Forest Biometry
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Lecture - 24
Canopy Cover and Closure

[FL]. In today's class, we will have a look at canopy cover and closure.

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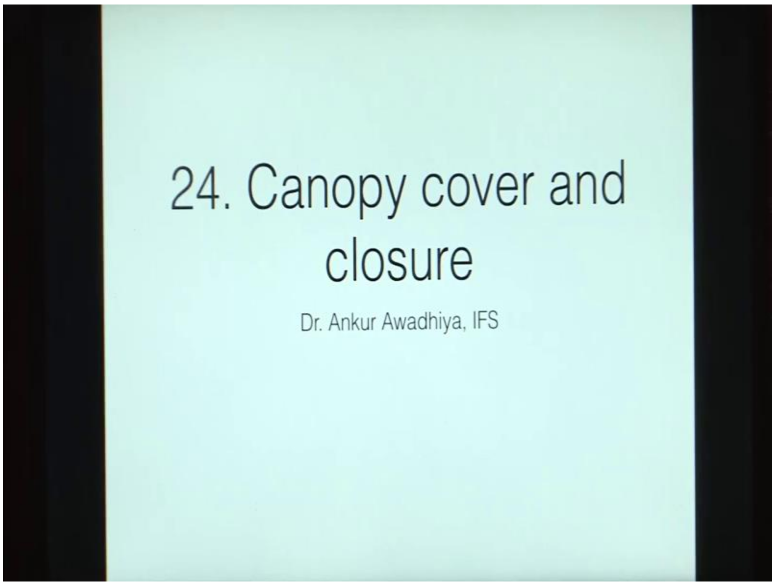

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So, when you go inside a forest and when you look up, you will see the canopies of a number of trees, but what does this figure signify here you can see in the sky and you can see a number of canopies that are now looking at as silvids or these black coloured regions against the sky. So, essentially when we are looking at this figure, they are also saying that light is able to reach from these points. So, like these white looking areas, but any light that is coming from this area has been intercepted by the canopy is not able to reach.

So, essentially the size of the canopy and the density of the canopy and the closure of the canopy are an indication of the amount of light that is reaching us. Now, why do we need to know the amount of light that is reaching this in this ground area? It is because light is an important constituent in the process of photosynthesis.

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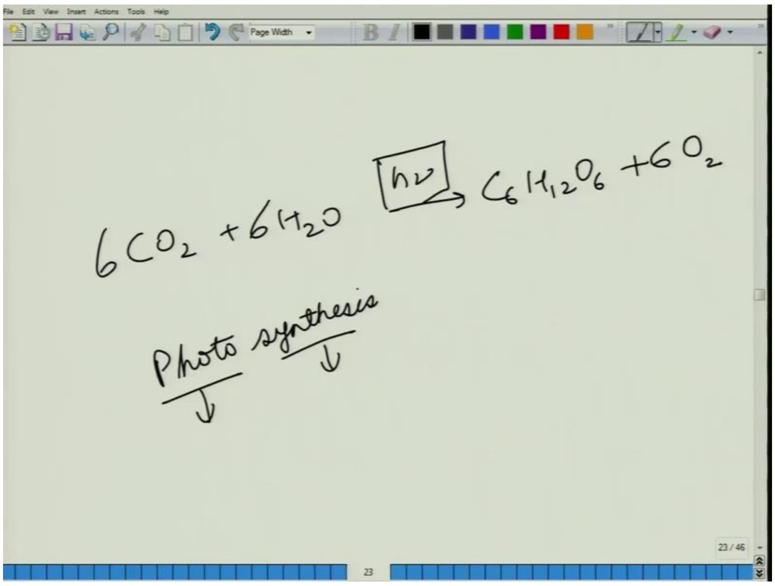

So, in photosynthesis as we saw before we have carbon dioxide plus water that in the presence of sunlight it is converted into sugars plus oxygen and we have balanced it before. So, this is the equation for photosynthesis. So, now it will not happen without the presence of light. So, this term photo synthesis itself says this is synthesis. That is the creation of something from you or using light that is photo which is light. This is photosynthesis.

So, measuring the amount of light that is reaching the forest floor is extremely important because it will tell us if suppose we have a one big tree and suppose it is throwing its seeds down into the ground, will those seeds be able to germinate and if that seeds germinates, will that plant be able to grow. So, for instance if that that small sampling is getting enough light, then it will be able to perform its own photosynthesis gather biomass and then, grow into a larger size sampling and maybe into a tree, but if it is completely covered by the canopies of its own mother tree and maybe other trees, then it will not be getting enough sunlight to produce the biomass and to be able to grow.

So, measurement of the amount of light is extremely important. So, how do we measure the light? We measure it through two measures.

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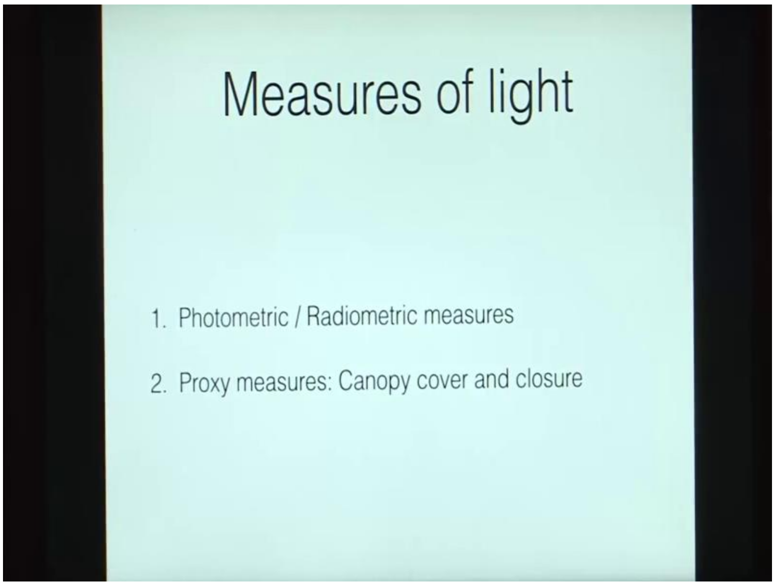

So, one is photometric or radiometric measures of light. So, in the photometric measure of light, we use a sensor to measure the amount of light that is reaching us in a radiometric measure. We measure the amount of energy that is there in any fixed wave lengths. So, for instance in the case of photosynthesis, the tree is used light blue and red regions of light. So, we can measure the amount of energy that is then in the blue portion of the spectrum and in the red portion of spectrum to get a radio metric measure of the amount of light that is reaching the forest floor or as a measure of light, we could use some proxy measures which include canopy cover and can be closure.

So, how do we do this photometric and radio metric measures of light? So, one such instrument that we use to measure the amount of light that is reaching of the forest floor is called a photo resistor.

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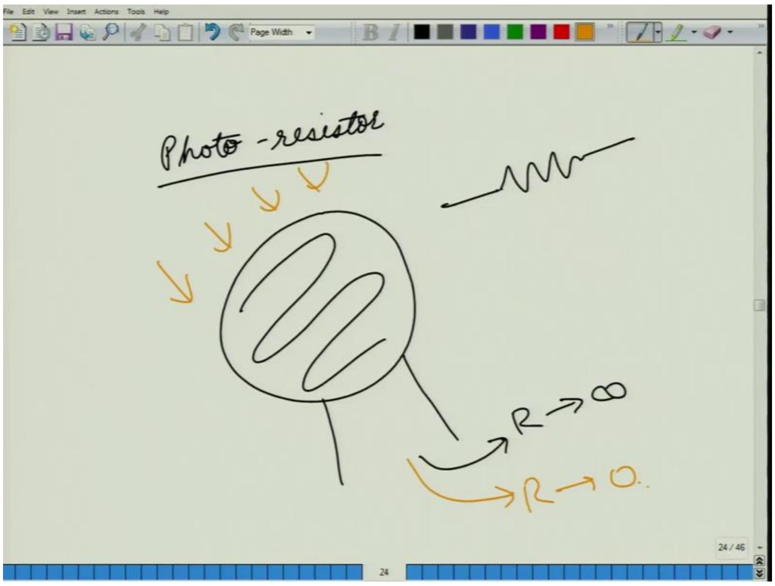

So, what is a photoresistor? A photoresistor is a device. So, it will look something like this. So, this is essentially a register. So, now we normally represent a resistor like this. Now, this is a photoresistor. So, when it does not get any light, then its resistance goes to infinity or it has a very large value of resistance. When you shine light on this device, then its resistance will drop and the resistance will go to a very low value. So, now if you wanted to measure its resistance, you could use a circuit like this.

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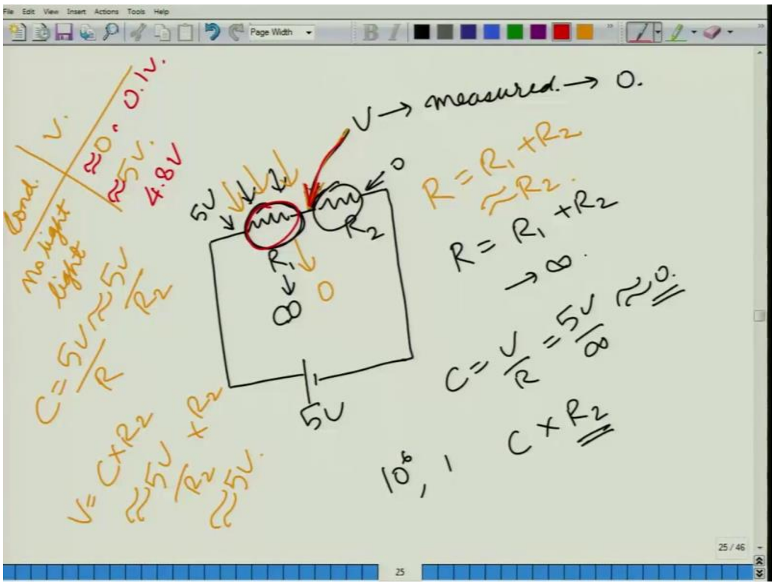

So, suppose this is your photoresistor and this is your normal resistance. So, call it R 1 and R 2.

Now, if we do not have any light that is falling on this device and we measure our voltage at this point. So, this is measured and suppose we have put 5 volt battery here. So, suppose consider two conditions. So, when we have R 1 going to infinity, when we do not have any light that is shining on this device, in that case your total resistance because both these resistance are in series. So, R as R 1 plus R 2, we shall go towards infinity.

So, now if you have an infinite value of resistance here, what will be the voltage at this point? So, the amount of current that goes through is given by current is equal to voltage by resistance is 5 volt by infinity is approximately equal to 0. Now, this value of R 1 is very large as compared to the value of R 2 in this case.

So, we can even consider R 1 to we say a very large figure say 10 to the power 6 and R 2 be approximately equal to 1 to take an example. So, what will be the voltage? Value of voltage at this point is 0, at this point it is 5 volts because we are considering our buyers to be having no resistance. The voltage at this point will be given by the current into R 2. So, because our current is 0 or close to 0, in this case and R 2 also is a very small figure. So, this voltage will go to 0. Now, this happens when we do not have any light shining on the photoresistor. If we have light shining on the photoresistor, in that case the value of R 1 will go to close to 0. So, in this case your total resistance R 1 plus R 2 is approximately equal to R 2.

Now, what is the amount of current that goes through? It will be 5 volt divided by R is 5 volt upon R 2. What will be the voltage at this point? So, this voltage that we are measuring V will be given by V equals the current into R 2 is approximately equal to 5 volt upon R 2 into R 2 is approximately equal to 5 volts.

So, essentially when we have condition and the voltage, so when we have no light, V is approximately equal to 0 and when we have light, we have V approximately equal to 5 volts that is considering the point where R 1 goes from 0 to infinity. Now, because this value of R 1 will not go to 0 and it will not go to infinity. So, these values will be somewhere in between. So, you are in the low light condition. We will have this voltage to be close to 0 and here it will be close to 5 volts. So, maybe you could have a voltage of 4.8 volts and may be 0.1 volt. So, these are the values.

So, just by measuring the voltage at this point, we can get the amount of light that is falling on this sensor. So, now we will go through a demonstration of how this is done. So, we will go through a demo in which we shall see how to use a photo resister to measure the amount of light that is coming through.

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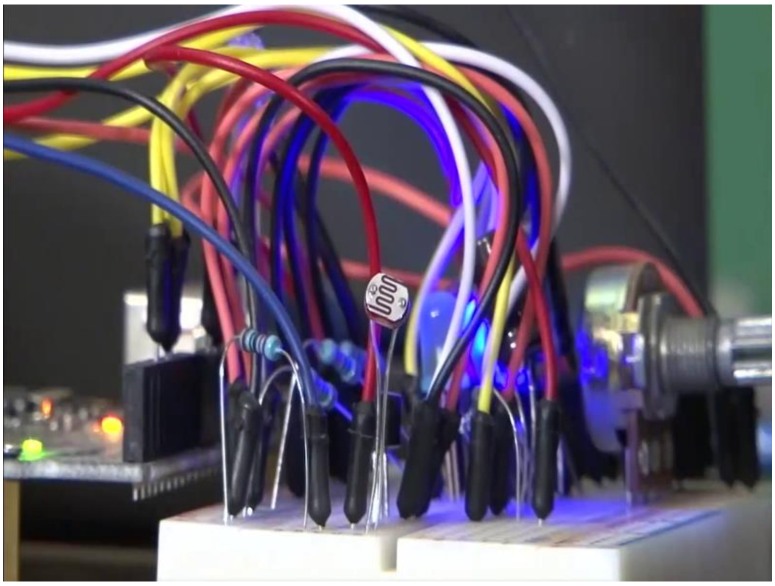

So, let us now have a look at how this photoresistor works. So, here we can see a photoresistor. So, this device is the photoresistor. So, it has two legs. We have connected one leg with this red cable to 5 volts; the other leg is then connected to this resistor. Now, the junction between the photo resistor and the register is being measured for its voltage by this blue cord. So, that goes into our instruments for measurement and the other end of this resistor is grounded. So, this voltage goes from 5 volts to ground and the voltage at the junction is being measured by this blue wire.

So, let us now have a look at the code. So, now coming to the screen.

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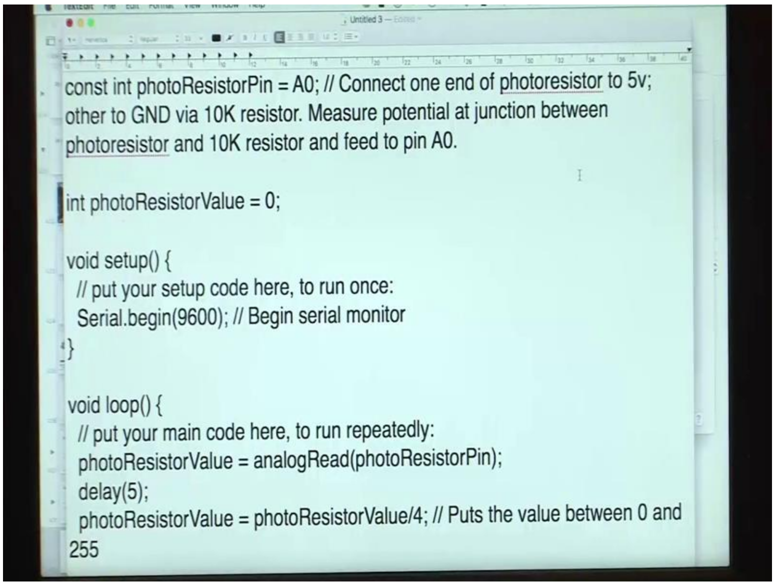

So, here we have defined. So, this is again and are in a code. So, it says constant and photoresistor pin is equal to 0. So, this 0 is the pin in which we have connected one end of the photoresistor to 5 volts and the other to ground with 10 kilo ohm resistor and we are measuring the potential at the junction between photoresistor and 10K resistor and giving the feed to 0 which is why you have this constant in photoresistor pin is 0. So, a zero measures the analog input we have said this variable photoresistor value we have given it an integer value and we have set it to 0.

Now, let us look at the void setup. Now, void setup is run only once. So, here we have set a serial dot begin 9600 that is we have begun the serial monitor. So, it will take the values from the input or this junction and then, it will show it to our computer.

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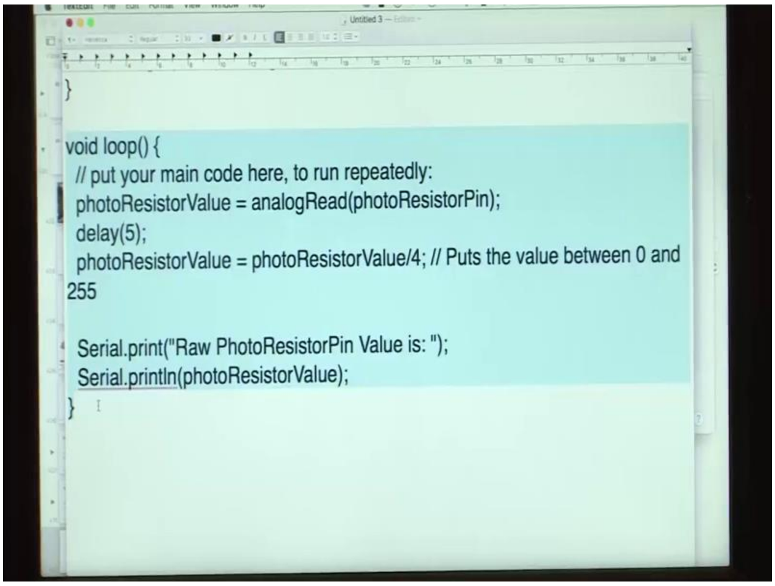

Next we have this void loop section. So, this section runs again and again and again indefinitely. So, here we have defined your photo registered value which was your, this integer value that we had said to be 0. Now, we have set it to be photoresistor value is analog read of the photoresistor pin and then, we have put a small delay 5.

Now, this photoresistor value will go from 0 to 1023, but if we want to say so, when we talk about 0 to 1023 and we say 0 to 1023.

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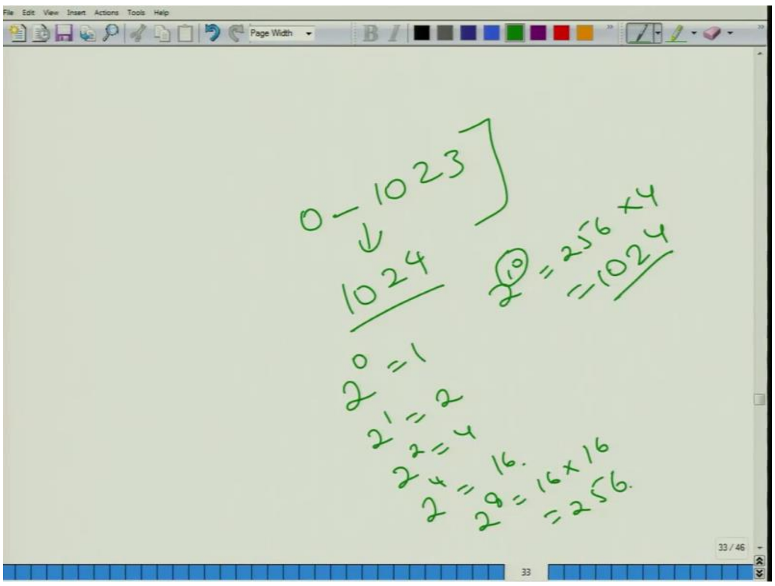

We have a total of 1024 values. Now, 1024 values if we write it as bits, so 2 to the power 0 is 11 is 22 to the power 2 is 4. Now, 2 to the power 4 is 8, 2 to the power 8 is 16 into 16 is 256, 2 to the power 10 is 256 into 4 or 1024. So, this is measuring 10 bit value from 0 2 1 0 2 3.

Next what we are doing is, we want a value between 0 and 255. So, we are divided by 4. So, this is an arbitrary value. So, in our code we asked to measure between 0 to 255 say suppose you wanted it to measure from 0 to 100. So, in that case you would divide your photoresistor value, this whole value you divide it by 1024 and then, multiply by 100. So, in this case we we wanted it to be between 0 and 255. Next we say serial dot print. So, we are asking it to print it to the monitor raw photoresistor pin value is and then, we are asking to print the photoresistor value.

So, let us now run this code.

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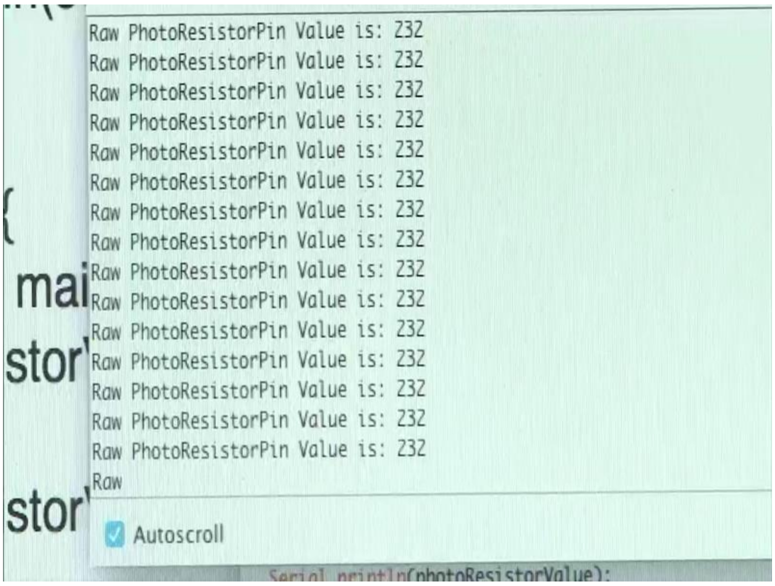

Now, look at the values that are being shown. So, if we now zoomed it to the output, it is showing the value to be 232. So, remember that our scale as from 0 to 255. So, now if we look that the photoresistor, now if we look at this photoresistor, it is being illuminated by the ambient light of the surroundings. So, now coming back to the values that are being shown there in these ambient conditions, this value is 232.

So, now let us again look at the photo resistant. Let us now cover it with our hands. So, now we will cover it like this. Now, if you look at the values now back at the screen. Now, the value is 81 or 80 or 82. So, the value has decreased. Now, if I remove my hands again, it will again go back to its normal value. So, by covering it and by removing it, we can change the values that are there. So, it is essentially measuring the amount of light that is getting to the device.

So, we can use a photoresistor to measure the ambient lighting conditions. Now, a photoresistor is not the best device to measure the amount of lighting that comes to the forest floor, but this could be used as one of the devices or maybe a variant of this device could be used to measure the amount of lighting that comes to the forest floor, and remember that this lighting will determine the amount of growth that we can expect sidling to under grow because more amount of lighting will result in more amount of photosynthesis will result in more amount of biomass that this we can use to grow in height in its growth.

So, by measuring the amount of light that we are getting, we can use this value as one of our management intervention conditions to regulate what is the best amount of thinning or maybe the best amount of others will be cultural management operations that we need in the stand for the best amount of growth. Now, that we have seen a demonstration of how this photoresistor works, let us continue our discussion.

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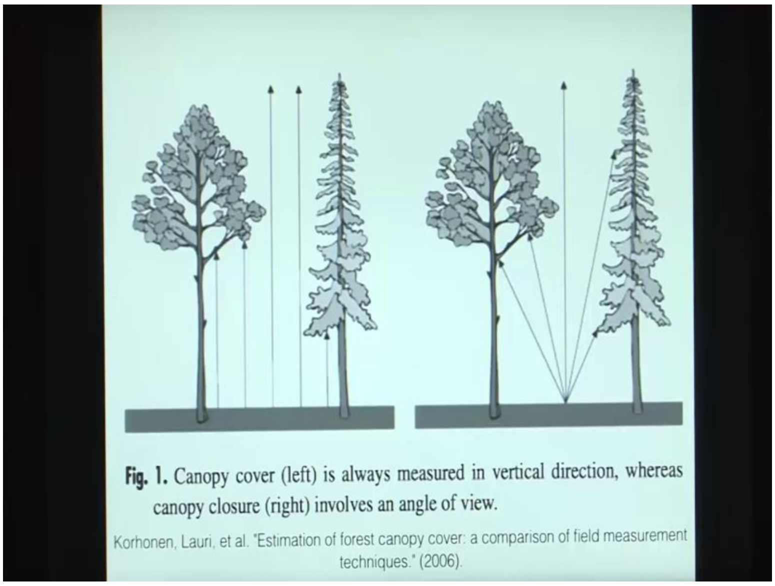

Consider canopy cover and canopy closure has two values. So, as you can see on your screens, canopy cover is a measure in which we are taking the projections of all the canopies and then, these projections are taken on the ground and we are seeing the proportion of the ground area that is not covered by these projections of the canopy or when the sun is directly overhead, what will be the amount of the ground area that will be illuminated. It gives us the canopy cover.

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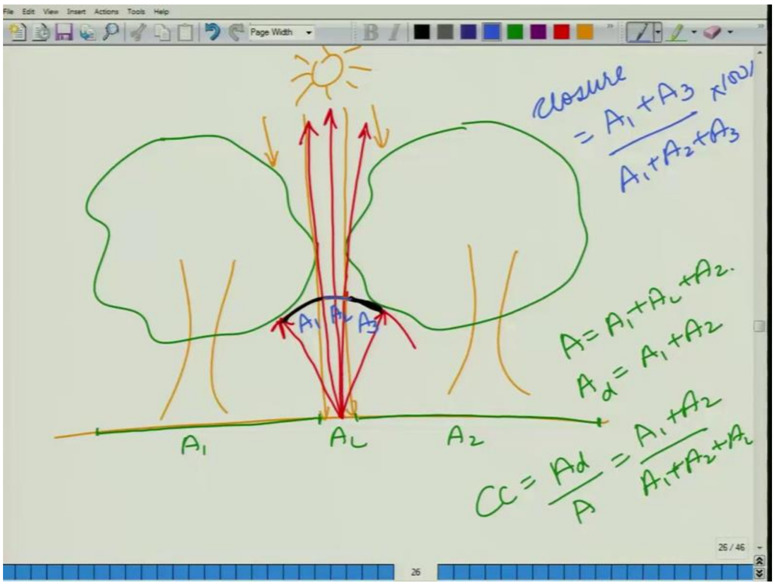

So, to show it on a diagram, suppose we have two trees like this and when the sun is directly overhead and we consider all the light rays to be parallel, so a light ray from here will go to the ground, light ray here will go around, but light ray that is coming on these sides will be blocked. So, the canopy cover will be given by the area that is blocked, that is this portion that is blocked by the first tree and this portion that is blocked by the second tree. So, let us call it A 1, A 2 and let us call it A L, the portion that receives the light.

So, the total area is given by A 1 plus A L plus A 2. The area that does not receive any light or the area in the darkness is given by A 1 plus A 2 and our canopy cover will be area in darkness divided by the total area that is A 1 plus A 2 upon A 1 plus A 2 plus A L or to show it in other terms, this ia our sample area.

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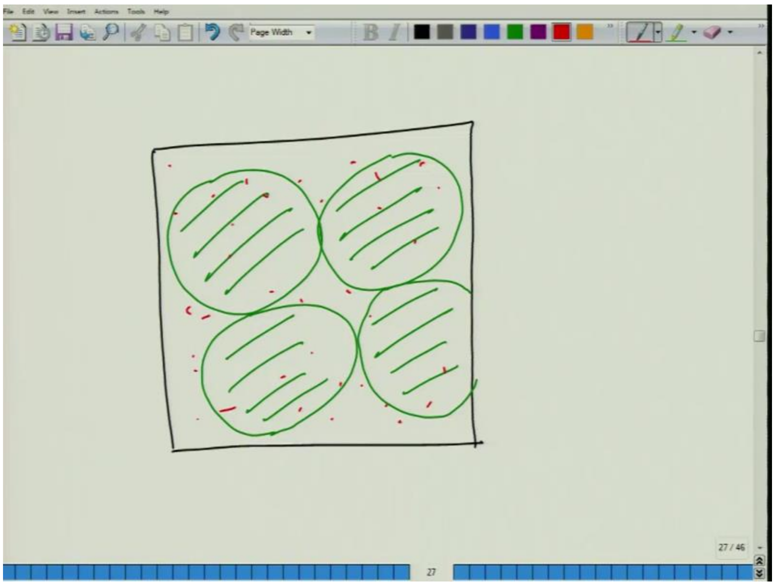

Suppose these are the canopies. So, when we are looking from the top, these canopies are appearing as these sections. So, now the canopy cover will be the area of these canopies or the projected area of these canopies on the ground divided by the total area of the sample multiplied by 100. So, that will give us the canopy cover in percentage. On the other hand, canopy closure is taken from a point on the ground. So, to take the previous example when we look at canopy closure, we are standing here and we are then trying to see how much of the area is appearing to be covered by canopies from this point.

So, for instance here we will be able to see this, the light. If we go from here, we will be able to see the light, but if we look in this direction, we will be intercepted by the canopies. So, this is what we had seen in the very first figure when we were looking for down towards the sky. So, now canopy closure will be considering this section, this portion that is covered by the canopies. So, we are considering a solid section. So, this portion that is covered by the canopies, this portion is able to see the light or this is able to see the sky.

So, let us call it A 1, A 2 and A 3. So, in the case of closure, we will be given by A 1 plus A 3 divided by A 1 plus A 2 plus A 3 may be in percentage terms. So, that gives us the canopy closure.

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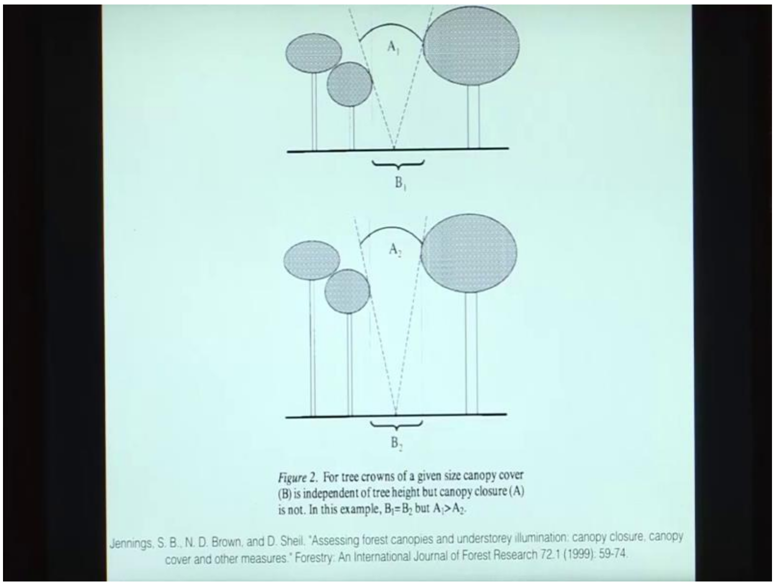

Now, if we look at the slides canopy closure will depend on the heights of the trees, but canopy cover does not depend on the heights of the trees. Why is that? It is because suppose we considered these two trees.

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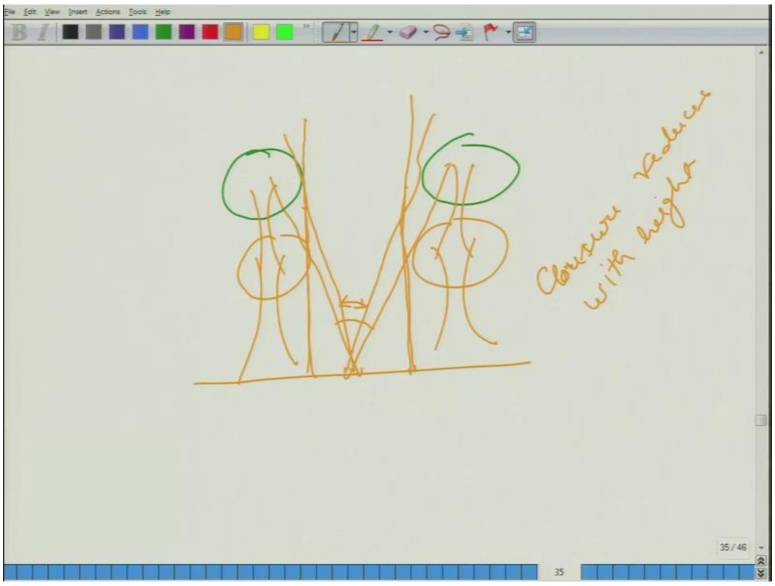

Now, our point on the ground is here. So, in this condition the amount that is able to receive light is this much. Now, let us increase the heights of the trees at the same locations. Let us move these canopies on the top. So, when we do that, this portion that was earlier able to receive light is now blocked. So, the closure, the amount of space that is able to receive light has gone from this large angle to this small angle. So, less amount of light is now reaching the ground from the point of the observer. So, the canopy closure reduces with height.

Now, let us have a look at the canopy cover. Now, in the case of canopy cover, we take projections on the ground. So, when we are taking the projections on the ground whether the height is this much or whether the height is the small one, the projection on the ground is going to be the same. So, in both the situations, the projection on the ground is this much which is why we can say that the canopy cover is going to remain the same even if the height of the trees increases.

So, now the next question is how do we assess canopy cover and the canopy closure?

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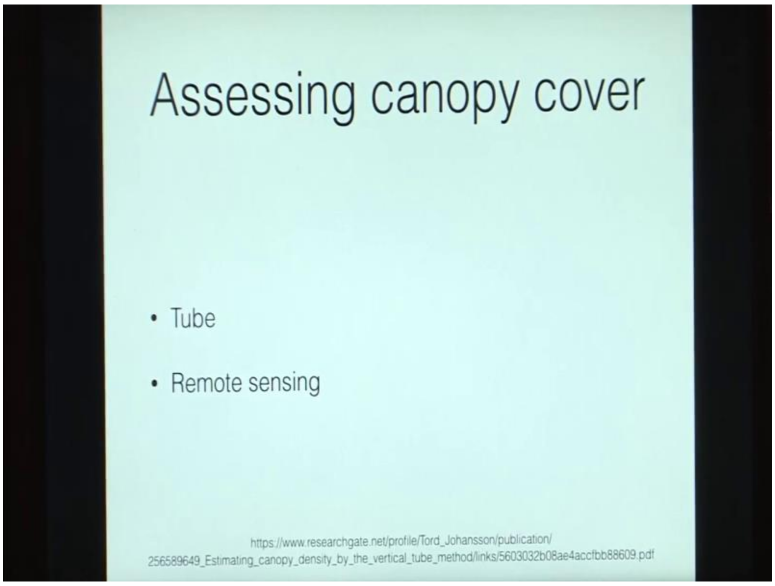

So, to assess canopy cover, we have two main methods.

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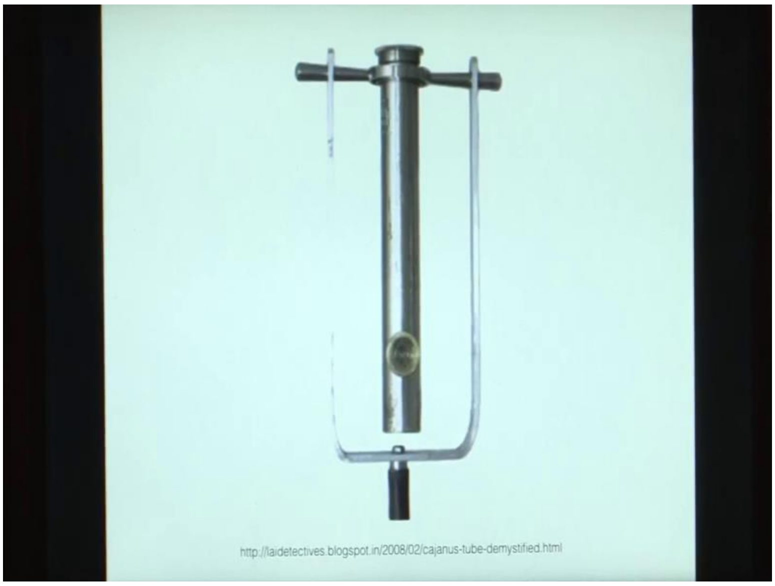

One is the method of using tubes and the second is the method of remote sensing. So, in the method of tubes, here we can see one tube that is known as Cajanus tube and here we have another tube that goes by the name of Emlen tube.

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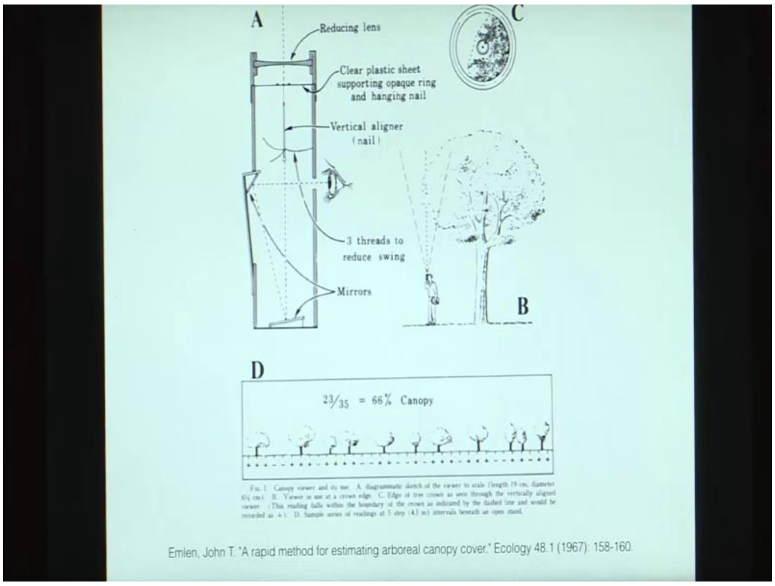

So, essentially what do these tubes do, they are very much like periscopes.

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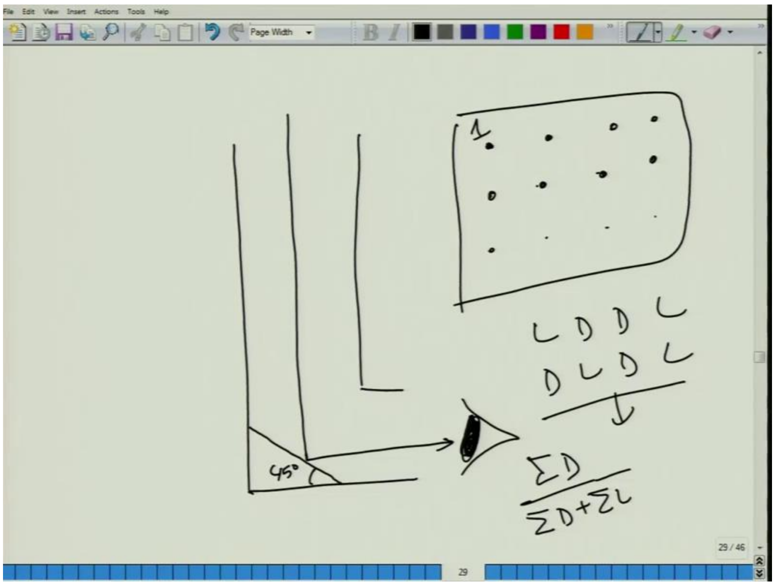

So, you can take a view from here. So, here you can take a view and here you have a mirror at say 45 degrees. This is 45 degrees. So, any light that is coming from the top will get reflected and go into our eyes. So, this is the simple principle of a periscope. So, what will you do with this tube? You will if this is your forest area, you will suppose take these sample points. Then, you will go to the sample points and then, you will use your tube to see what lies on the top. For instance, if at this position 1, you are able to see light in this position, you have darkness, then maybe darkness, then may be a light. Similarly, here you have darkness, then light, darkness, light and so on.

So, now when we want to figure out the canopy cover, we will figure out the proportion of darkness divided by the total number of spots and actual give us an estimate of the canopy cover. The second way in which we can measure the canopy cover is by using remote sensing.

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So, for instance if you look at your screens, now this is an image from google earth which is showing us how the forest is going to look from the top. So, here we can see a number of canopies. So, for instance this is one tree and this is canopy.

So, now these areas, the greenish areas that are reflecting the light are the canopies and these dark areas where the light was able to get into towards the soil because we do not have any canopy here like this is one big one, such big area. So, this area was able to met light to go towards the ground.

So, now the proportion of the area that is covered by the canopies; because here we are looking at a top view. So, this is the same as the projection that we will get if we projected all the canopies to the ground. So, the ratio of the area that is covered by the canopy is here in this picture divided by the total area will give us a measure of the canopy cover.

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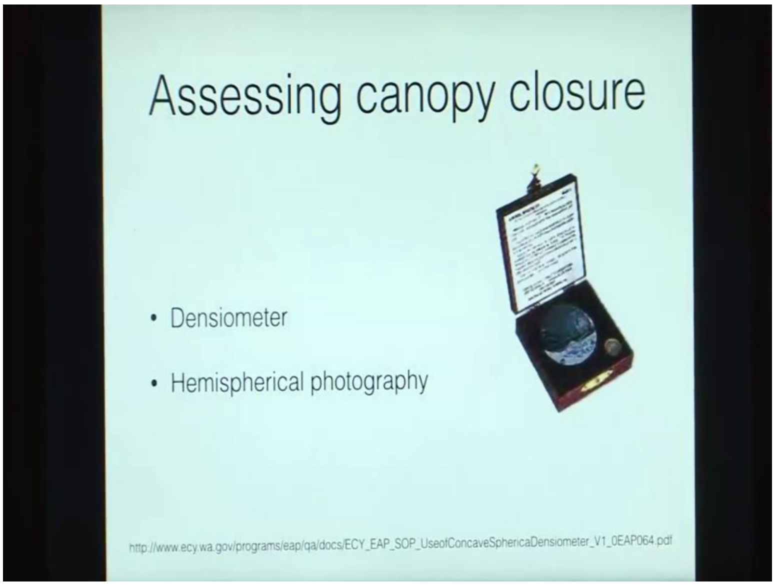

Similay, for assessing canopy closure also we have two main measures. One is the use of a device called a densiometer that we can see on the right. So, it is a very small device that you can hold in your hands and when you open the cover at this point, you have a hemispherical mirror and this mirror is divided into a number of sections. So, from one point you can observe how many of these sections are covered by tree canopies and how many of these are receiving light.

So, essentially if we looked at a densiometer, so if we place it near the ground, so looking at the tablet now.

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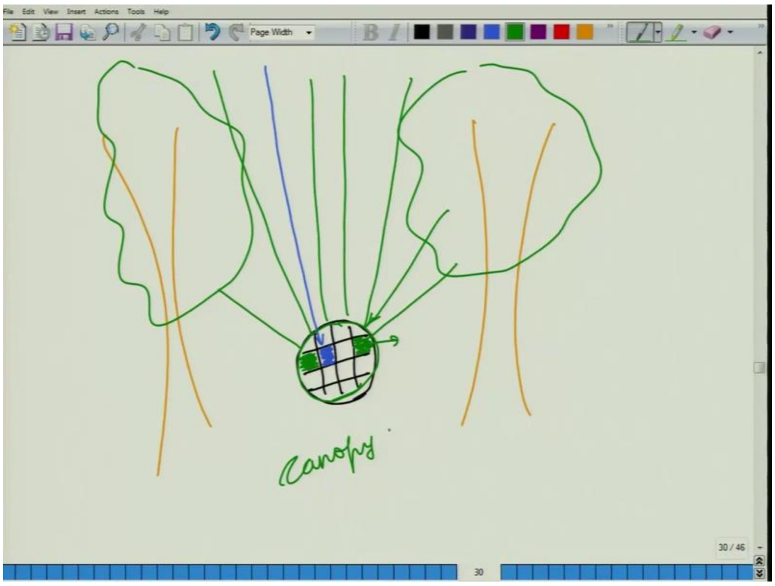

So, now this densiometer is placed at the ground level and it is divided into a number of sections. Now, when you have placed it at the ground and suppose we have canopies here, so at this point this is one hemispherical mirror. So, this portion is showing you a blue color of the sky, may be the light from this portion as getting to say this section.

So, this is showing as green, this is also showing as green. So, the number of grids or the grid points that are showing us the canopy divided by the total number of grids that are there in the densiometer will give us a measure of the canopy closure because here when we are putting it close to the ground, we are just observing all the different portions from the same device. So, this is an estimate of the canopy closure.

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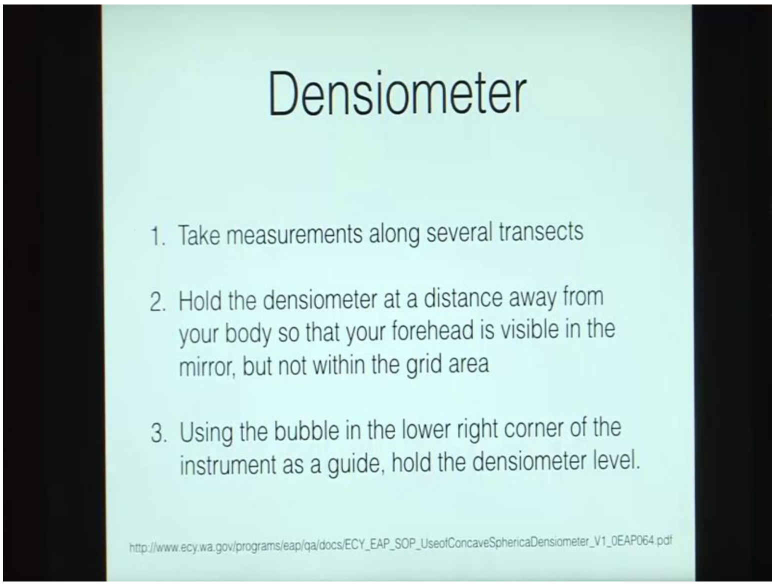

So, if we looked at the procedure, so looking at the slides now. So, we take measurements along several transects. Now, what do we mean by transect?

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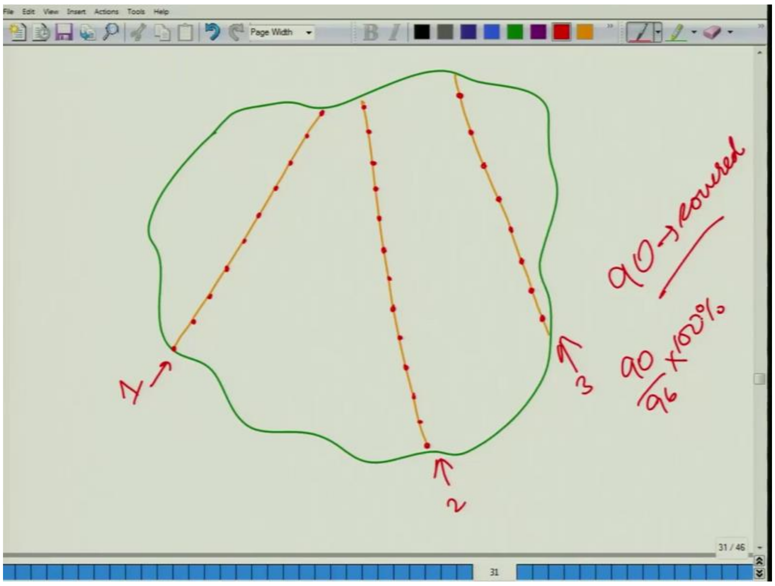

So, suppose this is your forest area and you need to take an average reading for the canopy closure. So, you will define a few lines. So, these could be there in a regular fashion or you could draw these randomly and you would say that say at every 200 meters, you are going to take a reading.

So, when you move across this line transect 1, you took a reading here, here, here, here, here, here, here, here, and here. Similarly, when you move across transect 2, we are also be taking a number of readings at every fixed distance. So, suppose it is 200 meters. So, on transect 1, you took at every 200 meters, in transect 2 you also took it at every 200 meters, in transect 3 also you took your readings at every 200 meters.

So, this gives you a sample of readings and then, you take an average reading from all these samples. So, now coming back to the slides we take measurements along several transects, hold your densiometer at a distance away from your body, so that your forehead is visible in the mirror, but not within the grid area. So, essentially we do not want to block the view of the grid area by our body, use the bubble in the lower right corner of the instrument as a guide to hold the densiometer level. So, your densiometer has to be kept parallel to the ground surface.

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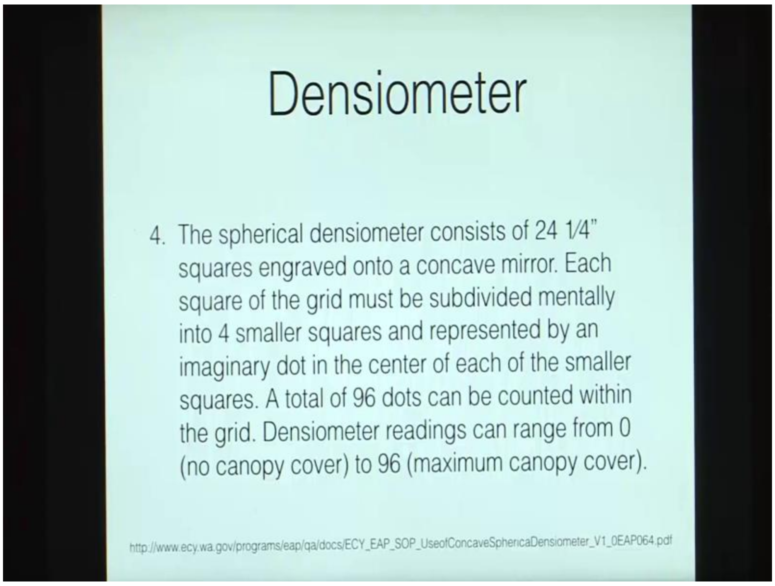

Next the spherical densiometer consists of 24 quarter inch squares engraved onto a concave mirror. Each square of the grid must be subdivided mentally into four smaller squares and represented by an imaginary dot in the centre of each of the small squares. A total of 96 dots can be counted within the grid. Densitometer radius can range from 0 that is no canopy cover to 96 that is maximum canopy cover.

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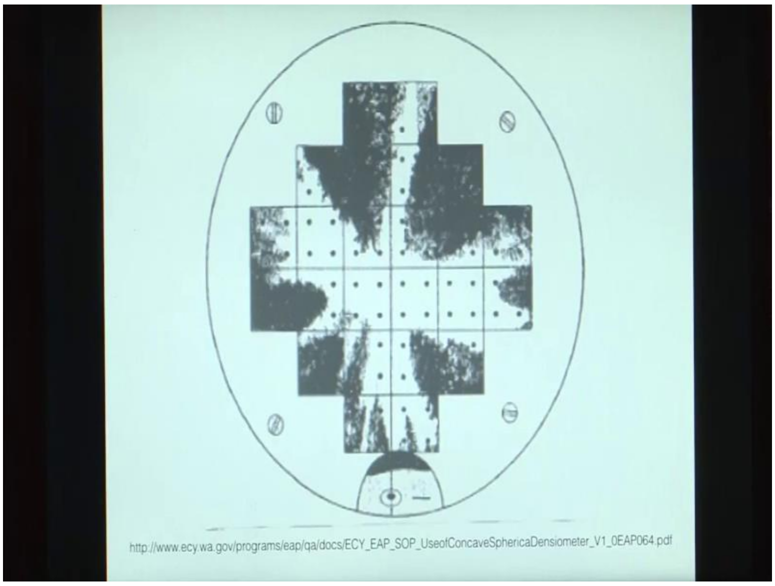

So, what we are seeing here is that we have a number of squares that are there. So, you can count the number of squares 1 2 3 4 5 6 7 8 9 10 11 12 and then, 12 symmetrically down. So, we have total of 24 squares.

Now, each of this square is mentally divided into cross. So, it divides into four smaller squares and the centre points of the squares are shown by these dots. So, we have a total of 24 multiplied by 4 that is 96 dots. Now, consider this dot. So, this dot is seeing this sky. So, it is not counted whereas, if you can consider say a dot here, this dot, this dot is covered with a canopy. So, the dot is saying a canopy. So, this dot will be counted.

So, if suppose you are able to count say 90 dots, so get into the tablet now. So, suppose you calculate 90 dots that were covered, so your canopy closure will be 90 divided by 96 into 100 percent. So, this is how you are going to measure it.

Now, coming back to the slides. So, using only the dominant eye, keeping the other eye closed, we count the number of dots in each engraved square that is blocked by canopy cover, enter the total number of dots blocked into the appropriate cell on your data sheet conversely, count the number of dots that are not occupied by canopy and subtract the total from 96.

So, for instance in case you were saying that maximum number of dots were covered with your canopy. So, in that case, it might be easier to measure or to count the number of dots that are not covered by the canopy and because total number is 96, we can subtract it from 96 to get the number of dots that are covered by the canopy. So, using this device we can measure the canopy closure.

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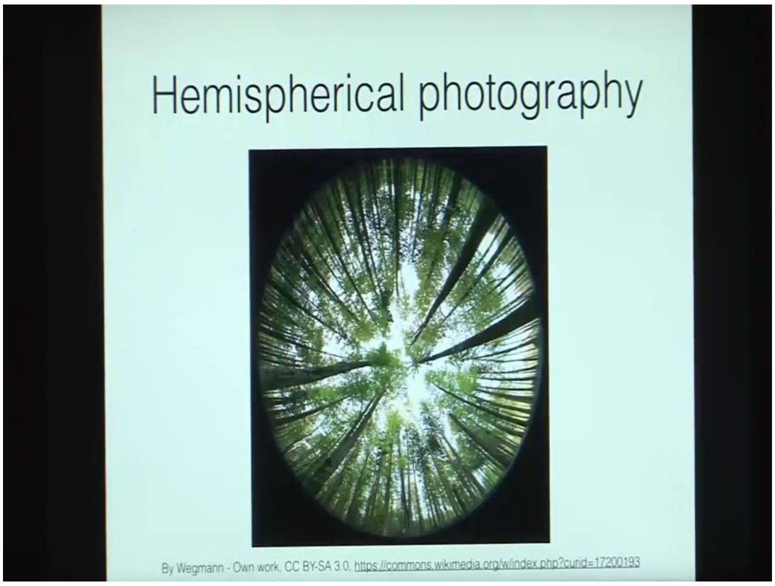

Another way in which we can measure the canopy closure is using hemispherical photography. So, this hemispherical photography uses a fish eye lens. So, using a fish eye lens you can get the image. So, for instance if you are standing in a forest.

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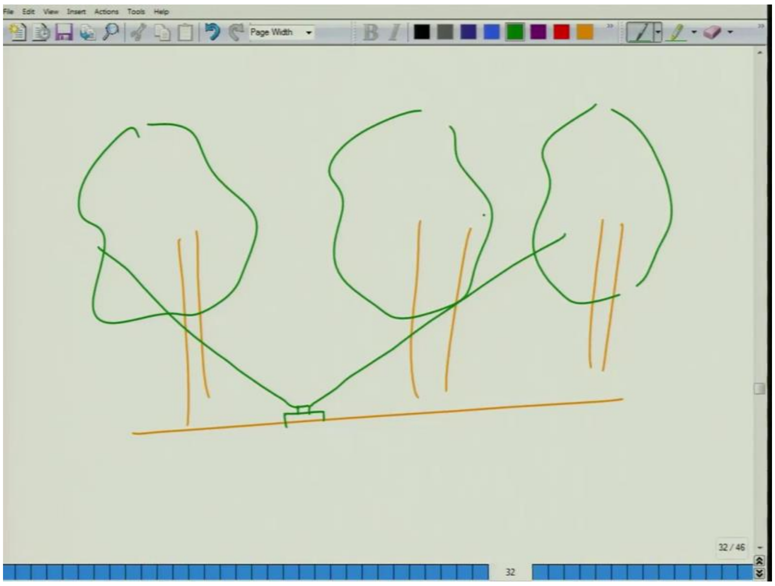

So, if you please your camera here with a fisheye lens, so the fisheye lens will give you a very broad coverage. So, all these portions will be seen in the photograph. So, now coming back to this slide. So, this is how your fisheye lens is showing you the whole region. So, you can see a number of tree boles and a number of canopies. So, once you have this picture, then you can later on use your same method of say 96 square. So, you can ask your computer to compute how much of the amount of this area is covered by your case and how much of the areas is getting sun light which is another way of calculating the canopy closure.

So, today we talked about how your canopy affects the growth of the saplings or the new seedlings in the forest by determining the amount of light that is reaching the forest floor and we have two measures of canopy. We can use canopy cover which is an estimate of the projected area of all the canopies on the ground that is covered by the canopies or you can also use canopy closure in which case you stand at one point and then, look above and then, see how much of the area that you can observe is covered by the canopies of various trees. We have also looked at the demarcation of how we can use instruments to measure the amount of light that has getting to the forest floor.

Thank you for your attention. [FL].