Forest Biometry
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Lecture - 21
Canopy Attributes - Part I

[FL]. In this week, we shall have a look at canopy attributes. Now, canopy as we know consist of the uppermost branches of the trees in a forest that form more or less continuous layer of foliage.

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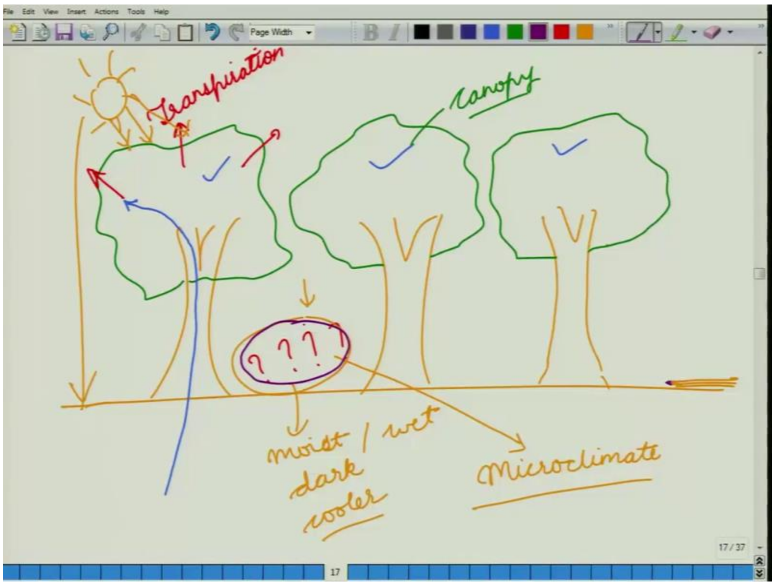

So, to represent it suppose we consider the trees in a forest, then these trees have this umbrella like structure of leaves. In most cases, it forms more or less continuous layer and this is known as the canopy.

Now, why is it important to know about these canopies? For one, they change the microclimate of the forest.

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So, if you looked at this image, we see a forest and down side we see a very lush growth of undergrowth including shrubs and herbs. Now, in the case of this canopy because all these leaves are giving out water through the process of transpiration, now in the process of transpiration water that is getting into the trees from its roots goes to the leaves and is then given out through evaporation. So, evaporation through the leaves is known as transpiration.

Now, if all these leaves here, here and here are giving out water vapour, what would happen to the amount of water vapour at this location? Naturally it will be a moist region. At the same time if we consider the sun over a piece of bare ground, all its rays are able to reach directly, but at this location, the rays of sun can only go to the canopy and very little amount of light will be able to reach through to this point. So, it will be moist because your sun rays are not leading to this temperature rise and leading to a loss of moisture. So, this region is moist. It is so moist or we could call it wet. It is also dark as compared to a bare ground.

At the same time, it is also cooler because your sun rays are not able to heat up this region. So, the climate of this point also known as the microclimate is very different from the climate over a bare piece of land that being said the nutrient that will be here on this portion will also be different.

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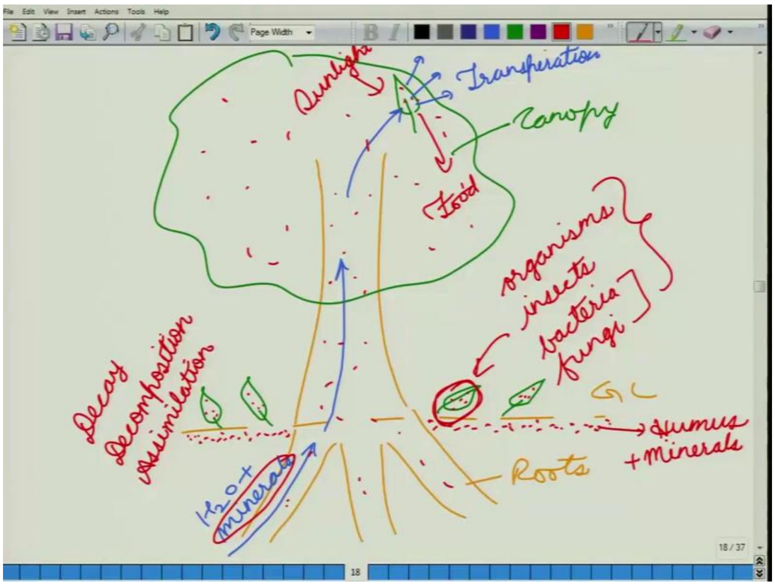

The nutrients we will be having here, why would that be so? It is because let us consider a tree. So, this is the ground level, these are the roots and then this is the canopy. Now, the roots are taking in water plus minerals from the soil. Then, that water and minerals, it goes up the bole and then, it comes to the leaves. From the leaves, the water gets lost in the process of transpiration plus the minerals that have gotten inside from with the water, they are then distributed. So, these leaves will use sunlight to produce food. Now, that food would consist of carbohydrates, sugars plus these minerals. They would also be distributed back to all parts of the plant through its flowing tissues. So, you will have minerals everywhere plus the food that goes to all the locations.

Now, what happens after sometime, after sometime this tree will get older and when it gets older or may be this leaf gets older or when a time comes when this trees shedding off the leaves, then these leaves will come down to the forest floor. Now, because these leaves also had these minerals, so we will get these minerals down here to the forest floor. After sometime these leaves would be eaten away by insects or by bacteria or by fungi or by some other organisms and then, these leaves, so all the energy that was there in the leaves that has gone into the bodies of the organisms, all the minerals that were there in the leaves have gone into the bodies of these organisms.

Now, what would happen to these leaves? Later on these would then be defecated out from the bodies of the organisms or if they are being eaten upon by bacteria and fungi, they would directly be decomposed. So, a process of decay decomposition, a process of assimilation would happen now. Not only would these leaves die after a while, but also these organisms that have fed up on the leaves. So, their bodies now have this energy. They now have these minerals and after a while, they will also decompose.

So, when all that happens, you will get this layer of soil that is very rich in humus. So, humus is the decayed portion of these leaves plus it will have lots of minerals. So, for instance if you looked at a layer of the soil in the forest road, if looked at the soil profile, so its peak we are looking at the soil profile.

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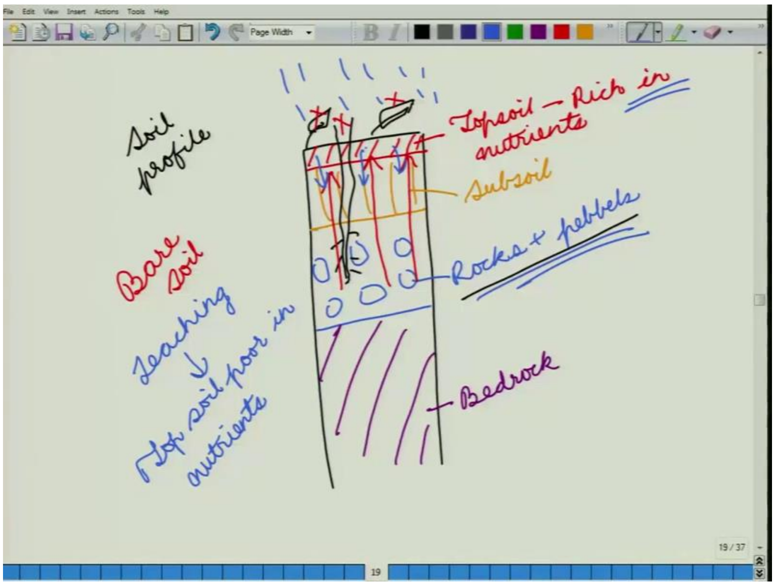

So, what is our soil profile? If you looked at different layers of the soil and then, if there are any differences, they would show up and that is known as soil profile. So, it would consist of a topsoil that is rich in nutrients. That would be followed by a subsoil that is poor in nutrients, that would be followed by a layer where you have rocks and pebbles followed by this big bedrock.

Now, what your roots have done in this case is that once these roots have gone down, they have their root hairs and they have been taking the minerals from these rocks and pebbles and later on in the form of leaves, they are throwing it down to the topsoil. So, now the the nutrients have gone from your rocks and pebbles layer to the topsoil. So, in this case, this topsoil beneath this canopy is very rich in nutrients, but what happens in the case of a bare soil. In a bare soil, you do not have all these processes going on. There are no trees that are sucking of these nutrients from the bottom, there are no leaves that are putting these nutrients back into the topsoil layer.

So, what happens in the case of bare soil? So, in the case of a bare soil, these two processes are not going on. So, what will happen is when you have rainfall, then these nutrients will get leach down. So, with the water they go down into the subsoil or maybe to these rocks and pebble layer back. So, that process of leaching makes the top soil poor in nutrients. So, it makes topsoil poor in nutrients.

So, now remember that all these processes are happening because of the presence of trees and because of the presence of the canopies. So, canopies have a predominant effect or an impact on the nutrient availability in the soil below.

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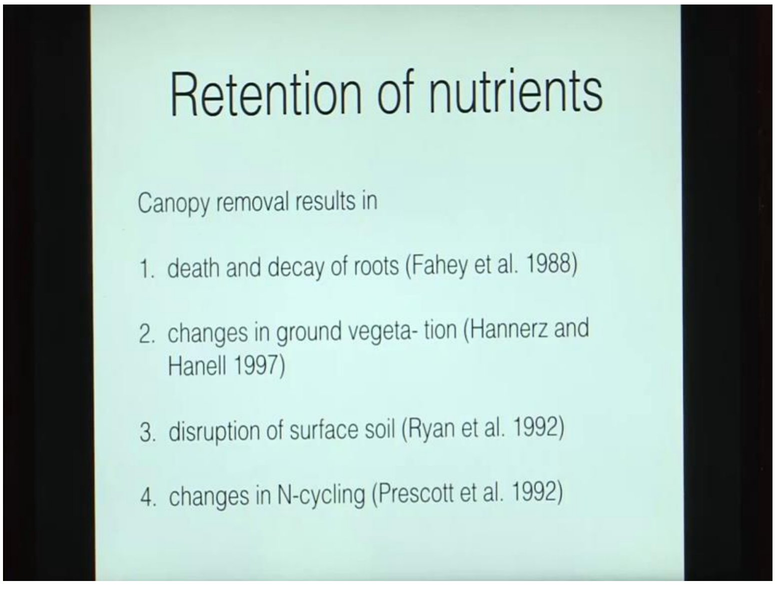

Now, if you remove the canopy from a site, it would result in the death and decay of roots. So, how do you remove a canopy? You could just clear fill a forest. So, the removal of its top layer would result in the death and decay of the roots as well because now the roots are not getting any nutrients. It would result in changes in ground vegetation.

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So, this is because when you have a land and when you have trees, then the microclimate of these sides is very different because this is wet, this is moist, this is cooler and it is darker. So, the kinds of organisms and the kind of vegetation that grows in this place would be very different from a place that is just exposed to the sun.

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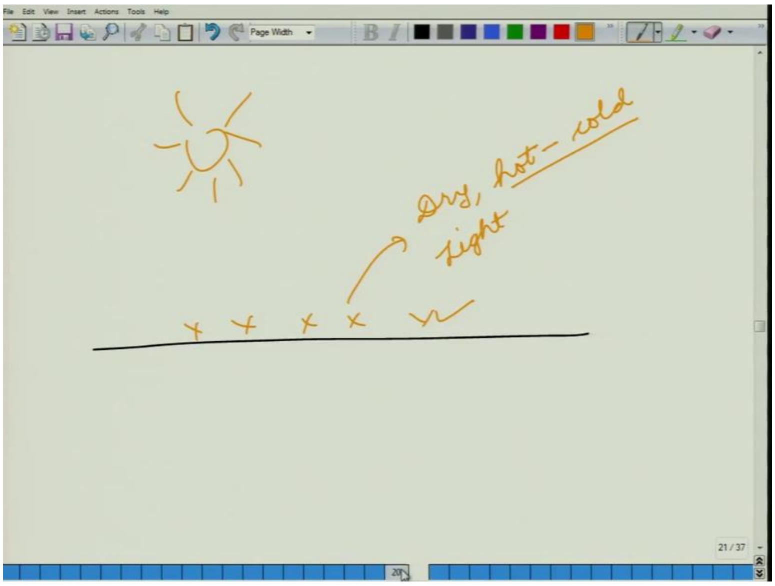

So, when this place is exposed to the sun, then what is the condition here? This would be dry, it would be very hot in the day to very cold in the nights. In the case of these forest areas, we are having an equable climate or inequable microclimate, but in this case we have a very hot condition to a very cold condition. We have this transition plus this area is lots of light.

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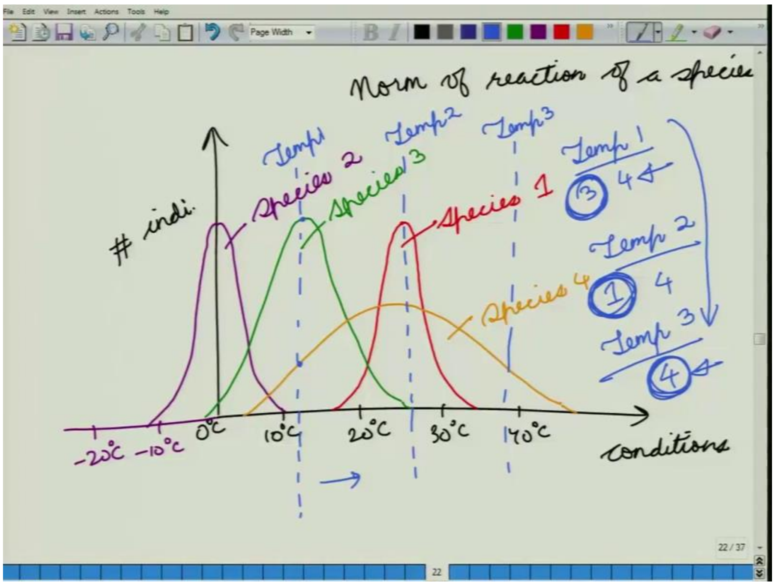

So, the kinds of species that you will find here will be very different from the kinds of species that you find here and why would that be is because of a condition known as a norm of reaction.

So, basically if you consider any species, we are talking about the norm of reaction of a species. So, if we plotted number of individuals on the y axis and the conditions on the x axis, suppose we take the condition of say temperature. So, we are floating it from 0 degrees to 10 degrees, then 20 degrees, 30 degrees and say 40 degrees. Now, for any organism, the most preferred temperature would be fixed. So, for instance in our case, we can generally live. I mean we are most comfortable when our temperatures say around 25 degrees, but if you put somebody into a place that has a temperature of say minus 20 degrees, he would not be comfortable. He would require lots of energy, he would require lots of woollen clothes.

Now, remember that other organisms say a monkey. Monkey does not have access to clothes, a monkey does not have access to air conditioners. Similarly, if you put somebody into a very hot place say a place with 50 degrees temperature, then your monkey will not be able to survive there. So, in the case of your monkey or say in the case of humans, we are most comfortable here at this point, but that does not mean that we cannot thrive at 30 degrees. We can thrive at 30 degrees, but the number of individuals that would be thriving at some other temperatures would go on decreasing. So, this would be our norm of reaction for species 1.

On the other hand, let us consider some other species say a polar bear. Now, a polar bear can very easily live in sub-zero conditions say minus 10 degree Celsius, minus 20 degree Celsius. Suppose this norm of reaction goes close to 0 degrees, so what will have in this condition is will have a situation like this.

So, this is for another species, species 2. Now, similarly for all different species will be having different norms of reactions; so this is for species 4. This is for species 3 and so on. Now, suppose you change the conditions. So, suppose earlier your temperature conditions was close to this, so at this temperature you are seeing a lot number of individuals of species 3, some individuals of species 4, but now let us move this temperature towards the right. So, suppose let us take this temperature, so at this temperature. So, let us consider this is temperature 1, let us consider this is temperature 2 and maybe let us consider this as temperature 3.

So, at temperature 1, what will species do? We see at temperature 1, we are seeing species 3 and we are seeing species 4 at temperature 2. So, 3 is found in large numbers here for found an the smaller numbers. Now, at temperature 2, we are seeing species 1, we are seeing species 4. Here species 1 is in the majority.

Now, if we looked at temperature 3, so at this 1, we only see species 4. So, as you can see species 4 was there in all the three temperatures, but the other species that are found around with species 4, so in the case of temperature 1, your species 4 did not dominate the scene. It was dominated by species 3, but when you shifted your temperature from temperature 1 to temperature 3, now your species 4 is dominating the scene.

Similarly, when you remove the canopy at a place, you are not only changing the temperatures, you are also changing the amount of moisture that is there, the amount of light that is there. So, the composition of the species in the bottom layer will change. So, not only will the plant species change, the animal species will also change there.

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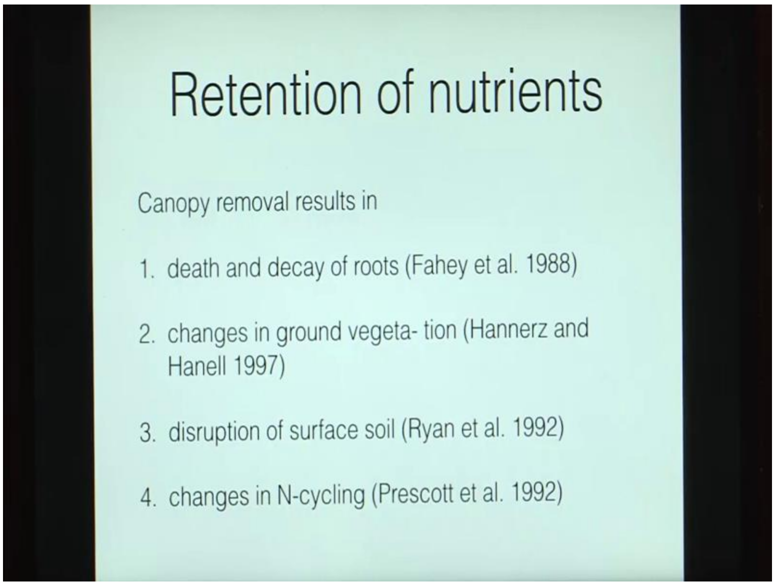

So, now coming back to the slide. So, we have seen that canopy removal results in changes in ground vegetation. It also results in a disruption of surface soil. Now, why would the surface soil be disrupted; because now the surface soil will not be having enough moisture. It will be exposed to the sun rays. Now, when this ground is exposed to the sun rays, what happens is that its top portion dries very fast and when that top portion dries up, it will also result in the death of the individual of the species that are found there in the top soil.

So, when that layer dries up, it results in the disruption of the surface soil also. When you have removed this canopy, all the nutrients that are there in the top soil will further get leach down. It also results in changes in nitrogen cycling.

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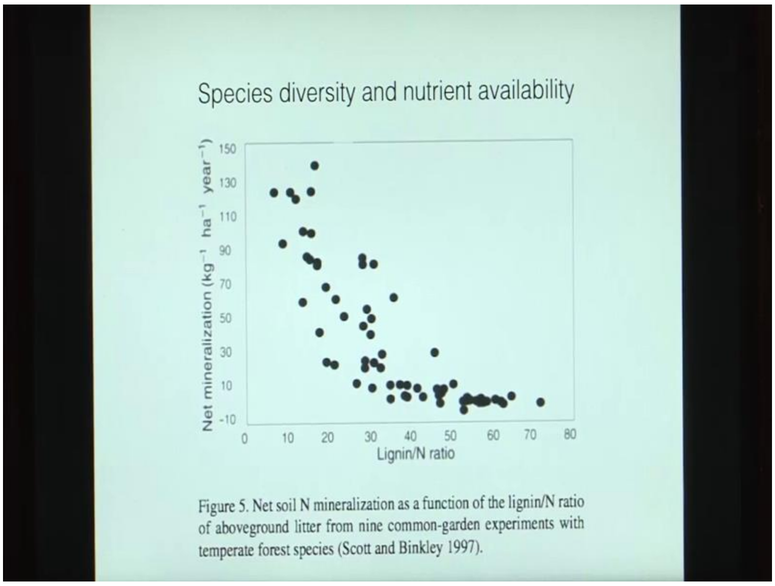

So, this is one curve from a paper which uses that the net soil nitrogen mineralization as a function of lignin by nitrogen ratio of aboveground litter from nine common-garden experiments with temperate forest species.

So, basically not only does this removal of canopy bring about these differences, but also if you change the species that were forming the canopy. For instance, if you go to a forest that is full of teak trees, the canopy there might have lots of teak leaves, but its bottom soil I mean its bottom layers, they will be having a very different composition as compared to this bottom region in a soil forest or maybe in a mixed forest.

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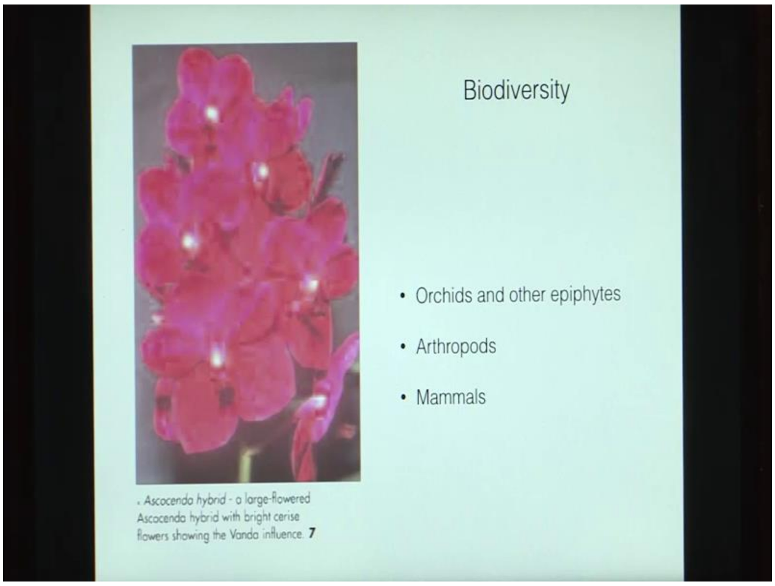

So, species diversity also changes the amount of nutrients that are available there. This canopy is also very important for the purposes of biodiversity.

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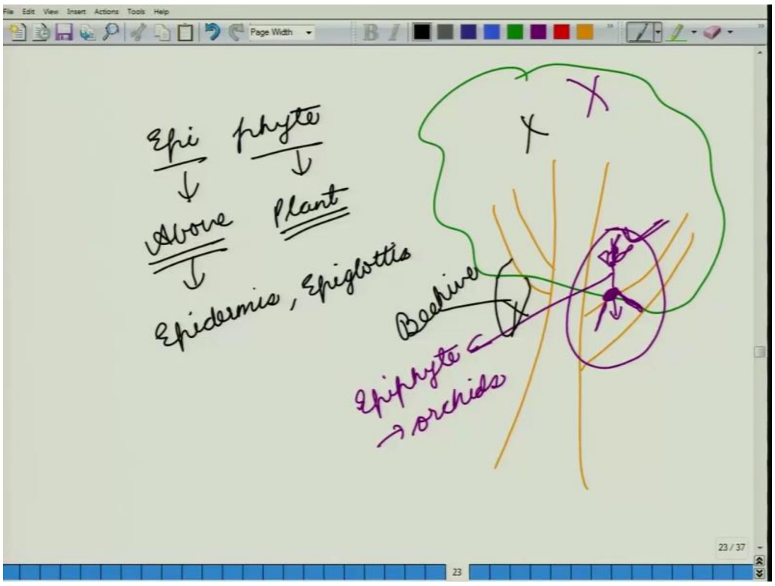

So, why is that important? So, this image of the flowers, it shows orchids. Orchids are epiphytes. So, now again coming back to the word roots when we say epiphyte, epi means above and phyte is a plant. So, epi is found in things like epidermis or say epiglottis. So, epidermis is the top layer of your skin and epiglottis is the structure that is formed above the glottis.

Phyte is a plant. So, epiphyte is a species that resides on top of a plant. So, how does that happen. So, let us consider the tree with some branches and suppose this is the canopy. Your epiphyte would take our position somewhere here. So, an epiphyte is not a parasite. So, basically it is not driving its nutrients from the tree, but it gives out some roots on top of this tree. So, it is not disturbing the tree, it is just using it as a place to live and then, it would give out its leaves and maybe some flowers. So, this is an epiphyte. A very good example is orchids.

So, orchids live on top of trees. So, if you did not have these canopies, then you would not have this specific microclimate. So, this microclimate is not connected to the soil. It is connected to the air and this microclimate is having lots of moistures, it is having an ambient amount of sunlight. So, it is not completely exposed to sunlight, it is also not completely exposed to sunlight. So, it is not living in dark conditions, it is living in conditions where your sunlight intensity is at a medium level which make this a very favourable microclimate for the thriving of epiphytes.

So, this is one portion of biodiversity that comes out because of your canopy cover. So, we move back to slides now. So, biodiversity for instance orchids and epiphyte, biodiversity including arthropods and arthropods including say insects. So, arthropods is a class of species that have joint legs. So, insects are the most common example.

So, for instance your canopy can be a store house for honey bees. So, you will have these canopies that are having some say beehives. So, if we did not have this canopy, we would not be having a beehive here because that again is a very specific climate that it also provides house to some mammals.

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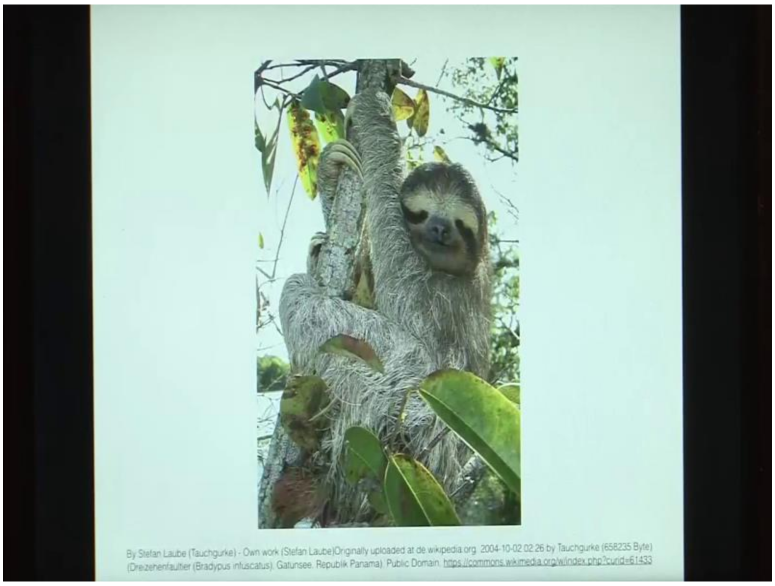

So, coming back to the slides. So, there are some mammals that live in the canopies; for example, the sloth. Now, sloth is an animal that lives in the canopies. It is a very slow moving organism which also results in the sloth referring to somebody not taking interest in activities. So, somebody who is a very lazy person is called a sloth. So, this animal, this beautiful living animal and you can see the nails that it has at this point, it has very sharp claws and it is a very sedentary animal. It will just live on top of the trees and it would just eat some fruits out there and so on.

So, this is one portion of biodiversity which you will not see outside of canopies.

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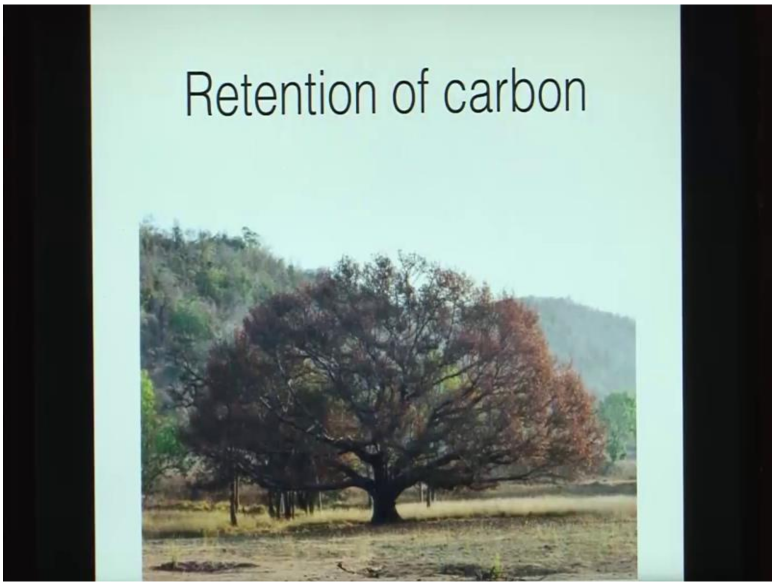

Now, canopies also have good store house for the retention of carbon. So, for instance in this tree that we have seen before, you have a lot of biomass that is retained in your canopies.

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So, it is important to understand the structure of canopies. So, what are the parameters or what are the attributes of a canopy? We could have canopy diameter.

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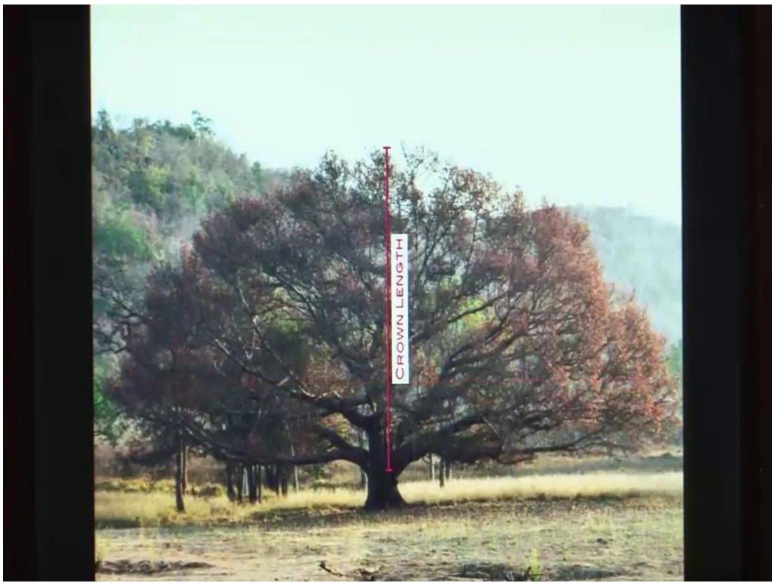

So, that is the diameter of this canopy. If you are looking from top, we also have a crown length. So, by using both of these, we can calculate the canopy volume and biomass or the amount of carbon that has been requested in a canopy, we can calculate that as well.

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So, these are some parameters or some attributes of the canopies.

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Also, when we have these canopies, we can have a look at the canopy closure. So, a canopy closure tells us the percentage of the area that is occupied by the canopies.

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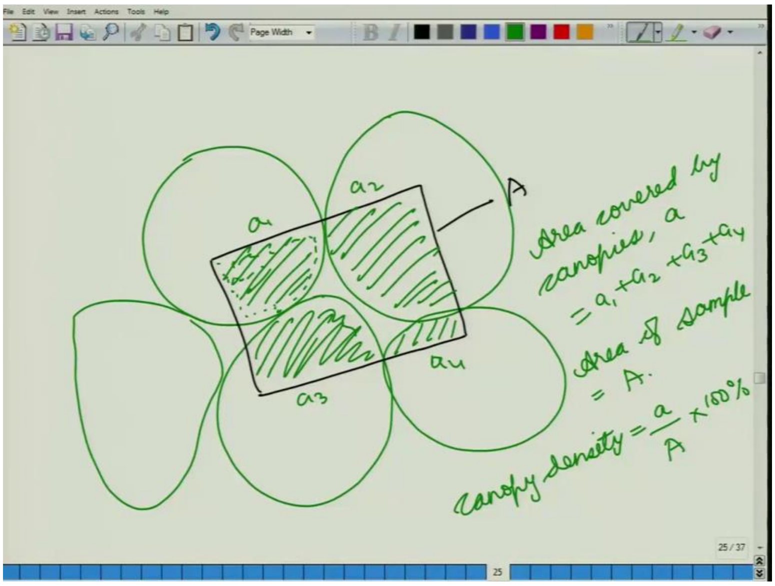

So, for instance suppose we in a forest we had a canopy like this. So, we are looking at the top view of a forest and suppose we take a sample. Suppose this is our sample area. Now, the area of your sample is suppose capital A. Now, the area of the sample that is occupied by the canopies is given by this area plus this area plus this area plus this area. So, let us call it small a 1, a 2, a 3 and a 4. So, the area covered by canopies that small a is equal to a 1 plus a 2 plus a 3 plus a 4. Now, area of sample or the sampling area is capital A. So, your canopy density is given by small a by capital A into 100 percent.

So, for instance in a dense forest, you might have this canopy density of greater than 0.7 or 70 percent. Whereas in a scrub forest for instance if you go to Rajasthan, you will find lots of sand use with very little less amount of trees. So, the amount of canopy density that you will have there might be less than 0.4 or less than 40 percent. So, in that case we will call it as scrub forest whereas, in the case of say 70 percent of greater canopy density, we will call it a very dense forest.

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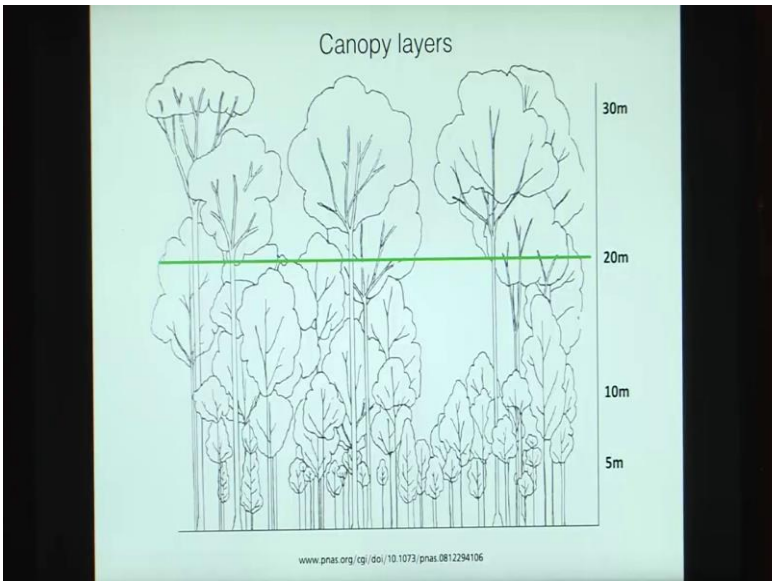

Now, in a canopy we can also look at canopy layers. So, what happens in the case of forest is that you not only have large trees.

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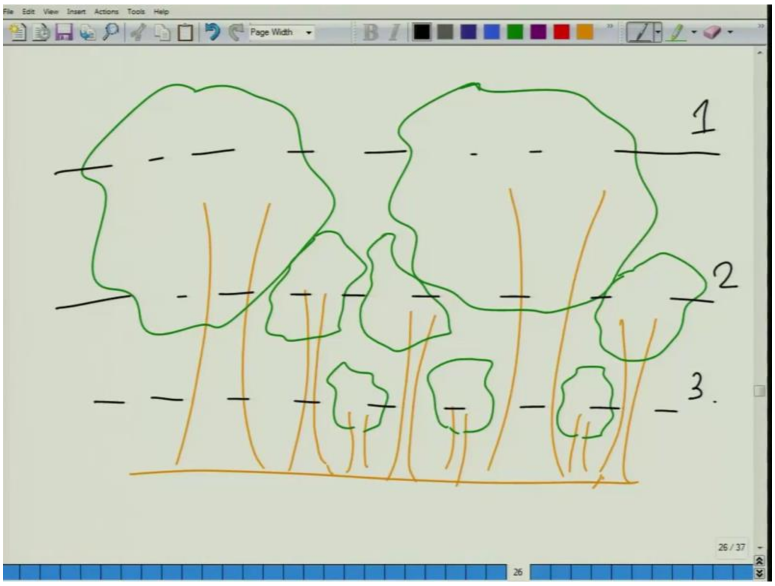

So, here are some large trees then you might also be having some species that are thriving here which are not able to access your complete sunlight, but are able to access some part of it. So, this will form another layer. Then, you might also have some other species that are growing here that are very deprived of sunlight, but then they are also thriving here. So, this layer would be one layer of trees, this would be another layer of trees, this would be the third layer of trees. So, this thing is known as canopy layers.

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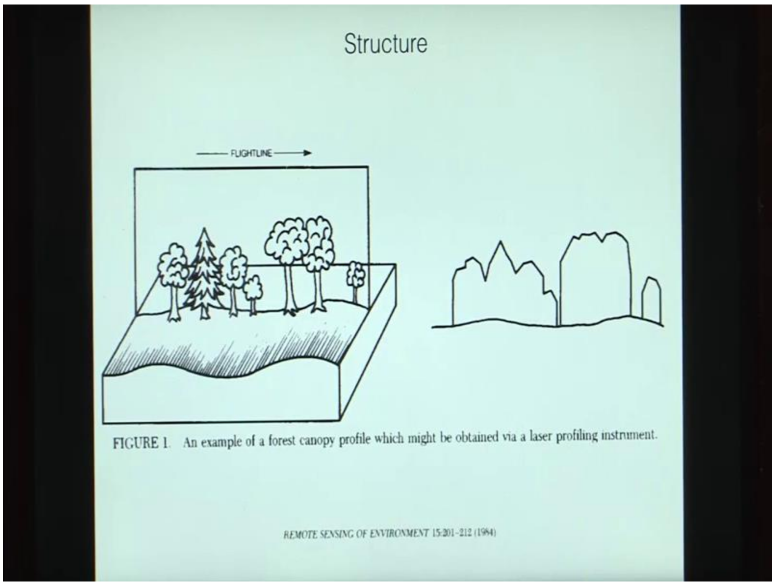

So, now coming back to the slide, here we are seeing a number of canopy layers at different heights. Now, to study these canopy layers, we could look at the structure of the forest. Now, structure of the forest can be very easily acertain by using Lidar. So, for example here we are saying a canopy profile. So, you have this as the plane of scanning. So, in this plane if you plotted these canopy covers, for instance this tree is making this canopy, then this pointed tree is making this canopy and so on. Now, these are joint canopies of both of these trees and then, this again is a small canopy that is found out of this small tree.

So, now if we took a scan of this region, we would be getting our Lidar profile as this. So, that can be used to study the structure of a forest.

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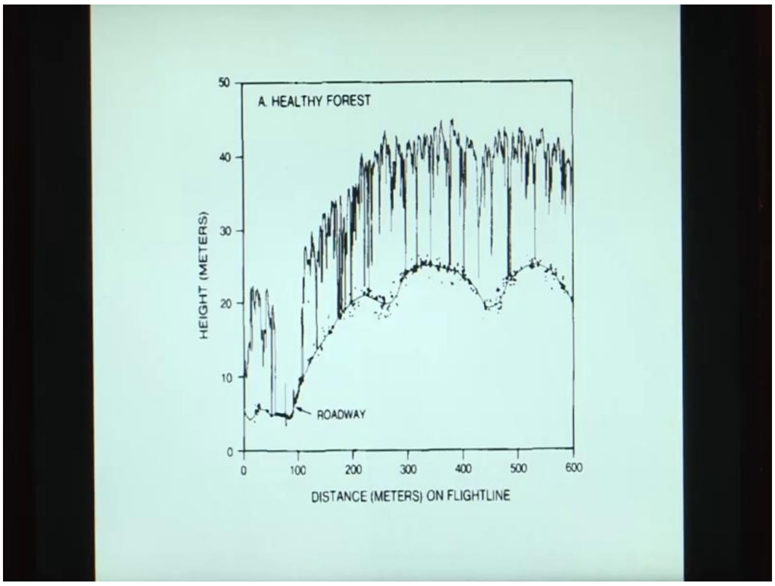

Now, the structure of a forest can also help us understand what is the health of the forest and as we saw before what the age structure of a forest is. So, for instance here we are seeing a healthy forest. In this healthy forest, it is a young forest in which most of our trees are having an appreciable diameter and the canopy is very close. So, this is one example of a very dense forest.

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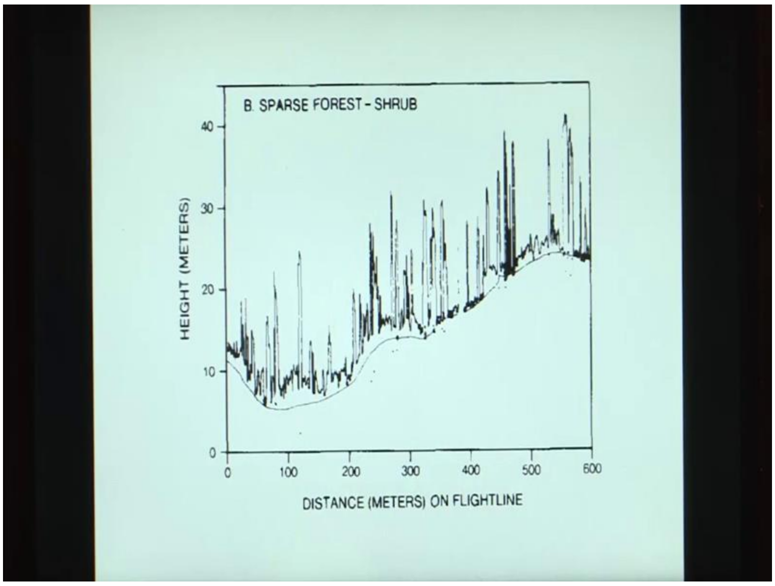

For instance, here we are seeing another forest which is a sparse forest that is dominated by shrubs. So, here we are saying very few trees and lot of this space has been occupied by shrubs. So, this could be called a scrub forest. For instance, this forest on the other hand is a heavily defoliated forest.

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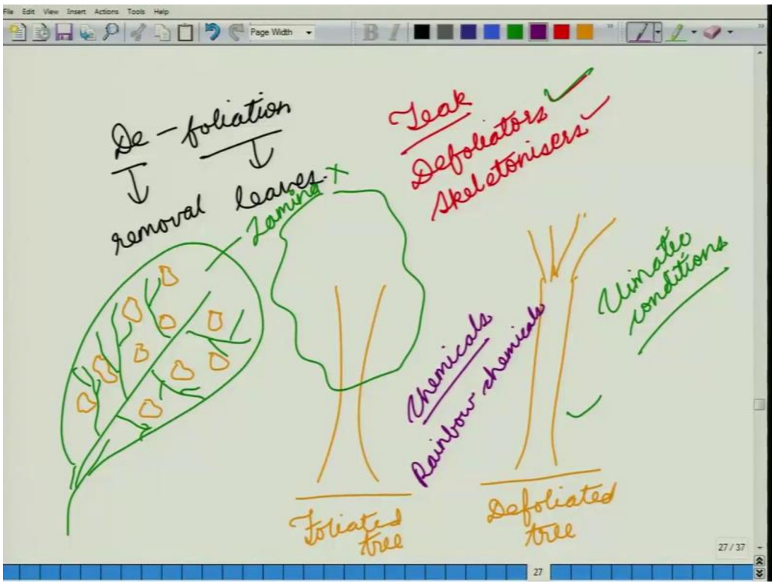

So, what is defoliation? De is the removal of foliation pollution of the leaves. So, for instance in the case of a deciduous tree, if you look at that tree in a bit season, it would look like this whereas, in a dry season it would give out all its leaves and you would just be able to see the branches. So, this is a foliated tree and this is a defoliated tree.

Now, a tree might be defoliated because of a number of reasons. For instance, in the case of teak we have some insects called defoliators and some other insects called skeletonisers. Now, what does a defoliated do? A defoliated just makes all the leaves drop down to the forest floor whereas, in the case of skeletoniser what it does is suppose consider this to be a leaf. So, a skeletoniser would start eating into the lamina and then, later on this removal of the lamina would be so much that you would only be able to see these veins of the leaf, but you will not be able to see any of the leaf blade or the lamina. So, all the lamina is eaten away and whatever remains it looks very much like a skeleton. So, that is the skeletoniser.

So, some insects such as these defoliators can result in the defoliation of a tree. Also, some climatic conditions might result in defoliation. For instance, in the case of a deciduous tree if it is exposed to a dry spell, then it will shed all its leaves as a way of conserving moisture. So, that can also lead to defoliation.

Another thing that can result in defoliation is some chemicals. So, there are some chemicals called defoliators. For instance, those chemicals that were very highly used in Vietnam war, they went by the name of rainbow chemicals. So, they were used by the army on the forest, so that all the leaves got shed and then, people would be able to spot their enemies very easily.

So, if we went back to slide, this is now showing a heavily defoliated forest. So, in this case, we are able to see all the boles, but then there is no canopy on top. So, this is a heavily defoliated forest. So, when we are talking about the canopy structure and by using Lidar, we can see whether our forest is healthy, whether our forest is of a young age or an old age, what is the amount of foliation in the forest and so on.

So, understanding of the structure of a canopy and its attributes is a very important part in understanding the forest itself. So, this is something that we will look into greater detail in this week.

Thank you for your attention. [FL].