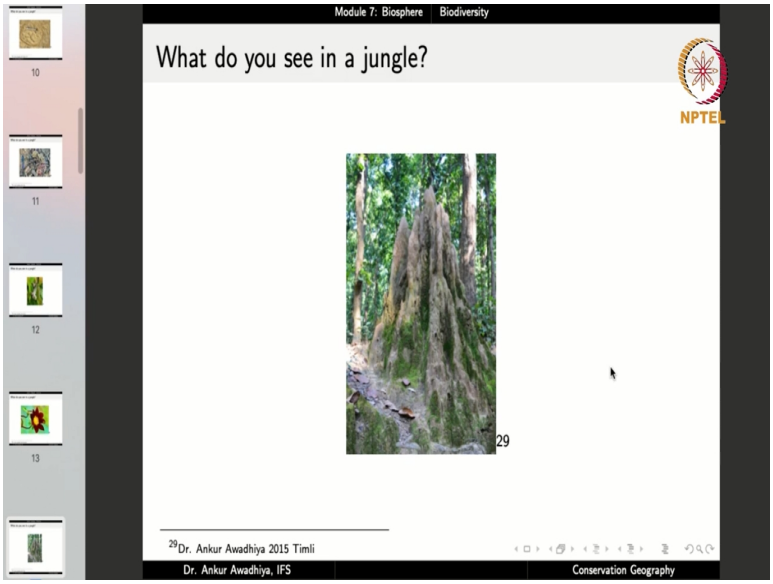

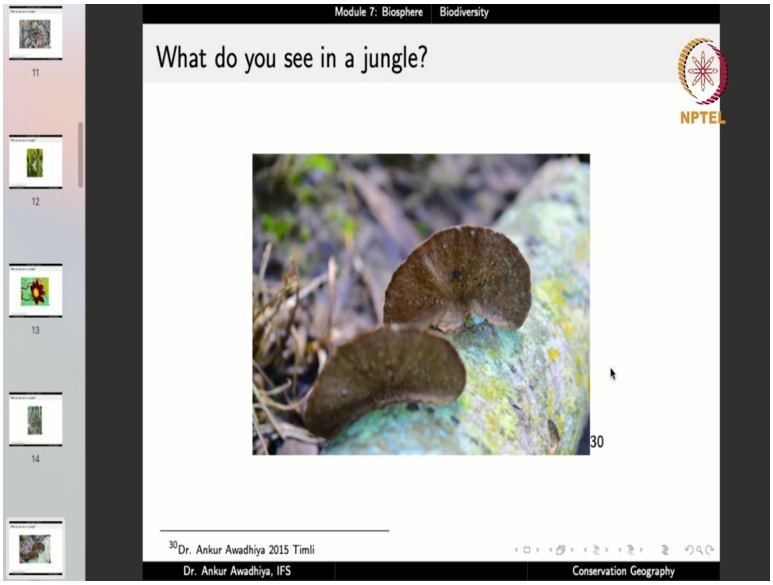

So even in one category of organisms, that is the insects, you have a large amount of biodiversity. You will find termite hills, again another types of insects. Or, if you look down, probably you'll find a lot of fungus. So even in the case of fungus, there is a large diversity. And fungi play a very big role in the forest in the working of the ecosystems.

They help a large number of plants to gather nutrients from the soil through structures that are known as mycorrhiza. They also play a role in decomposing the parts of plants and animals that have fallen down, that are dead parts, or even things like faeces. So fungus helps degrade them and release the nutrients back into the ecosystem.

So we saw this in the last lecture when we were talking about the nutrient cycles. So when, even in the case of fungi, you will find a great amount of diversity. There are a lot many other microorganisms that probably you won't see. So there are microorganisms that are living on the bodies in the guts, in different parts of different organisms, helping them in a number of ways.

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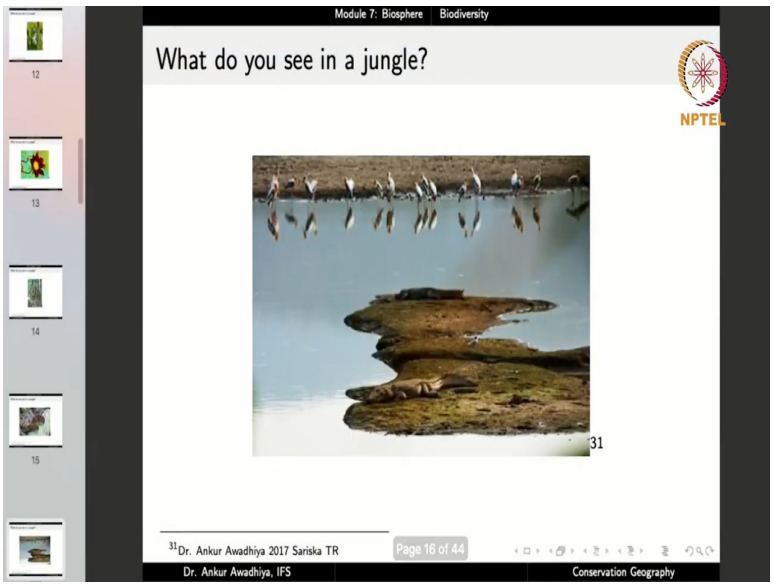

So a large number of insects are able to digest cellulose because of protozoa. Certain fungi and certain bacteria that are found in the guts are providing organisms with certain micronutrients such as vitamins. So you will find different kinds of diversity even in the case of microorganisms. Then, if you are lucky enough, you will probably find large animals such as the crocodiles.

Now the crocodiles are reptiles. So if you talk about reptiles, in the forest you will probably find crocodiles, you will find different varieties of snakes, you will find different varieties of tortoises, even things like lizards or skinks and so on. So these are all different kinds of varieties.

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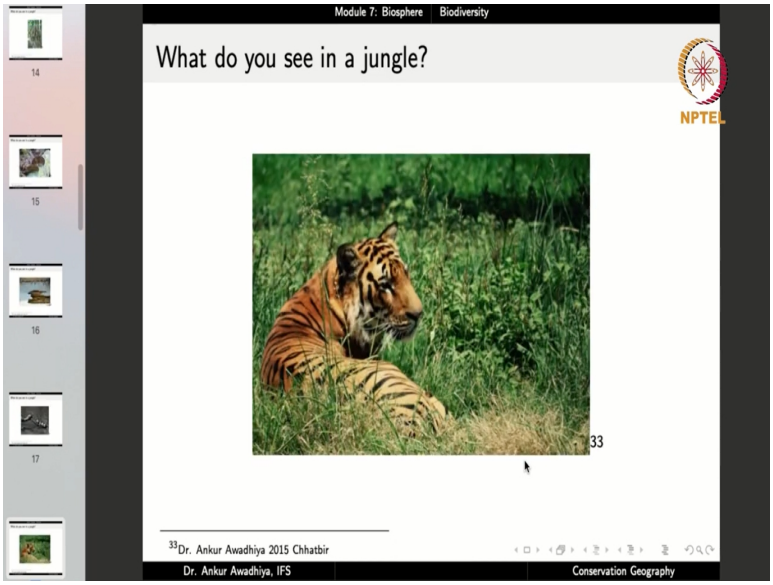

What do you see in a jungle?

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[34] Dr. Ankur Awadhiya 2015 Agra

What do you see in a jungle?

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[35] Dr. Ankur Awadhiya 2016 Kaziranga

All of these are signs of biodiversity!

So this is an image of turtles are found in Kaziranga, or if you are very lucky, you will probably even observe a tiger. You will observe large animals such as the bears or the elephants. Now, all of these are different signs of biodiversity. Signs of diversity of life. So how do we define biodiversity?

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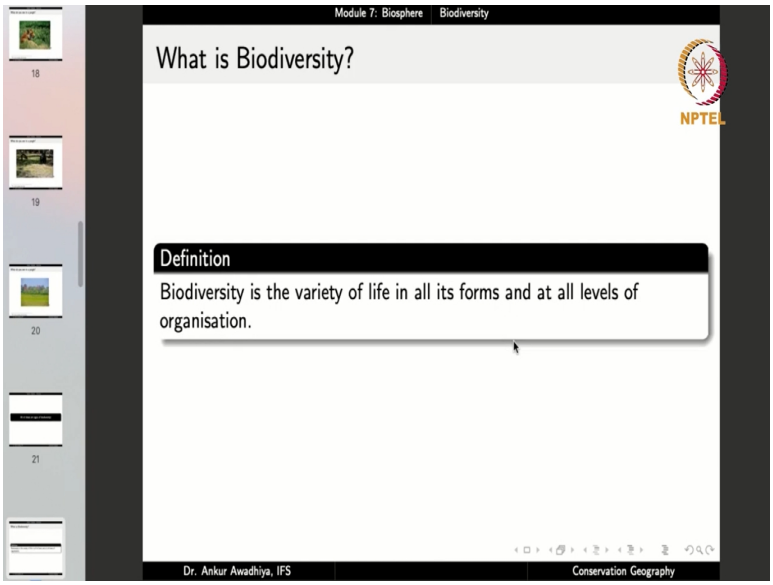

Biodiversity is the variety of life in all its forms and at all levels of organization. Biodiversity is a variety of life, the kinds of variations that we find in living beings in all its forms, and at all levels of organization. What do we mean by that?

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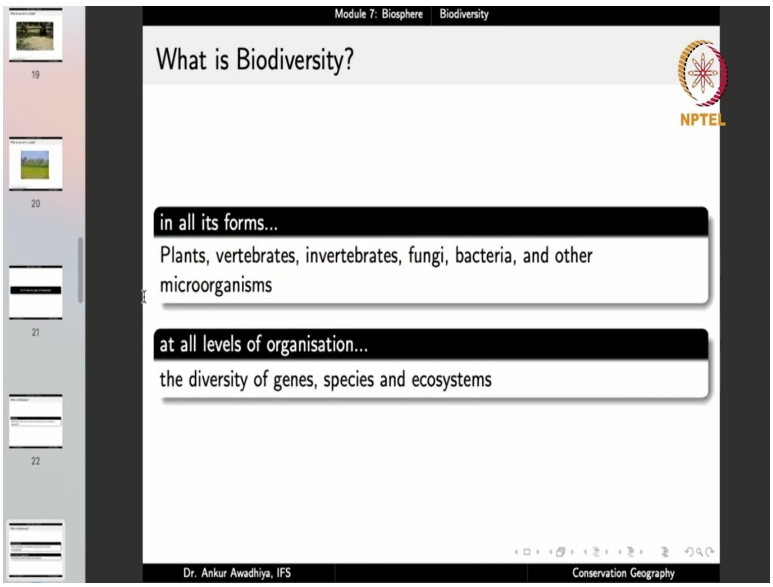

In all its forms meaning that we are talking about plants, vertebrates, invertebrates, fungi, bacteria, microorganisms, and a lot of other different forms of organisms. So you will find biodiversity in all of these different forms, and you will find biodiversity at different levels of organization. You will find even in the case of a single species, you will find that there is a diversity in the level of genes. Or, if you look at the community, you will find that there is a diversity in the level of species.

At a much larger scale, you will find diversity in the level of ecosystems. How many ecosystems does a forest have? Does it only have woodlands or does it also have grasslands? Does it also have water bodies? Does it have only the stagnant water bodies or does it also have flowing water bodies such as streams, and creeks, and rivers?

In the case of stagnant water bodies, does it have all the water bodies that are of, say, a particular depth, or is there a difference is there as well? Because we observed in the case of hydrosphere that the top part of a water body is the photosynthetic zone because light is able to reach there. But if the water body is deep enough, probably the bottom parts will be so deep that there is no light that is able to reach there.

So those will support a very different kind of organisms, different diversity of organisms than, say, a water body that is having a shallow depth. So these are all different kinds of diversities that we are observing. So we find biodiversity in all different forms and at all different levels of organization, especially at the level of genes, species, and ecosystems.

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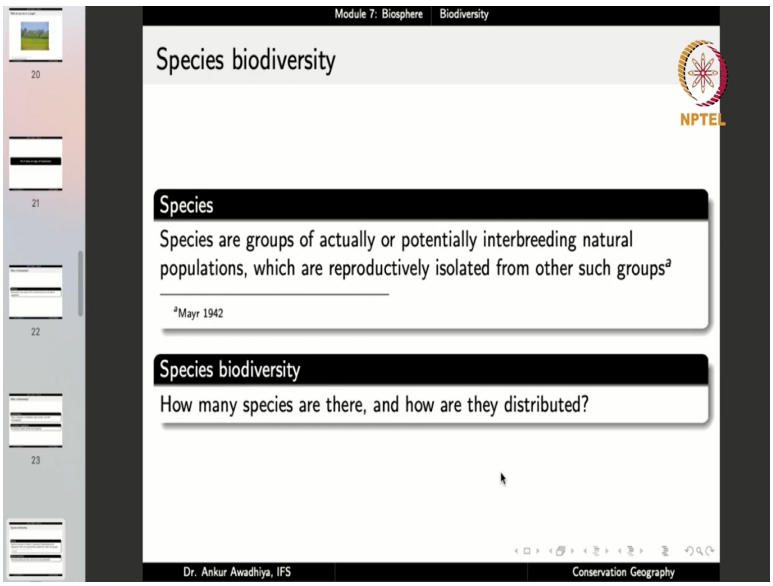

Now, if you look at all three of these separately, let us look at species biodiversity. What is a species? A species are groups of actually or potentially interpreting natural populations, which are reproductively isolated from other such groups. Species are groups of actually or potentially interbreeding populations meaning that if you take a tiger from, say, Tamil Nadu, if you try to mate it with a tigress from Assam, will both of them be able to mate together?

And will both of them result in the production of a fertile offspring? The answer is yes. Now, if the answer is yes, we'll say that both of these belong to the same species. Now, when we talk about these matings, they can be actual matings, or they can be potential matings. So for instance, a Tiger in a forest in Karnataka is mating with a tigress in the forest in Karnataka, when that happens we're talking about actual interbreeding because they are close together. But when we talk about the tiger in Karnataka mating with a tigress in Uttarakhand then we are talking about potentially interbreeding, or let us say an experimental interbreeding or let us say a thought experiment.

Now, organisms that belong to the same species will be able to interbreed with each other and result in a fertile offspring. But organisms that belong to different species will either not be able to interbreed or if they do interbreed, they will result in an offspring that itself is infertile. And so this interbreeding cannot go on for a very long period of time.

For instance, if you try to mate a tiger, with say, a horse or a donkey then this interbreeding will just not be possible. Now this is how we define species, groups of either actually breeding, or potentially interbreeding natural populations which are reproductively isolated from other such groups.

So when we say that Tiger is a species, it is because tigers are able to actually or potentially interbreed amongst themselves, and they are reproductively isolated from other species, such as lions or such as horses or donkeys or any other species.

So there are two criteria. One, if we see that this is a species, then organisms should be able to breed with amongst themselves. And two, they must not be able to breed with any other species. Only then we will say that this is a species.

Now when we talk about species biodiversity, we are asking the question, how many species are there and how are they distributed. So if there is a forest that is, say, having 10 species of

organisms. And there's another forest that is having 1000 species of organisms. Which one will you say, will have a greater amount of species biodiversity?

Well, the one that has 1000 species. So more the number of species, more is the amount of species biodiversity. At the same time, we also have to take care about the distribution of animals in these different species. Now, suppose you have a forest, in which you have four species, and the species composition is that you have 25% animals in species A, 25% animals in the species B, 25% animals in the species C, and 25% animals in the species D. That is, let us say that you have 500 individuals of species A, B, C, and D.

Now, in such a forest, if you go anywhere, you will probably find a few animals of A, B, C, and D. On the other hand, if there is another forest that again has these four species, but the species distribution is say, 99%, 0.5%, 0.25%, and 0.25%, meaning that if you go to any particular location, you will only probably observe the individuals that belong to species A, because they have 99% of the individuals of all the species combined.

So if you go anywhere, you only find this species. In this case, we will say that the amount of species biodiversity is less than another forest that was having 25% individuals in each of these four species because in the case of a more equitable distribution at any location you find a good amount of representation of different species. Whereas in the case of a lopsided distribution, for the most part (you can say that) we can approximately say that 100% of the individuals belong to species A, and B, C and D are so less that they can be as good as neglected or ignored.

So in this case, the distribution of individuals in different species also plays a role. So when we talk about species biodiversity, we are asking two questions. One, how many species are there. And two, how are they distributed.

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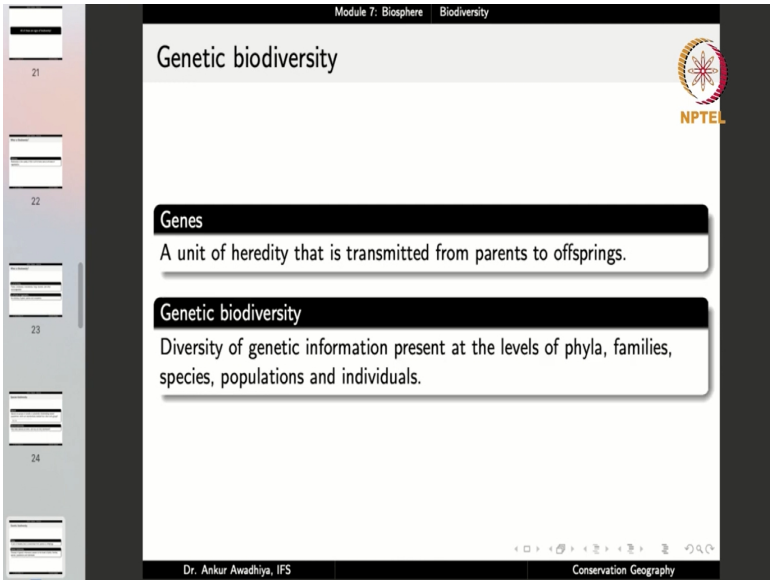

When we talk about genetic biodiversity, we are asking about the genes. Genes are units of heredity that are transmitted from parents to offsprings. So they are units of heredity, meaning that they pass on certain amount of information, that is the genetic information, from parents to offsprings.

So they in turn pass on certain information based on the lineage. And from a chemical or a biochemical point of view, genes are sequences of nucleotides that are present in their DNA, which is residing the chromosomes or the nuclei. So if this information changes, the genes change.

Now, genes are important because they code for certain information. So you will have genes that determine, say, eye color, or that determine hair color or the shape of the hair, whether it is curly or whether it is straight, skin color, height, intelligence, and so on. So you have different kinds of genes that code for different kinds of traits.

Now, if the sequence of nucleotides changes, there will be a change in the trait that has been produced. So probably there is a certain gene that codes for eye color, and one variant or the is coding for black color. Now, if there is certain amount of mutation or change in the sequence; in place of making a black eye color, it now makes a brown eye color or say a blue eye color.

Now, all of these are also differences, variations, diversity. So here we are talking about diversity at the genetic level. So genetic biodiversity is diversity of genetic information. And this diversity can be present at the level of phyla, families, species, populations, and individuals.

So when you're talking about genetic biodiversity, you can ask the question that, okay, if you take a certain protein, say haemoglobin, now, what is the amount of variation in hemoglobin gene in a particular species such as tigers? Or you can ask the question, okay, what is the variation in haemoglobin in all the mammals in the forest? Or you can ask the question that what is the variation or diversity in haemoglobin in all the animals of the forest?

So you can look at the genetic diversity at different levels. You can look at it at the level of species, or you can look at it at the level of genera, or you can look at it at the level of families and so on. So genetic diversity is the diversity of genetic information present at the level of phyla, families, species, populations, individuals, and so on at different levels.

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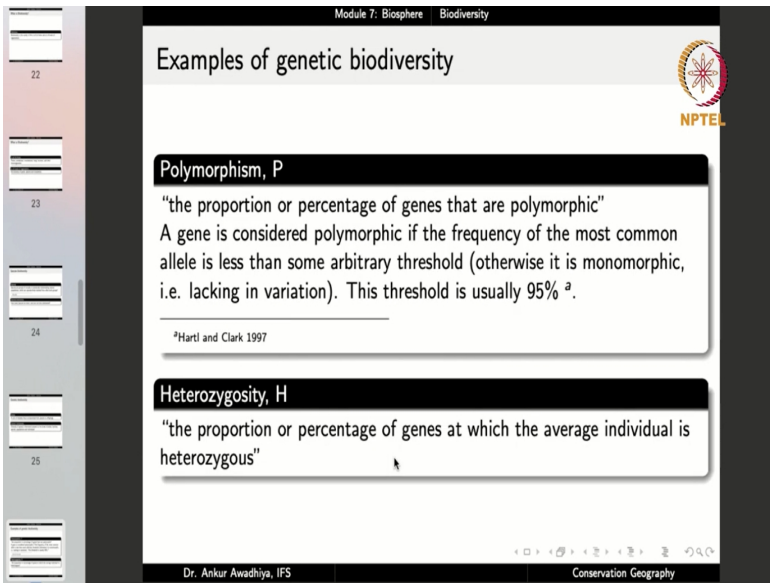

Examples of genetic biodiversity include polymorphism, and heterozygosity. So how do we quantify these genetic differences? What is polymorphism? Polymorphism is a proportion or percentage of genes that are polymorphic. And a gene is considered polymorphic if the frequency of the most common allele is less than some arbitrary threshold.

Otherwise, it is monomorphic or lacking in variation. And typically this threshold is 95%. So for instance, if we talk about eye color, then you have different colors of eyes in the human

population. We have black eyes, we have brown eyes, we have blue eyes, we have green eyes, and so on.

Now, is the eye color gene monomorphic or polymorphic? Now, suppose, 99% of individuals have black eye color. Then we'll say that this particular gene is monomorphic because it just lacks a variation. 99% of everything is the same.

Whereas, if it turns out that 60% of people have black eye color. 30% have brown eye color, and the rest of the eye colors make up 10% of the individuals. So in that case we'll say that there is a significant amount of variation in the different alleles of this gene, different way variations of these genes. And in that case we will say that this particular gene is polymorphic.

It has got different forms. Poly refers to many, morph refers to form. So polymorphism is the presence of different forms of a gene, different alleles, different varieties of a gene and polymorphism is the proportion or percentage of genes that are polymorphic. That is, if you talk about any individual of a species, the individual has a great number of genes.

In the case of humans, we have roughly around 30,000 genes. Now, when you talk about polymorphism, you are asking the question, how many of these genes are polymorphic. So the proportion or percentage of genes that are polymorphic is polymorphism. And the gene is polymorphic if the frequency of the most common allele is less than some arbitrary threshold, such as 95%.

Another way in which we quantify genetic biodiversity is heterozygosity. The proportion or percentage of genes at which the average individual is heterozygous, that is, if an individual gets the allele for black eye from the father, and the allele for blue eye from the mother. So in this particular gene, the person has got two alleles which are different.

Now, all the genes are present in two copies because we get one set of chromosomes from our fathers, and one set of chromosomes from our mothers, that is, one set of genes from our fathers and one set of genes from our mothers. Now, if we consider the alleles or the variations that we are getting from our fathers and our mother, then are both of these alleles or variations the same or are they different?

If an individual gets the allele for brown eye from father and brown eye from mother, then we will say that this particular gene is homozygous. Whereas, if he or she gets a different allele from father and from mother, we will say that this particular individual is heterozygous for this gene. And heterozygosity asks the question, what is the proportion or percentage of genes at which the average individual is heterozygous.

That is, if you take an average individual, for how many genes is this particular individual heterozygous and for how many genes, is he or she homozygous? So we are talking about the average individual. So this is a way in which we can quantify the genetic biodiversity. We can make use of polymorphism, or heterozygosity. Then, we also have biodiversity at the level of ecosystems.

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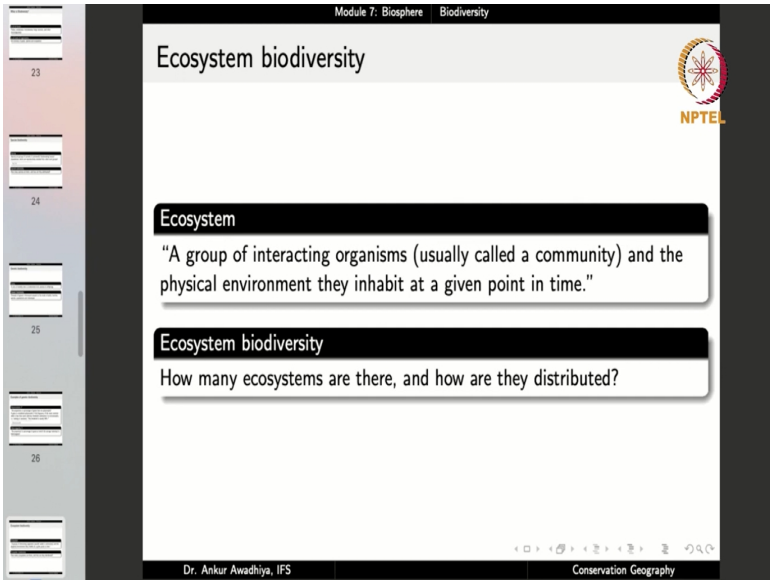

Ecosystem is defined as a group of interacting organisms, usually called a community, and the physical environment that they inhabit at a given point of time. So it is a group of interacting organisms plus the physical environment. So when you are thinking about ecosystems, you can think about things such as a pond.

Now, in the case of a pond, you have a large number of organisms that live in the pond, a great variety of species that live in the pond. Probably, you will have different species of fishes, different species of crabs, different species of reptiles, different species of amphibians, and so on.

Now, when you have all of these different species, they are living together, they form a community. Now, this community is living in the same physical environment that is a watery environment because there is water everywhere. Now, the combination of the community with the environment becomes the ecosystem. So the pond is an ecosystem.

Similarly, a river is also an ecosystem, a grassland is also an ecosystem comprising of different species of grasses, different species of insects, different species of mammals, different species of reptiles, birds that are all dependent on these clusters together with the physical environment comprising of the soil, the moisture, the sunlight, the air and so on.

Now, when we talk about ecosystem biodiversity, we are asking the question, how many ecosystems are there and how are they distributed. That is in your forest, is it so that you only have woodlands, or do you also have grasslands, or do you also have rivers, or do you also have ponds and so on? How many types of ecosystems do you have? What is the number of ecosystems that you have? Plus, how are they distributed?

That is, if you have 99% of the forest that is comprised only of woodlands, and just 1% is having the aquatic habitats, the grasslands, and everything else, then in that case we will say that the amount of ecosystem biodiversity is less than a forest that perhaps has 25 percent woodland, 25 percent grassland, 25 percent ponds, and 25 percent rivers. So here again, similar to what we asked in the case of species biodiversity, here again we are asking the question, how many ecosystems are there, and how are they distributed.

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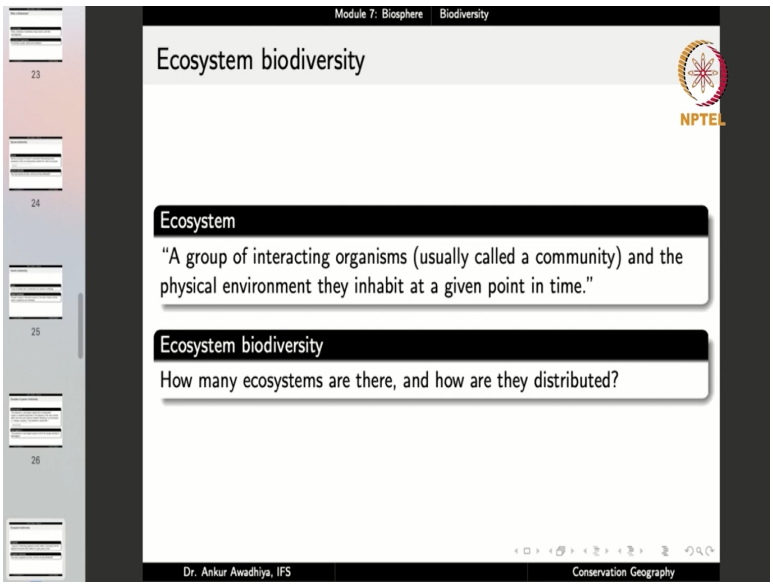

So that is ecosystem biodiversity, and to measure the biodiversity we can make use of certain indices. So for instance in the case of species biodiversity, we can have two things. One is the species richness, that is, the number of species that are present, and the species evenness, that is the distribution of individuals of different species.

Now, suppose you have two forest. The first forest has 100 different species, but it has a lopsided distribution, that is, species one comprises 90 percent individuals, and all the others comprise just 10%. But it has more number of species, 100 species. A second forest has only 30 species, but it has more equitable distribution of organisms. Now, in such a case, which forest will you call to be more diverse and which will you call to be less biodiverse?

So to answer these questions, we make use of certain indices. So these indices will combine the data on species richness and species evenness to give us a value of biodiversity. But then the question is, how do we compute these two values, richness and evenness?

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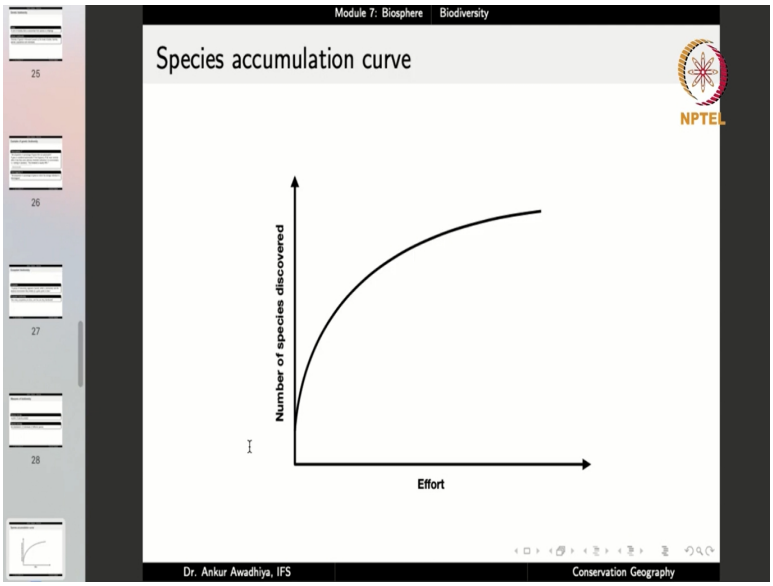

To compute richness, we make use of species accumulation curve, where on the x axis we plot effort. Now, effort can be something like the number of hours spent to look for different species, or the number of days that are spent to look for different number of species. So suppose you get to a forest, and on day one, you start noting down what all species that you have seen in this forest.

You are only interested in see a particular category that is mammals. So on the first day you get into the forest and you see that the first animal that you saw is a monkey. So you note

down number one, monkey. Then after some time you find a chital deer. So number two chital deer.

After some more time probably you find a bison. So number three is a bison, and so on. And at the end of the day, you probably found 20 species, and so your species count on day one is 20. So you go back, you take rest. On the next day, you come back again.

Now, on the second day, again, there are certain species that are more common. So again, you find the same chital, again you find the same bison, you find the same monkeys. So now, you're not going to note down these species, you're only going to note down species that you did not find in the day before.

So probably today were also able to cite a wolf. So you note down that okay, today I found the 21st species, which is a wolf. After some time, you even see a tiger. So number 22, I also saw a tiger. But probably you did not find anymore species, anymore new species. You go back home. You come back the third day. And today, again, you are able to see only two species. So what is happening in this case is the species count is increasing, but on the first day you were able to see 20 species, so your species count was 20. On the second day, it increased to 22.

On the third day, it increased to 24. On the next day it probably increase to 25, 26, 27, 28, and so on. But ultimately, there will come a stage where you are not finding any more species. So this is what the species accumulation curve talks. On the x axis, you plot the effort. So in this case, you will write the number of days. On the y axis, you will write the number of species. So first day, you found 20 species, next day you only increase the amount to 22.

Next day, you increased it to 24, next day you increased it to 25, the next day 26, and so on. Ultimately, you will reach a stage where you are not finding any more species, and if you draw a line parallel to the x axis, the point where it cuts here is the number of species that are there in this forest. So this is an estimate of the species richness, and once you have the list of species, next you can go about finding out the evenness.

So for evenness, you'll go to the forest and you'll note down how many individuals of each species are you able to find. So we can convert these data into indices such as the Simpson's diversity index.

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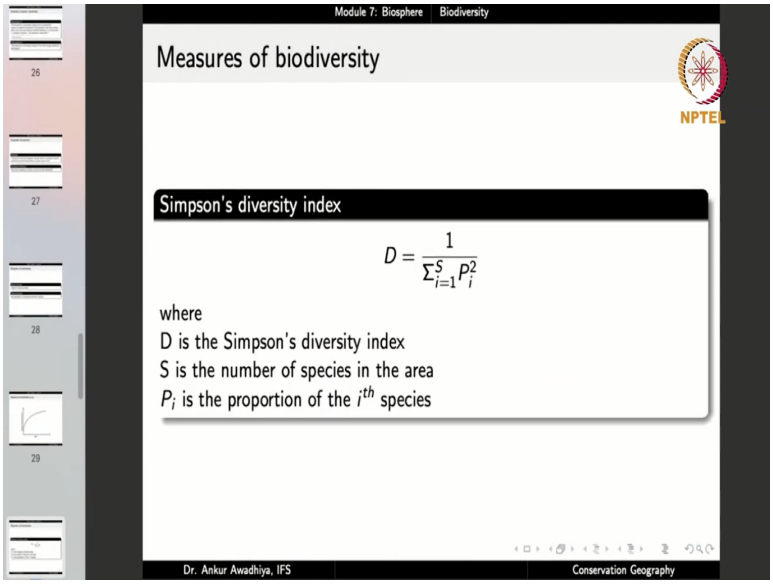

So it is written as D is equal to one divided by sum over all the species, i is equal to one to S, where S is the number of species, Pi square, where Pi is the portion of the ith species, that is, the number of individuals in the ith species divided by the total number of individuals that you found in this forest. And if you compute this value, you get the Simpson's diversity index.

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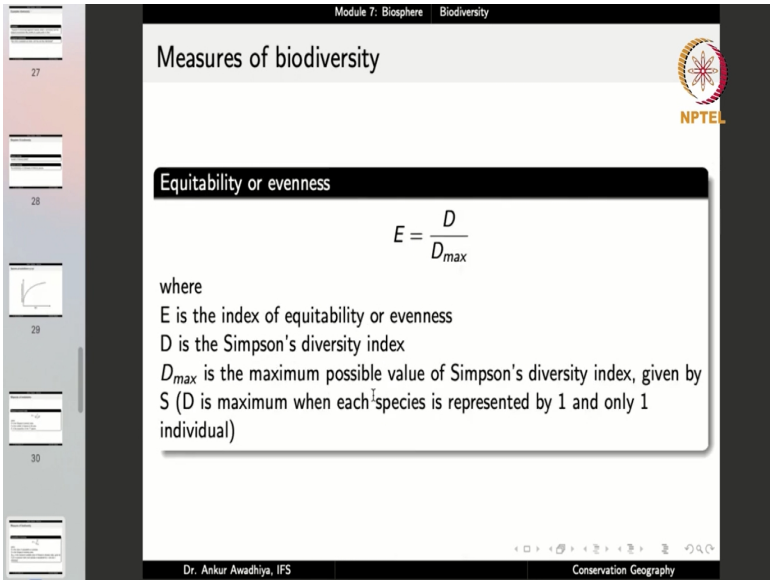

To understand this, we make use of the evenness values or the equitability values. E is given as D divided by D max. So D is your Simpson's diversity index. The maximum value of D is written in the denominator. So D max is the maximum possible value of Simpsons diversity index, given by S.

So when you have D max, it occurs when each species is represented by one and only one individual. So that is the proportion of each species is the same. So when you compute equitability, you are asking the question, what is the percentage of biodiversity that I have in this forest compared to the maximum theoretical possible biodiversity in this area.

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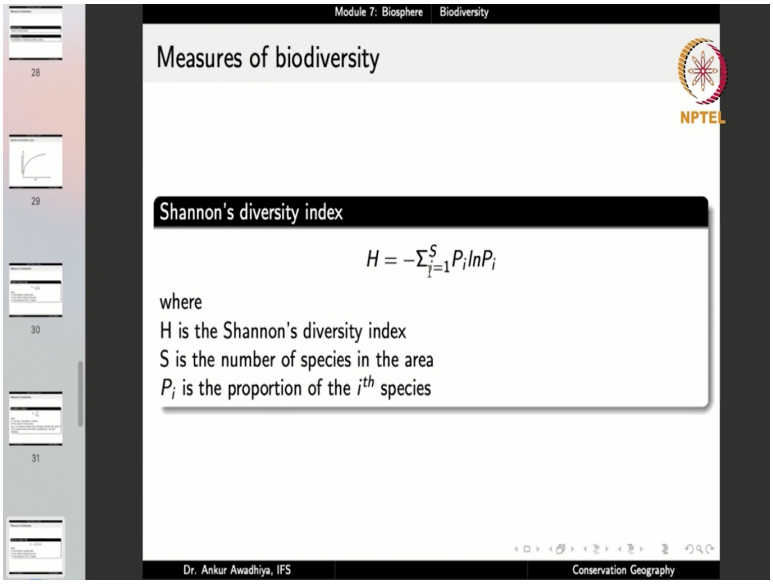

So you get to a certain figure that you can use to compare between two different forests. Another way is the Shannon's diversity index, which is minus sum over the number of species Pi into log of Pi. So this log is the natural logarithm and Pi is the proportion of the ith species.

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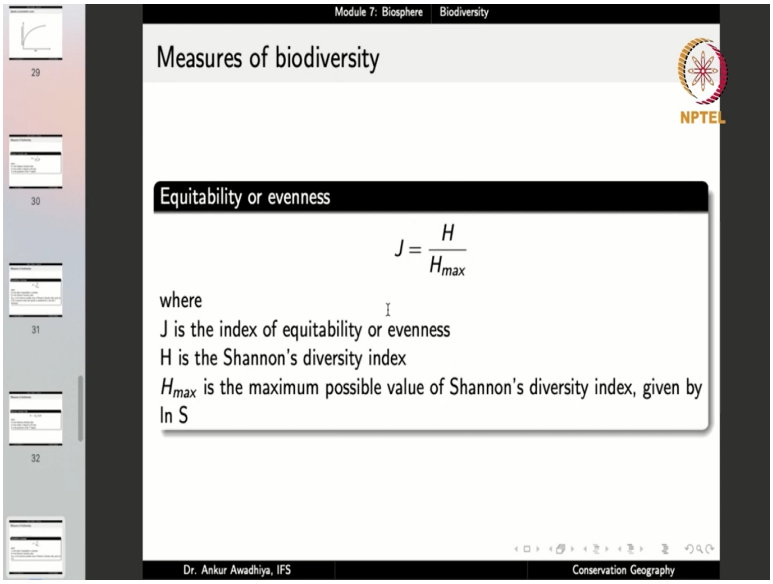

Here again, you can find the equitability or evenness given by H divided by H max. The value of Shannon's index divided by the maximum value possible. So by doing this computations, we come up with a value for each forest, and the one with a greater value of

evenness or equitability has more amount of biodiversity. So this is how we are able to compare between different biodiversities, or different areas with different biodiversities.

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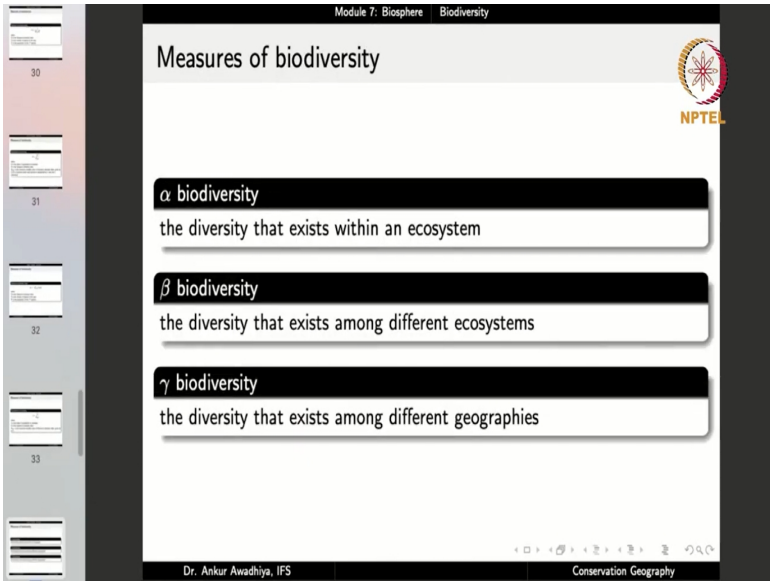

Another concept here is the alpha beta and gamma biodiversity. What is the scale at which we are looking at biodiversity? Alpha biodiversity is the diversity that exists within an ecosystem. What is the amount of biodiversity in a pond, what is the amount of biodiversity in a grassland is the sort of question that you are asking here, in the case of alpha biodiversity, the level of biodiversity in a ecosystem.

Beta biodiversity is the diversity that exists among different ecosystems. So now, you're comparing between different ecosystems and you are asking the question what is the level of biodiversity. And gamma biodiversity asks the question what is the amount of diversity among different geographies. So areas that are far off from each other. Now, concepts like these become important, because in a number of cases, if we are not careful about the scales at which we are measuring the biodiversity, we may perform something that is completely against the concept of conservation.

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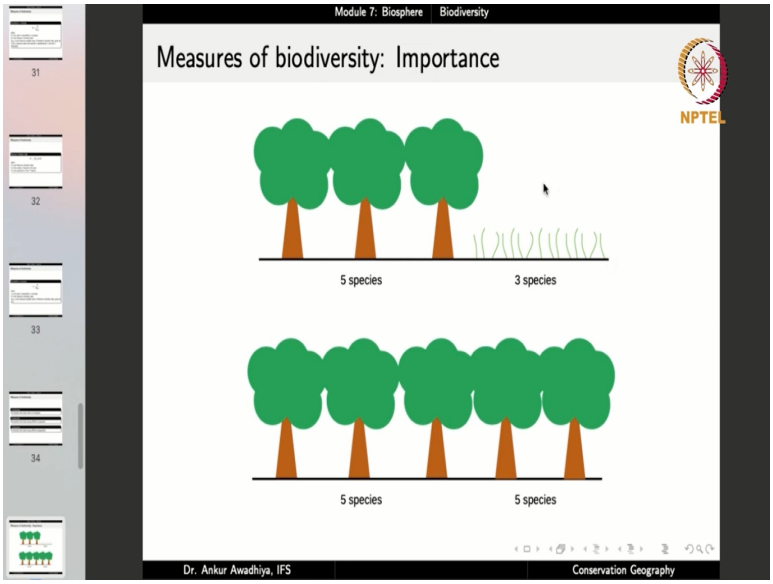

For instance, suppose you have a forest, and this forest has two ecosystems. One is a woodland, and this woodland has five species, and the second is a marsh area, which has only three species. Now, somebody may come to this area and say that okay, a marsh has three species, whereas a woodland has five species. Why don't we drain this marsh? And in that case when this area is drained, it becomes land, trees come up, and then our biodiversity will increase from three to five. That is, in this area, currently, there are three species. Later on, there will be five species.

Now, such an idea, on the face of it, it looks absurd. Why? Because when you are converting this area into a woodland then here also you have the same five species, here also you have the same five species. So earlier, we were having five species of woodland plus three species of the marsh, giving a total right in the forest, but now here we have five species, here again five species, and here again five species.

So if we look at a larger scale, we are finding that there is a reduction in the number of species. But on a smaller scale, if you only talk about this area, then there is an increase in the biodiversity. So when we are talking about conservation, we have to be very careful about what we are doing because in a large number of cases, what we do is that we finish of a particular ecosystem, convert it into something else in the hope of increasing biodiversity, whereas in reality, we completely destroy the biodiversity.

Good examples include things such as planting of natural blanks. So in the case of our forests of certain areas that are only able to support grasses. Why? Because they are in a level of ecological succession where the soil cover is not that deep that it would be able to support the trees. So it is at the herbaceous stage.

But then, you'll always find people who come to this area and say oh, this is a blank area, it only has certain grasses, so let us remove all these grasses and let us plant trees in this area. In that case, we will convert this area into a forest.

Now, in that case, the person who is suggesting this is suggesting that we remove the existing biodiversity and replace it with certain other diversity. Now, if you do this, you will have a forest. In a large number of cases, such things will just not work, because this area is not suitable for trees so trees, inevitably will fail. So you'll have a failed plantation. But in those cases where you become overseres, bring in soil from other areas you dump that soil into these grasslands and then you plant trees then to what is happening?

You're reducing the biodiversity because earlier you had two ecosystems, the woodlands and grasslands and plus you also had an ecotone, which is the area between both of these ecosystems. So there are certain species that live in the ecotones as well, species that need to, say, make use of the grasses for their food and make use of the forest as their shelter.

But later on, if you completely covered this area with soil, you planted trees, now you only have one ecosystem. No ecotones left. And the species diversity also goes down. So you have to be very particular when somebody suggests that we should do such and such modification of ecosystems to increase the biodiversity.

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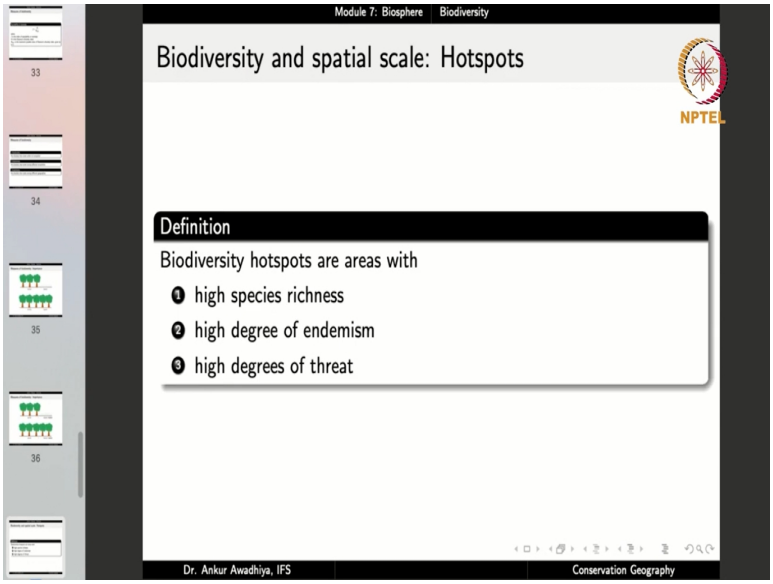

Now, when we talk about biodiversity, and the scale at which we are talking about biodiversity, there are certain hotspots. Biodiversity hotspots are areas with high species richness, high degree of endemism, and high degree of threat, meaning that these are those areas where you find a large number of species, areas such as our western ghats.

So when we were talking about the physiography of India, we talked about the Western ghats. Now, the western ghats are the areas that are between the western coastal plains and the plateau area. Now these mountains, they have not been used very much because they were largely inaccessible and plus, the soil is not that fertile, but they are the climatic divide.

So on the western side of western ghats, you have a very heavy down pour because that is the windward side of our monsoons. On the eastern parts, you have a very dry area on the leeward side. So overall, in the western ghats, you find a tremendous amount of biodiversity because you will find those organisms that need more amount of water, plus you will find those organisms that need less amount of water. And at the same time, these areas have not been diverted for human use.

So it is not the situation that we have converted all of these forests into grasslands, or into agricultural fields or into building complexes. So these are the areas which we still have a large amount of species richness. When we talk about high degree of endemism, it means that there are certain species that are only found in these areas and there are not found anywhere else. And especially in the case of our western ghats, you will find a large number of species

of frogs or species of snakes that are not found anywhere else on the whole world. So that is the view of endemism.

And high degrees of threat. Why a degree of threat? Because every other year, you will come to know through news that searching such and such person wants to mine these areas for such and such minerals. Or such and such person wants to convert these areas into agricultural fields, or to convert these areas into, say, sea facing bungalows.

So there is a greater threat to these areas. People want to convert these areas into something else. Now, areas which have high species richness, high degree of endemism, and high degrees of threat are hotspots. They are extremely crucial because they are facing a high degree of threat, if we do not save them then will be lost forever. And the areas we are talking about, have a large number of species that are found and a very large number of species that are found nowhere else.

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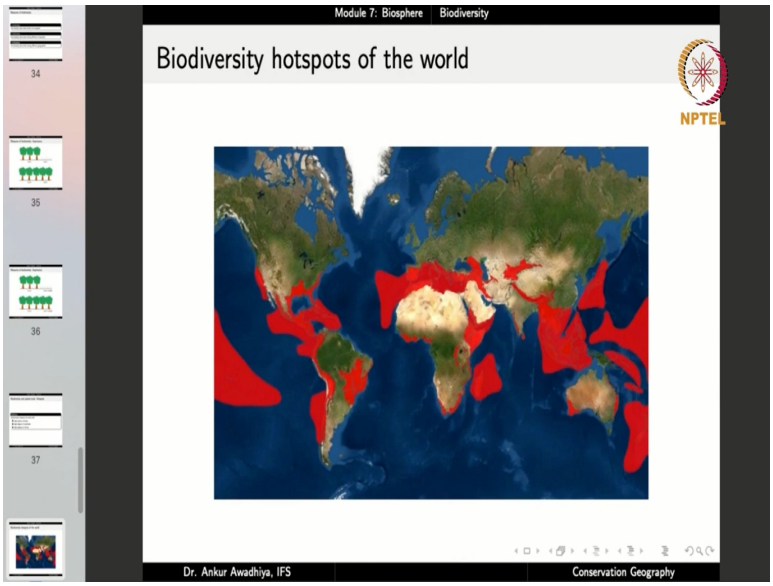

So if you lose these areas, you will lose the species as well. So this is a map of the biodiversity hotspots of the world. Western ghats, a biodiversity hotspot. The Himalayas, another biodiversity hotspot. Now, from the geographical point of view, we can see from this map that okay, there are certain areas that need to be protected much more than other areas. So conservation in this geographical areas is of paramount importance. The next question is, why are these areas the diversity hotspots? Why do we have these areas that have more biodiversity and the other areas have less biodiversity?

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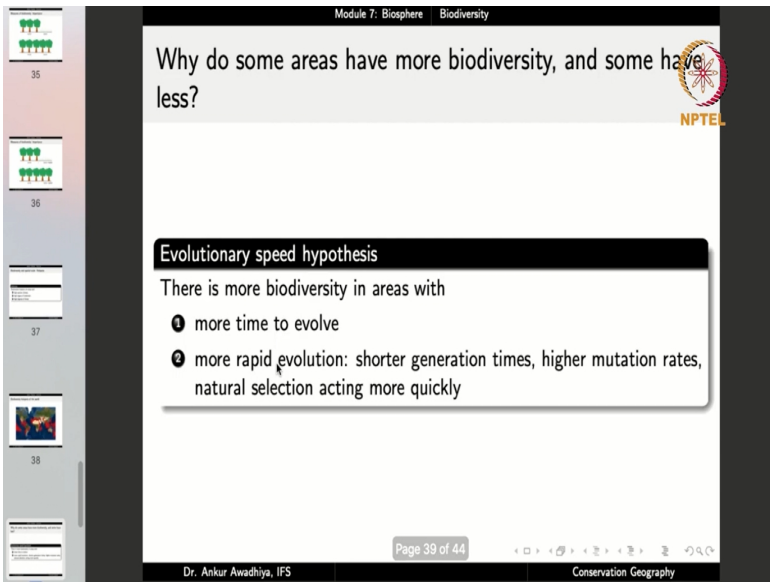

So in this context, we have certain hypotheses. Not any of these hypotheses will be able to explain all the situations, but these hypotheses give you an idea about what leads to more biodiversity. The first one is evolutionary speed hypothesis. There is more diversity in areas with more time to evolve. Why? If you consider a bare rock, there is practically no biodiversity, no species whatsoever. You give it time, it goes through ecological succession and it moves into a climax forest with a large number of species.

It takes time. But at the same time, if an area has more rapid evolution, that is, areas with shorter generation times, you have species that produce the next generation of offsprings very soon, higher mutation rates, natural selection acting more quickly, then you will have more number of species.

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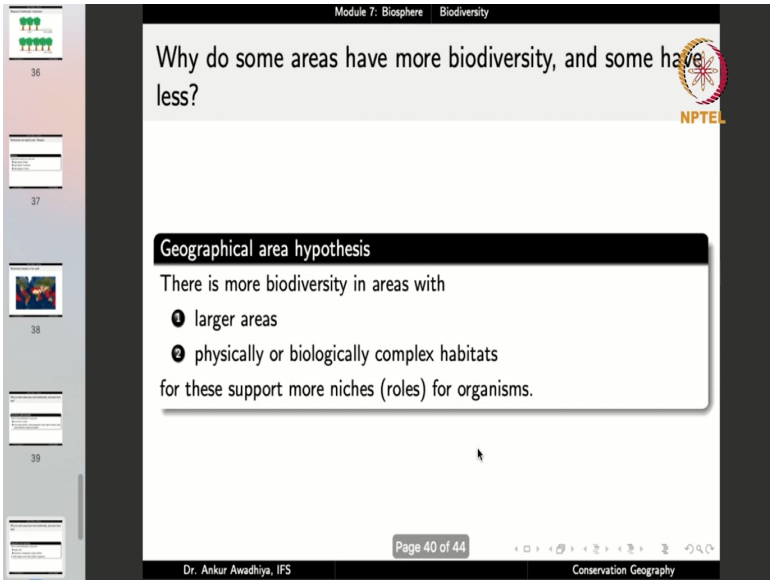

Another is the geographical area hypothesis. Areas that are larger can support more number of species. Areas that are complex, either physically or biologically, they have more number of species because there are more number of habitats, there are more number of ecosystems, more niches for organisms, and so the biodiversity will be more.

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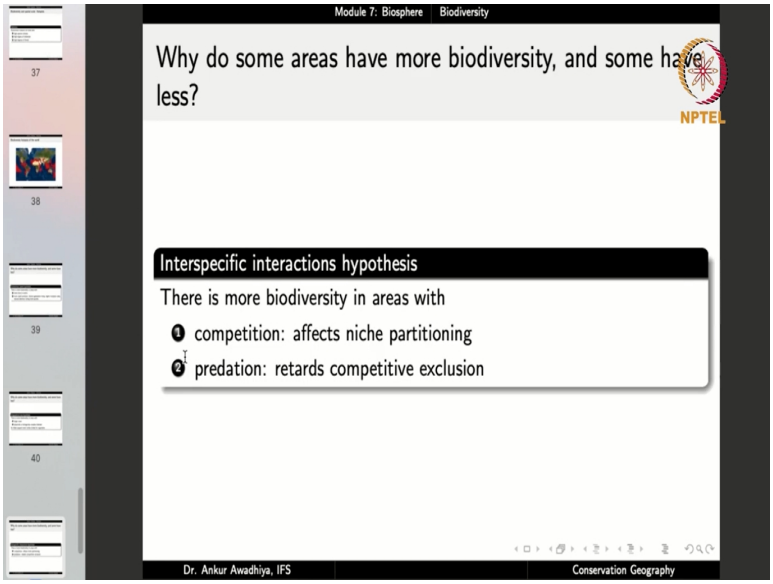

The interspecific interaction hypothesis. There is more biodiversity in areas with competition. If organisms are competing for resources, then they will become more specialized. When they becom specialized, they ultimately result in the formation of new species or new varieties.

Similarly, in areas where there is predation, you have the development of newer forms because here, again, you have predators that are evolving more and more, faster speeds, better camouflage, better responses, and same with the prey. So more competition and more predation result in more amount of interspecific interactions, which result in more biodiversity.

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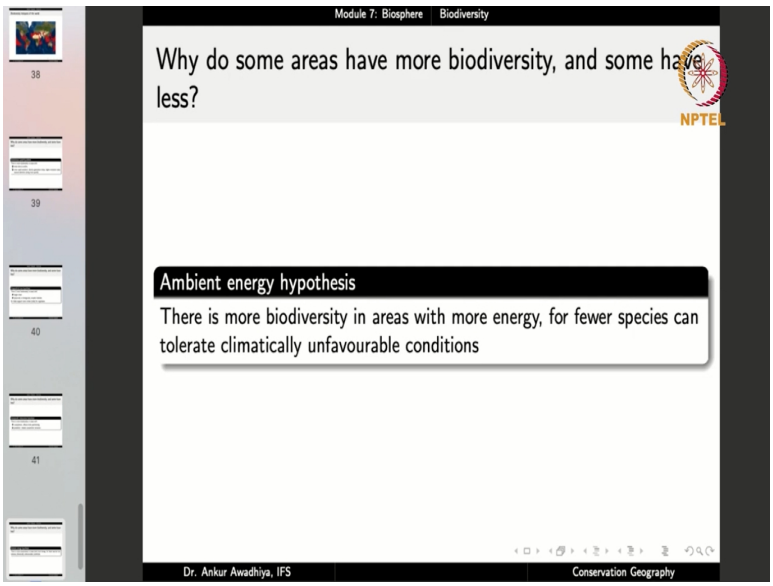

Ambient and energy hypothesis. There is more biodiversity in areas with more energy because very few number of species can tolerate climatically unfavorable conditions. So for species to exist, they require energy. And so the amount of biodiversity in polar will be very less because there is hardly any energy. It's in energy deficit area, but the equatorial rainforest will more amount of biodiversity because they have more amount of sunlight that is coming there, more amount of primary production that is going on.

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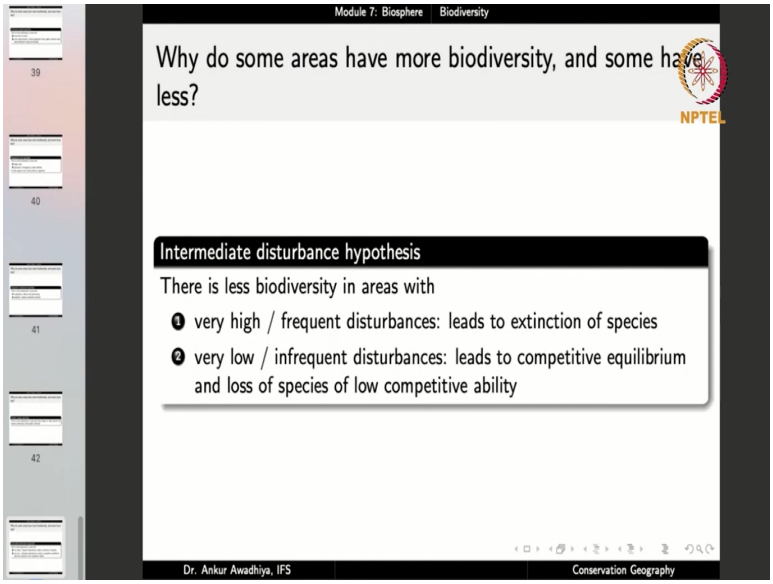

Next we have the intermediate disturbance hypothesis. If an area has a very high or frequent disturbance, such as floods every year or forest fires every year, then the species die every year, and there is a huge amount of extinction. You will hardly find large biodiversity in that area.

At the same time, areas with very low or infrequent disturbances, again, you have a very stable condition. And so you do not require more number of variations for organisms to survive. So in those areas where there is very less amount of disturbance, you will find a set of organisms that are well suited, but you will not find anything else.

So this leads to competitive equilibrium and loss of species of low competitive ability. But those areas where the disturbances are intermediate, neither very high nor very low, they will have a greater amount of biodiversity.

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So in this way, we can explain different amounts of biodiversity in different areas and this is another correlation of biodiversity with geography. So that's all for today. Thank you for your attention. Jai Hind!