Forest Biometry
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Lecture - 27
Stand basal area, crop diameter and crop age

[FL]. In the previous class we looked at what we what we meant by basal area and how do we calculate the basal area of a tree and the basal area of a stand. So, we will continue our discussion further and in this class we shall look at how to calculate the stand basal area by other methods, how to calculate the crop diameter and the crop age?

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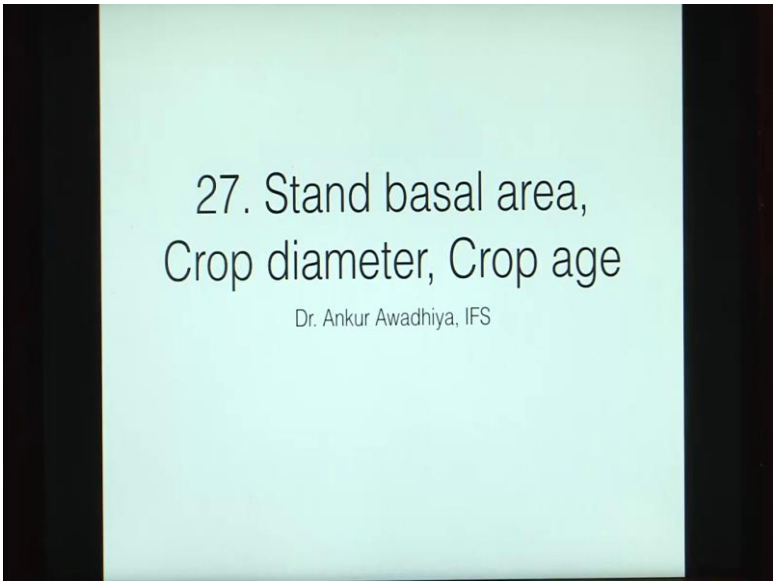

So as we saw in the previous class there are 3 methods of calculating the stand basal area.

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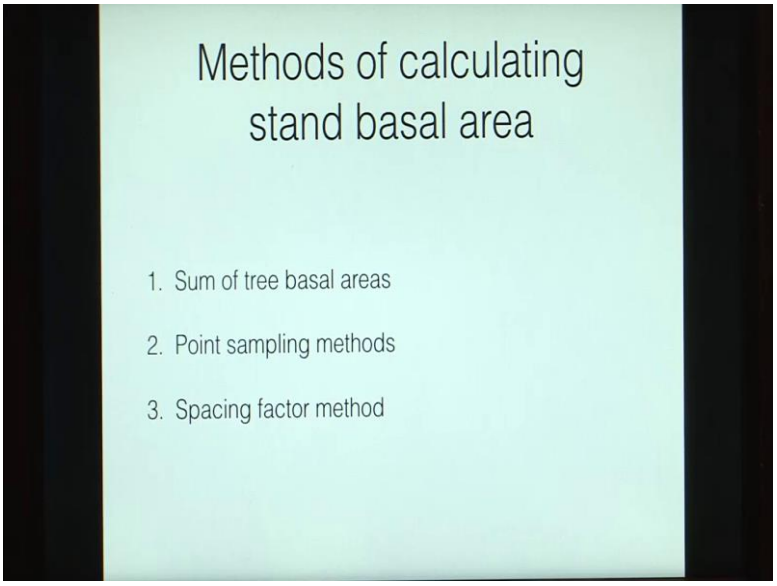

Now remember that the stand basal area is given in the unit is of square meters divided by the area of the plot which is given in hectares. So, the stand basal area is given as meter square per hectare.

So, in the last class last we saw how to calculate the stand basal area as the sum of the tree basal areas divided by the area of the plot, now there is another method known as known as point sampling method which we shall discuss in a later class. Today we shall look at the spacing factor method. Now what is the spacing factor?

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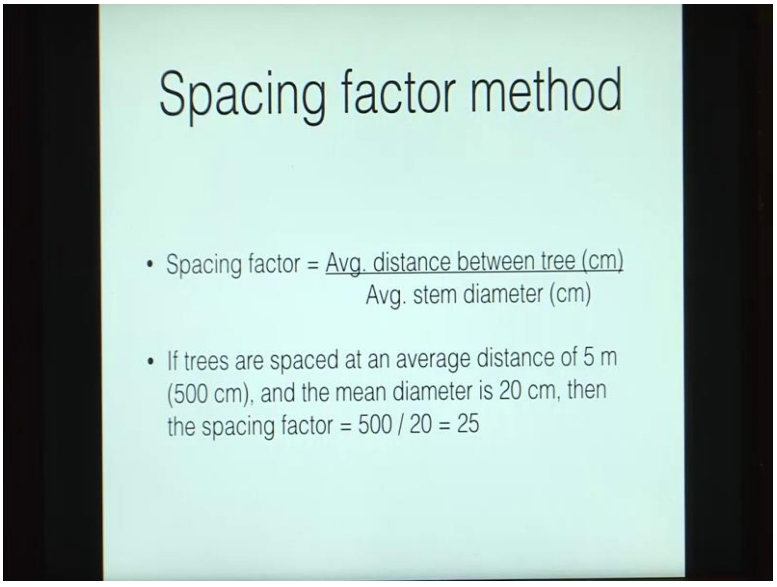

Method the spacing factor is defined as the average distance per tree in centimeters, divided by the average stem diameter in centimeters. Or you can represent both of these in meters and you will be getting the same value.

Now, generally we measure the stem diameter in centimeters and we measure the distance between trees in meters. So, whenever you are questions are given in this in this format that one is given in centimeters and the other is given in meters you should either convert both of these into meters, or you should convert both of those into centimeters.

So now, coming back to the slide the spacing factor is given as the average distance between the tree divided by the average stem diameter. So, to take an example if trees are spaced at an average distance of 5 meters; so 5 meters is 500 centimeters and the mean diameter of the trees is 20 centimeters then the spacing factor will be given by 500 divided by 20 or a spacing factor of 25.

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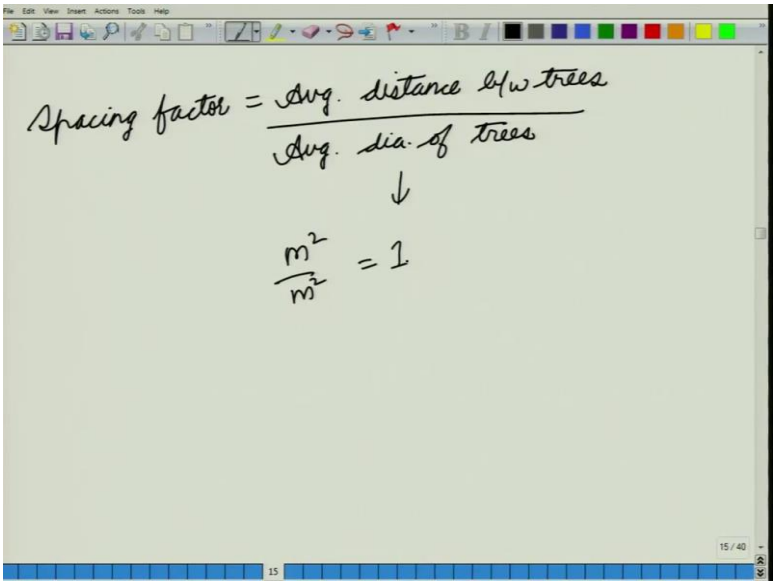

We have that the spacing factor is the average distance between trees divided by the average diameter of trees. So, what will be the unit of spacing factor it will be meter square divided by meter square. So, it is a unit less quantity. So now, why do we need the spacing factor? So, let us plot the spacing factor and the basal area of the of the stand in meter square per hectare.

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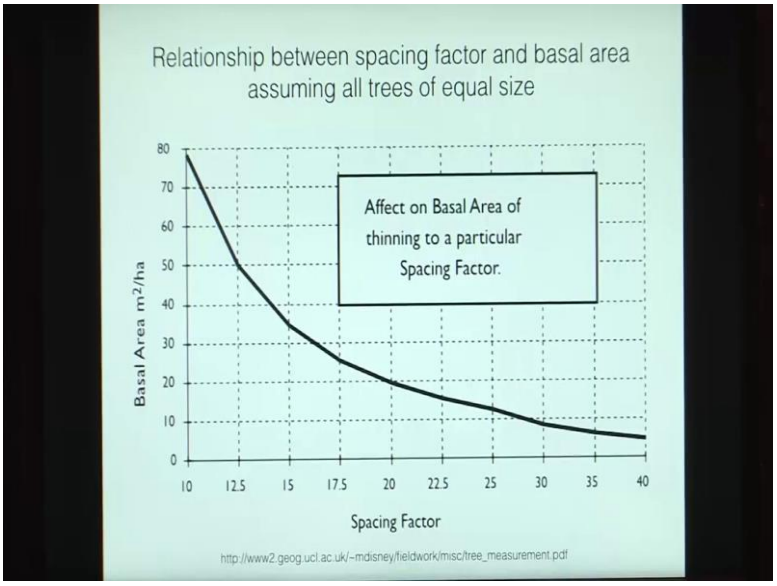

So, in this plot we see that the spacing factor is plotted on the x axis and the basal area in meter square per hectare is plotted on the y axis.

So, if we joint all of these; and if we consider that that all the trees are of equal size. So, this is a theoretical construct, this is the kind of the curve that we shall be getting. So, how do we use this curve? We can use this curve to calculate the amount of thinning that is required in a stand.

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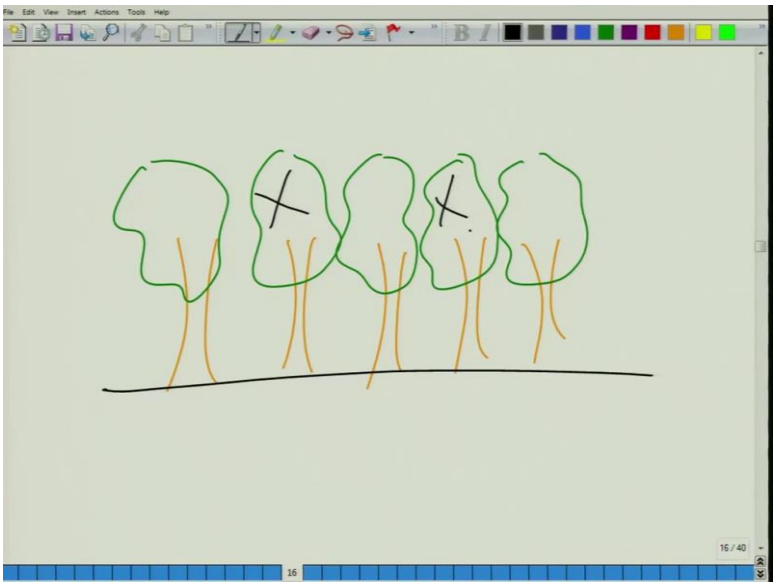

So, as we talked about in a previous class. So, thinning is done to reduce the amount of competition in a stand. So, suppose this is your stand all the canopies are now touching each other. And so, there is a huge amount of competition. So, what do we want to do in the case of thinning is that they reduce the number of trees that are there in the stand. So, maybe we could remove this tree and this tree. So, currently this stand looks very crowded, but what will happen if we remove both of these trees, is that once you have removed these trees now this stand is not appearing crowded by any sense.

So, but the next question is how many trees should be removing from our stand. In this case out of 5 trees we have removed 2 trees, or we have removed every alternate trees that is we have reduces it is density by a factor of 50 percent, but is 50 percent the norm or could we have gone for say 25 percent or 33 percent. So, how do we calculate that? So, we can do that by using the curve. So now, let us look at an example.

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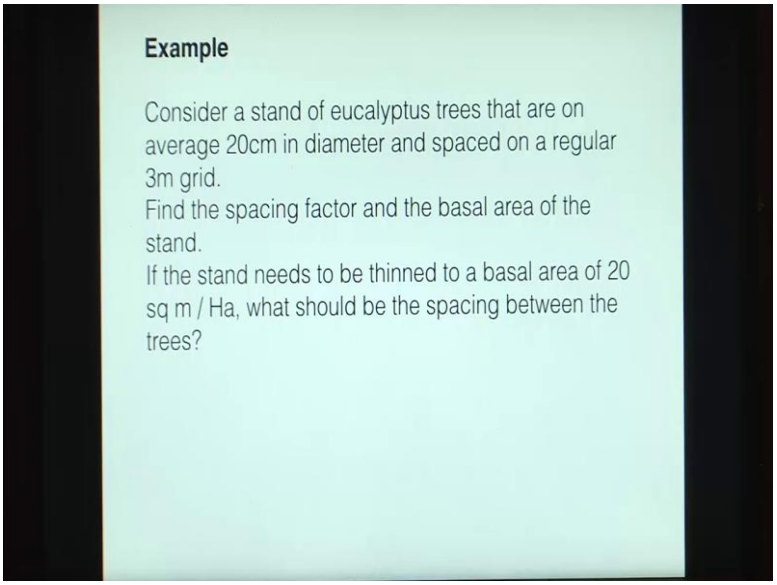

Now it says consider a stand of eucalyptus trees that are on average 20 centimeters in diameter, and spaced on a regular 3 meters grid. So, when we say spaced on a regular 3 meter grid, what we mean is that the distance between the trees. So, coming back to the tablet.

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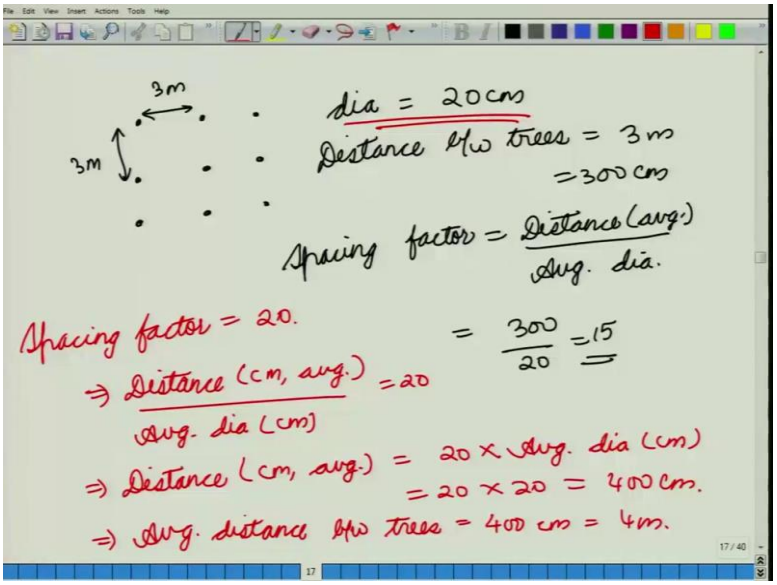

So, they are spaced like this the distance between 2 columns is 3 meters, and the distance between 2 rows is also 3 meters.

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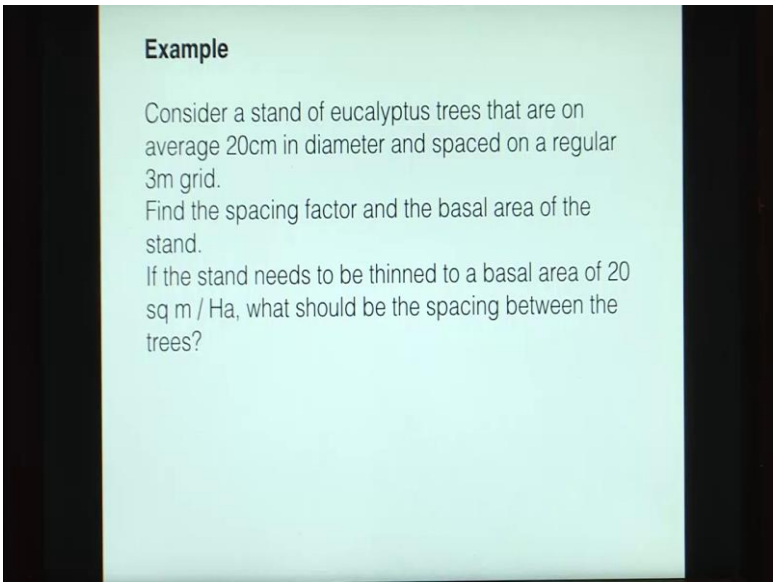

So, we have a stand of eucalyptus trees that are on average 20 centimeters in diameter. So, that is the tree diameter, and they are spaced on a regular 3 meters grid. So, that is the space between 2 trees or the distance between 2 trees. We are required to find the spacing factor and the basal area of the stand. So, spacing factor as you remember it is

the distance between the trees divided by the diameter of the trees, both taken as averages. And the basal area of the stand. So, how can we calculate the basal area? We could use this plot because it shows us the basal area verses the spacing factor.

So, if we know a spacing factor we can calculate the basal area, further the problem says that if the stand needs to be thinned. So, we consider this stand to be crowded and we want to reduce the density. And it needs to be thinned to a basal area of 20 square meters per hectare then what should be the spacing between the trees. So, let us now solve this problem. We are given that the diameter is 20 centimeters, and the distance between trees is 3 meters or 300 centimeters. What is the spacing factor? It is given by distance between the trees averaged out divided by the average diameter. So, it which will be 300 divided by 20 is 15. So, 15 is the spacing factor.

So, coming back to the slides.

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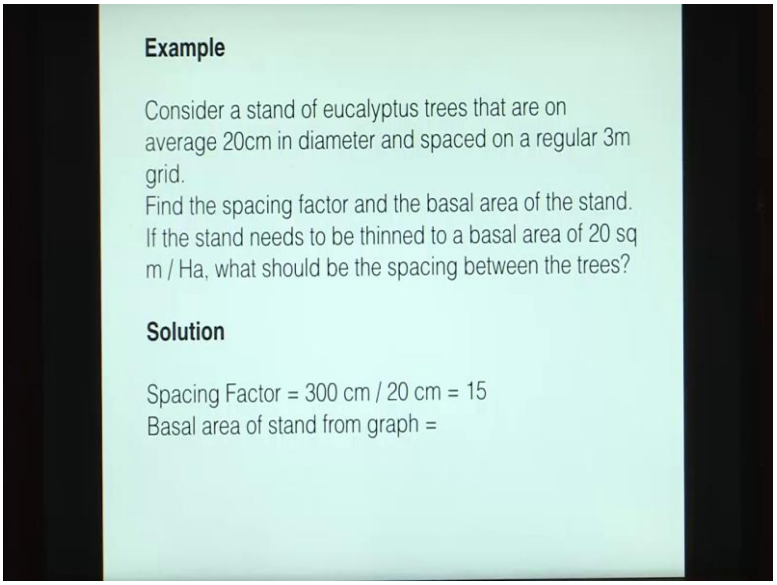

We have spacing factor is 300 divided by 20 which is 15. So now, we need to calculate the basal area of the stand from the graph. So now, coming back to the graph, when you have a spacing factor of 15 what is the basal area? So, if you look at this graph here we have the spacing factors 10 12.5 15. Our stand has a spacing factor of 15. So, what is the corresponding basal area? So, we move up and then we move towards the left it comes to around 35. So, from the curve we have that the basal area of the stand from the graph or from the curve is 35 square meters per hectare.

Now so, that is the first part of the problem. The second part states that if the stand needs to be thinned to a basal area of 20 square meters per hectare. So, currently the basal area is 35 square meters per hectare we need to bring it down to 20 square meters per hectare. What should be the spacing between the trees? So, for a basal area of 20 square meters per hectare will we need to calculate the spacing factor. Because we want the spacing between the trees and we can calculate it by using the spacing factor. So, for 20 square meters per hectare what would be the spacing what would be the spacing factor?

So, currently our stand is somewhere here, we need to bring it down to 20. So, when we have 20 square meters per hectare the spacing factor from this curve comes out to be 20. So, for the basal area of 20 square meters per hectare the spacing factor is 20. Now what do we mean by this 20 square meters? By this 20 spacing factor, now coming back to the tablet if we say that the spacing factor is 20. It means that the distance in centimeters that is have reached out divided by the average dia in centimeters is 20.

Now, we are given that the average diameter is 20 centimeters. So, we have distance between trees in centimeters and averaged out is 20 into the average dia in centimeters which is also 20. So, we have 20 into 20 is 400 centimeters. So, the average distance between trees is 400 centimeters or 4 meters.

So now coming back to the slides, we have the average spacing is 4 meters now remember that earlier we had a spacing of 3 meters. So now, coming back to the tablet, here we have a spacing of 3 meters. Now if we wanted to make the average distance to be 4 meters. So, 4 meters would be somewhere here. So, of course, if we remove these trees as a row completely, then we would have an average spacing of 6 meters, but we want to have an average spacing of 4 meters. So, in that case we will not be removing this row completely, but we would be removing some trees from this row to give us an average spacing of 4 meters. So, this is the utility of the curve the utility of this curve to calculate the amount of thinning that is required and to calculate the spacing that we would require.

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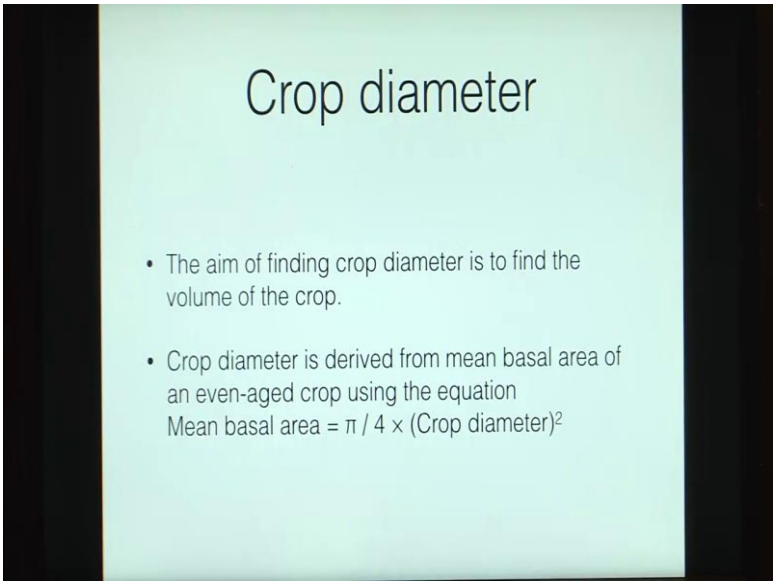

So, the next concept is that of a crop diameter. Now remember that we know how to calculate the diameter of a tree, we can also calculate. So, a diameter of a tree can be calculated either by using a tape or maybe by using calipers. So, if you have a tape you can calculate the girth of a tree and now girth is given by pi into d. So, we can calculate the diameter.

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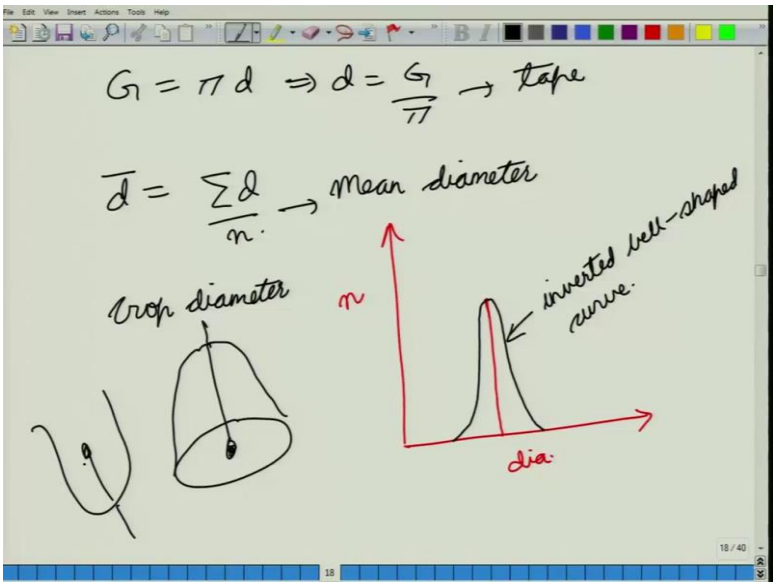

So, if we have the girth which is equal to pi times d. So, we can calculate d by g upon pi for the case of a, tape in the case of calipers we directly get the diameters. Now we can

calculate the mean diameter of a stand. So, a mean diameter of the stand would be the sum of all the diameters of the trees in the stand divided by the number of trees.

So, basically mean diameter or d bar will be given by sum of d divided by n. So, that is the mean diameter, but crop diameter is a completely different concept. So now, coming back to the slides.

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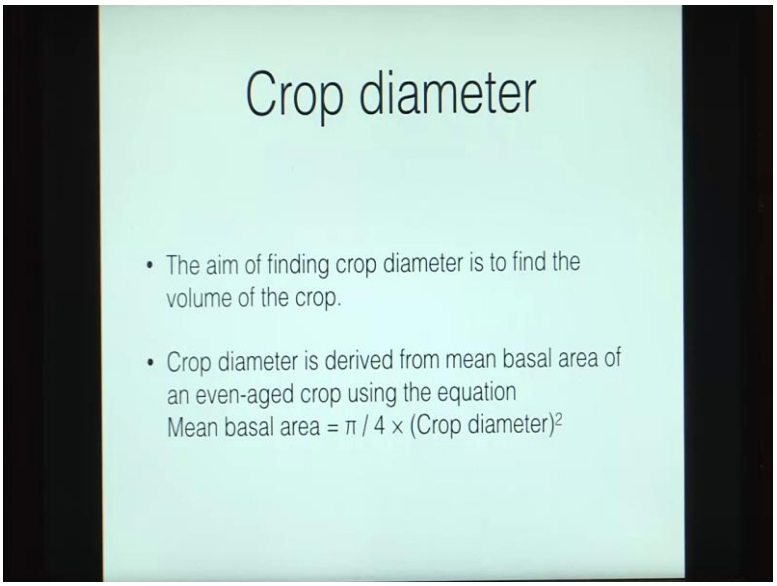

It states that the aim of finding crop diameter is to find the volume of the crop or the volume of the stand. So, in this case we are not interested in getting an average diameter we are interested in getting a crop diameter. Now how do we calculate a crop diameter? The crop diameter is derived from the mean basal area of an even aged crop using the equation mean basal area is pi by 4 d square. What does it mean? To calculate the crop diameter we first of all need to calculate the mean basal area of the crop.

Now, it also states that you can find out a crop diameter only for an even aged crop. So, what is an even aged crop? So, consider a crop in which you have all the trees in the same diameter. So, essentially we are plotting the number of trees verses the diameter. So, if all the trees are of a single diameter, then it would be the crop of an even aged, but this is only a theoretical concept. Practically we will have some variation in the diameters.

So, if you remember your class of measures of central tendency and dispersion it stated that in place of having this shape we will be having a shape like this, or an inverted bell shaped curve. So, this shape is called an inverted bell or you could even call it a bell shaped curve. So, if you drew a bell it looks very much like this. So, here you have a gong. So, this has a very similar shape. So, you can either call it a bell shaped curve or an inverted bell shaped curve, depending on whether you consider your bell to be like this or to be like this.

Now, when you have this shape then you call it an even aged crop. So now, coming back to the slides, you can calculate the crop diameter only for an even aged crop and it is derived from the mean basal area of the stand by the equation pi by 4 d square.

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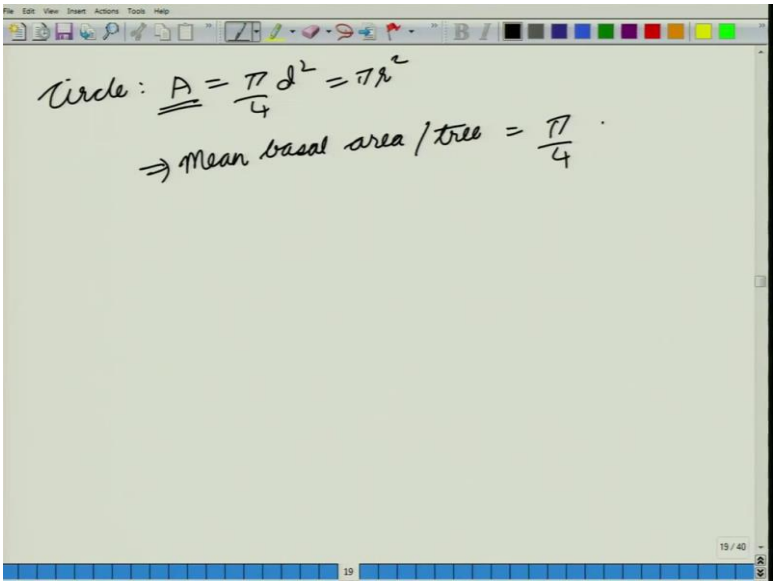

So, in the case of a circle we have area is equal to pi by 4 d square which is pi r square. So, we can calculate if we take the area to be the mean basal area. Now this mean basal is the mean basal area per tree. And if we used it in the same equation pi by 4 d square now, then the value of d that we shall be getting will be the crop diameter. It is also represented as d q.

So now let us look into an example.

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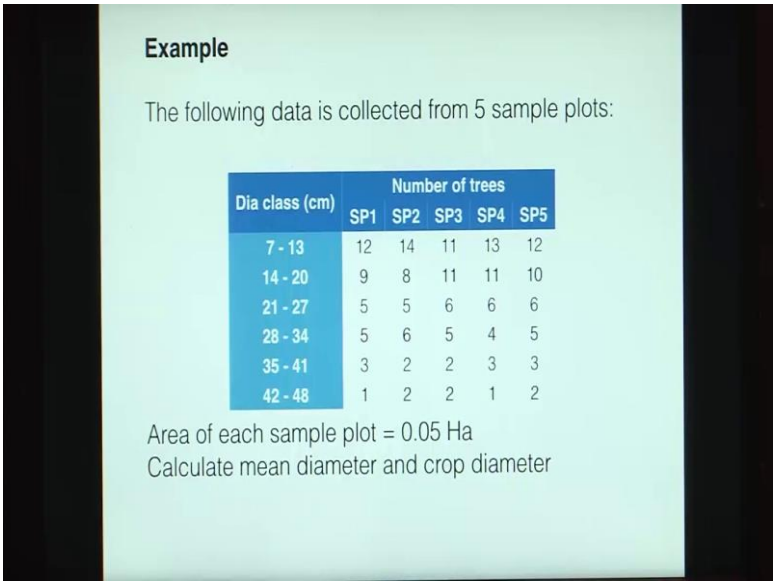

The following data is collected from 5 sample plots. So, here we see the number of trees of all the diameter classes. So, these are the diameter classes these are the number of trees in 5 different sample plots SP 1 2 3 4. And 5 now area of each sample plot is given to be 0.05 hectares. And we are required to calculate the mean diameter and the crop diameter.

So, how do we calculate this? So, we are given the class diameters we can calculate the class mark, now class mark. So, when we say that we have a table in which our diameter classes are 0 to 10 10 to 20 20 to 330 to 40 and so on.

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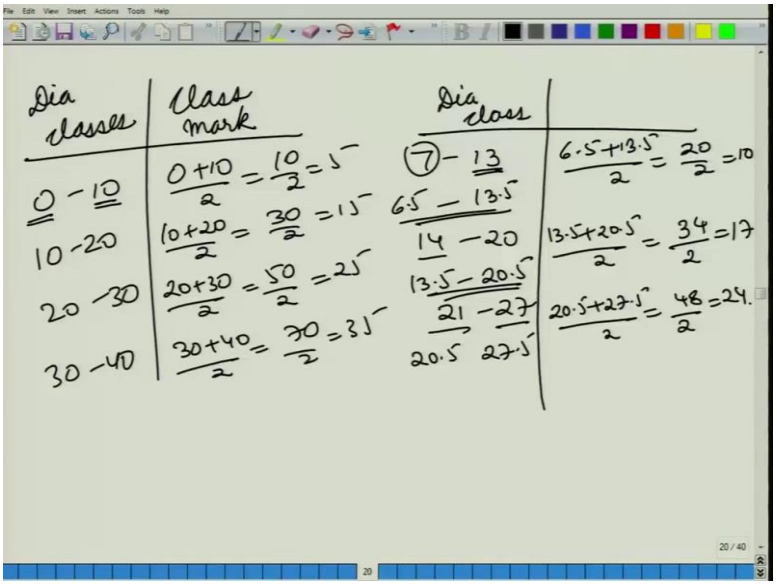

Then the class mark is the average of the lower limit of class and the upper limit of the class. So, for 0 to 10 it will be 0 plus 10 upon 2 which is 10 by 2 which is 5. For this one we will have 10 plus 20 by 2; that is 30 by 2 or 15. Here it is 20 plus 30 by 2 plus 50 by 2 is 25. Here it will be 30 plus 40 by 2, which is 70 by 2 which is 35. So, this is how we calculate the class mark.

Now, coming back to the slides here we have the diameter classes that are not continuous say. So, they go from 7 to 13 and the next diameter class does not start from 13 it starts from 14. So, it is 14 to 20 21 to 27 and so on. So, how do we calculate the class mark here. So, so we have it as 7 to 13 14 to 20 21 to 27 and so on. So now, let us increase the upper limit by 0.5. So, it becomes 13.5 and decrease the lower limit by 0.5. So, it becomes 6.5 to 13.5 here also we do the same thing. So, it becomes 13.5 to 20.5 here it becomes 20.5 to 27.5.

So, in that case if we calculated the class mark using this it will be 6.5 plus 13.5 upon 2 which is 20 by 2 which is 10. Here we will have 13.5 plus 20.5 by 2, which is 34 by 2 which is 17. Here we have 20.5 plus 27.5 by 2 which is 8 48 by 2 which is 24. So, this is how we calculate the class marks here when the classes are discontinuous.

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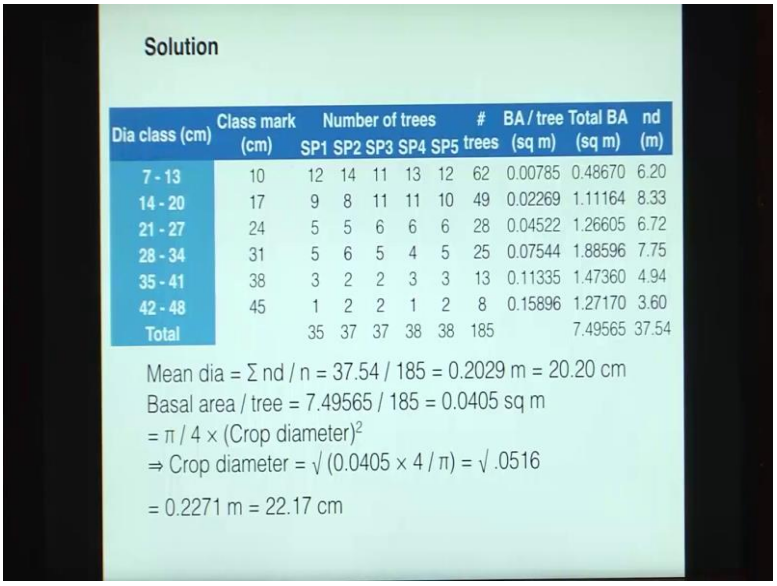

So, it is 10 17 24 and so on. So now, coming back to the slide here we see the class marks as 10 17 24 and so on. Now the numbers of trees in all the sample plots are given. So, we can calculate the total number of trees in each sample plot as this figure. So, here we have 12 plus 9 plus 5 plus 5 plus 3 plus 1 which is 35.

Similarly, the number of trees in the second sample plot comes to be 37 and so on, for all the sample plots. You can also calculate the number of trees in each diameter class. So, for instance here we will have 12 plus 14 plus 11 plus 13 plus 12 which gives us 62 number of trees in this diameter class 7 to 13. Similarly we have 49 trees in the diameter class of 14 to 20 and so on, and this gives us the total number of trees in all the diameter classes combined.

Now, we require the mean diameter. So, how do we get the mean diameter. So, we can consider the this diameter of the class mark as a representative diameter for this diameter class. And the number of trees in this diameter class is 62. So, if you multiplied 62 by 10, now this is 10 centimeters or 0.1 meters. So, if I wrote the class mark in meters it would be 0.1. So, multiplying this 0.1 with 62 we get 6.2. So, that is the number of trees multiplied by the diameter and written in meters. So, that is 6.2.

Similarly, for the second row we have 0.17 meters is the diameter or the representative of diameter we have 49 trees. So, n into d becomes 8.33. So, similarly we can calculate n times d for all the diameter classes, and we can find out the total.

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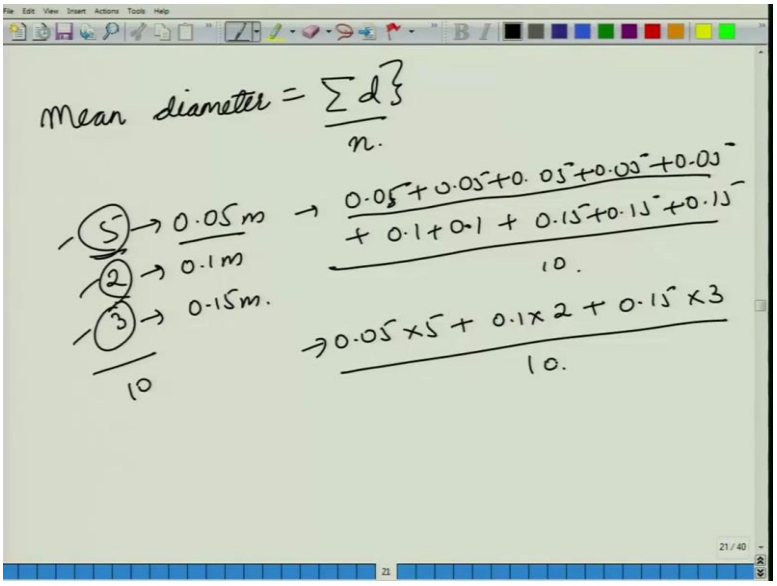

So, what are we doing here? Essentially is that for the case of a mean diameter, we need to find out the sum of all the diameters divided by n. Now suppose you have 5 trees of 0.05 meters 2 trees of 0.1 meter, and suppose 3 trees of 0.15 meters. So, I if we wanted to calculate sigma d, we could either do it like this 0.05 plus 0.05 plus 0.05 plus 0.05 plus 0.05, because we have 5 trees here plus 0.1 plus 0.1 for these 2 trees, plus 0.15 plus 0.15 plus 0.15 for this 3 trees, whole divided by total number of trees which is 5 plus 27 plus 310.

So, we can either calculate our mean diameter by this way or else we can take this diameter and multiply it with this. So, here we have 0.5 added up 5 times. So, we could have written it as 0.05 multiplied by 5 plus 0.1 multiplied by 2 plus 0.15 multiplied by 3 whole divided by 10. So, these are essentially one and the same thing. So now, coming back to the slide, here we have n times d which is summing up your average diameter for all the number of trees. So, this is what we are doing here and then we are totaling it up. So, this is now the sum of all the individual diameters. So, we can also say that here, the sum of n times d which we have calculated here is the sum of all the diameters.

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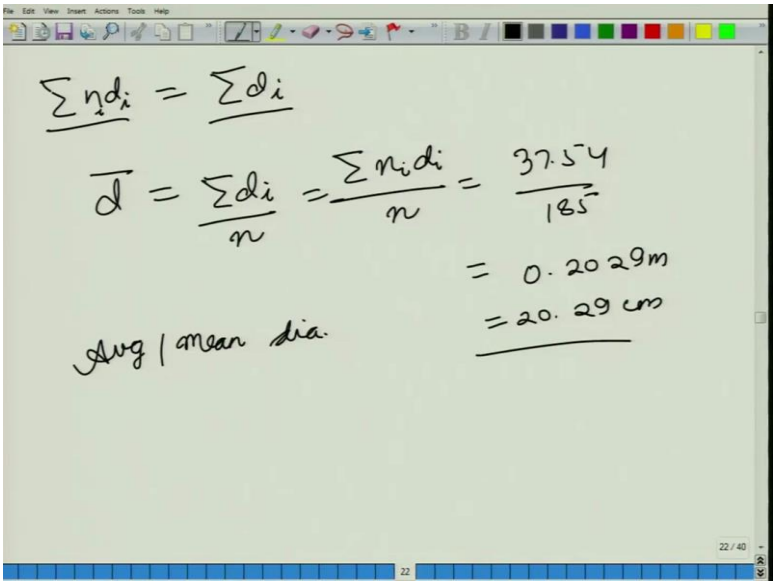

Now, coming back to the slide, here we have the sum of n d. And here we have the sum of the number of trees. So, this is 185. So, when we are trying to calculate the average diameter that is sum of d i divided by n now because d i is same as sum of n i d i. So, we can also write it as sum of n i d i divided by n. So, looking back at the sides now some of n i d i comes to be 37.54 and the number of trees is 185. So, sum of n i d i is 37.54 divided by 185 which comes to be 0.2029 meters or 20.29 centimeters. So, this is the average or the mean diameter of the stand.

Now, the second thing that we wanted to calculate is the crop diameter. So, how do we calculate the crop diameter?

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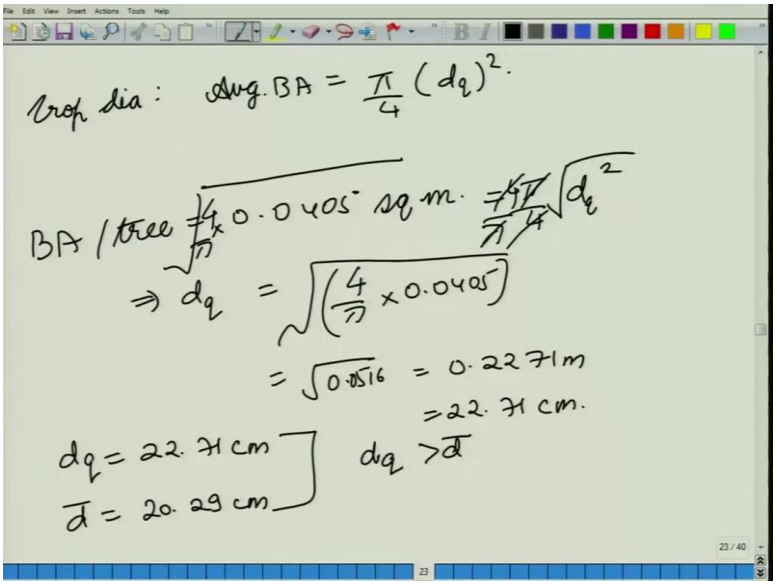

As the average basal area. So, we calculated by using this equation, the average basal area is 5 by 4 times the crop diameter square. So, how much is the average basal area? So now, coming back to the slides. Here we are calculated the basal area per tree. So, we have the number of trees in the basal area per tree. How do we calculate the basal area per tree? It is given by pi by 4 times d square, d we have taken from the class mark. So, pi by 4 into 0.1 into 0.1 will give us this figure of basal area per tree.

So, we have similarly we have calculated the basal area per tree for all these diameter classes by taking these class marks. So now, the total basal area for this class mark will be given by the basal area per tree multiplied by the number of trees. So, 62 multiplied by 0.00785 would give us this value. So, this is the total basal area in a square meters of all the trees that are in this diameter class of 7 to 30.

Similarly, 1.0064 is the total basal area of all the 49 trees with an average basal area of this that belong to this diameter class of 14 to 20. So, here we have the total basal area for each diameter class. So now, we can calculate per total basal area of all the trees combined. So, this is the total basal area of all the 185 trees. So, if 185 trees have this basal area, what is the basal area per tree? That we can calculate by dividing this value by 185.

So, if you do that we get 0.0405 square meter. So, we have basal area per tree is 0.0405 square meters which is equal to pi by 4 d q square. So now, we can calculate d q by

multiplying both the sides by 4 by 5. So, if I multiplied by 4 by 5 this portion gets cancelled out and to remove the square you can take a square root of both the portions. So, d q is equal to 4 by pi into 0.0405 it is square root which is the square root of 0.0516 which is 0.2271 meters or 22.71 centimeters.

So, here we have d q is equal to 22.71 centimeters and the average diameter that we earlier calculated to be 20.29 centimeters. So, here we can see that your d q is greater than the d bar that is the crop diameter is greater than the mean diameter in this particular instance. But is it generally the case? Can we always say that the crop diameter is greater than mean diameter? Well, the answer is yes.

So, let us now see if the crop diameter is greater than mean diameter in all the cases. So, we define crop diameter or d q is equal to the square root of sum of d i square divided by n.

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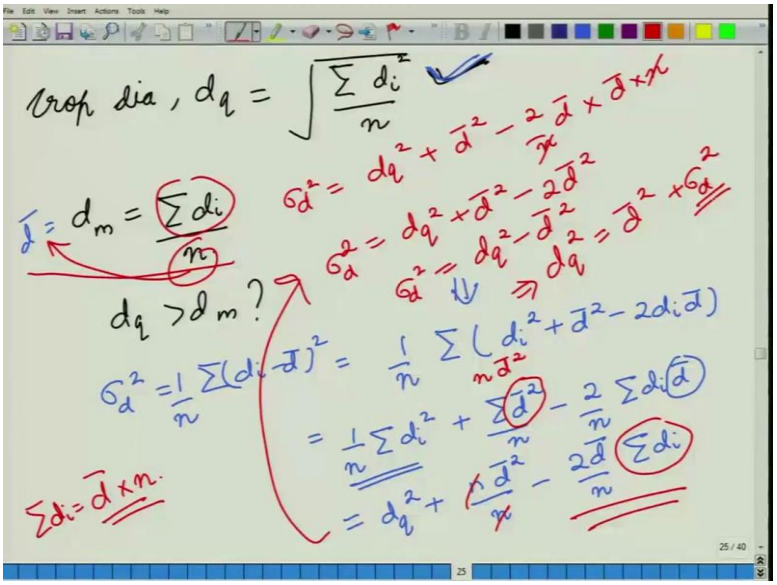

Because looking at the previous slide. So, to calculate the crop diameter we use the sum of the basal areas, now basal area is given by pi by 4 d square. So, here we are summing up all the basal area, when calculating the average and then using this equation of pi by 4 d square is the this equation pi by 4 of c d square is the sum of the pi by 4 d i squares.

So, this is how we define the crop diameter. What about the mean diameter? So, let us call it the mean diameter is given by sum of d i sum of all the diameters divided by n. So

now, can we say that d q is greater than d m, can we say that? So, let us now look at another quantity which is called sigma d which is the standard deviation. Now if you remember our class on the measures of central tendency and dispersion, you know that the standard deviation is given by the square root of sum of all the deviations. So, it is y minus d bar. So, d bar d bar can also be written as d m it is square whole divided by n. So, this is the standard deviation. So, if we squared it, what will we get? We get sigma d square is equal to 1 by n sum of d i minus d bar it is square.

Now, d m can also be written as d bar. So, we will use it interchangeably. So, this is equal to 1 by n sum of now d i minus d bar square can be expanded as d i square plus d bar square minus twice of d i d bar. So, which is equal to 1 by n sum of d i square plus sum of d bar square by n minus 2 by n sum of d i d bar. Now if you look at this quantity 1 by n sum of d i square it is this quantity. So, this is equal to d q square plus. Now d bar is a constant term. So, sum of d bar square will be nothing else, but n times of d bar square. So, here we have plus n times of d bar square by n minus here also we can take d bar outside. So, twice d bar upon n sum of d i which can further be written. So, let us write it here now. So, we will write it here I will remove this.

So, we have sigma d square is equal to d q square plus now here n, n n get cancelled. So, it is d bar square minus 2 by n d bar, now sum of d i is nothing else, but d bar multiplied by n because we have d bar is sum of d i by n. So, sum of d i is equal to n multiplied by d bar. So, this term can now be written as 2 by n d bar multiplied by d bar multiplied by n. So, n and n get cancelled. So, this is equal. So, we can write that sigma d square is equal to d q square plus d bar square minus twice of d bar square, which is d q square minus d bar square. So, this is sigma d square. So, we can say that d q square is d bar square plus sigma d square.

Now, if you remember our class on the measures of dispersion the sigma d is a positive figure till the point that all your trees have the constant diameter which is equal to d bar. Now because that thing is not physically possible, so your sigma d square is a positive value. So, this would give us that d q square is greater than d bar square. Now taking the square roots of both the sides we can say that d q is greater than d bar, which is what we wanted to prove in the first case that the crop diameter is greater than the mean diameter.

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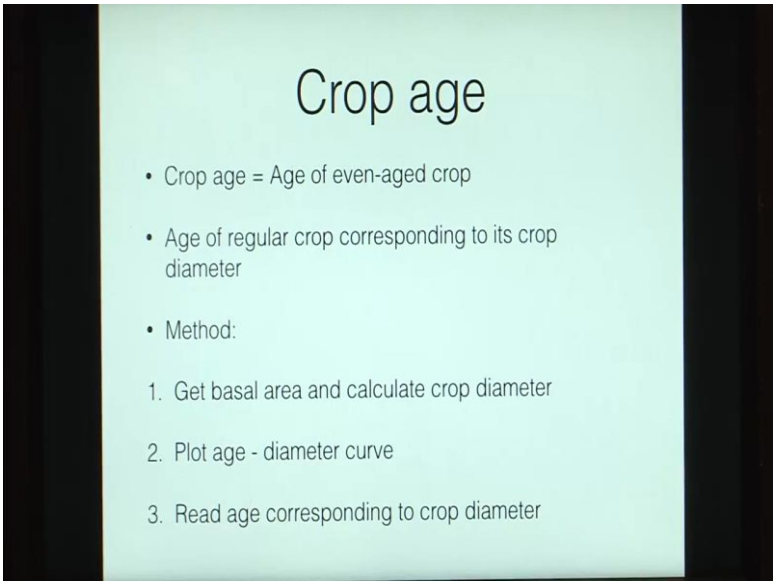

Now, let us look at one other factor here; one other variable which is known as the crop age. Now crop age is defined as the age of an even aged crop. So, if we represented the number of trees in all the diameters, if this is our distribution of the number of trees verses diameter we want to calculate the age. So, age of this crop also known as the crop age is defined as such. So, coming back to the slides crop age is the age of an even aged crop or the age of a regular crop corresponding to it is crop diameter, so because all the trees in your stand have different diameters. So, you calculate the crop diameter. So, crop diameter we have already calculated in this lecture.

Once we have calculated the crop diameter we next look at the age diameter curve.

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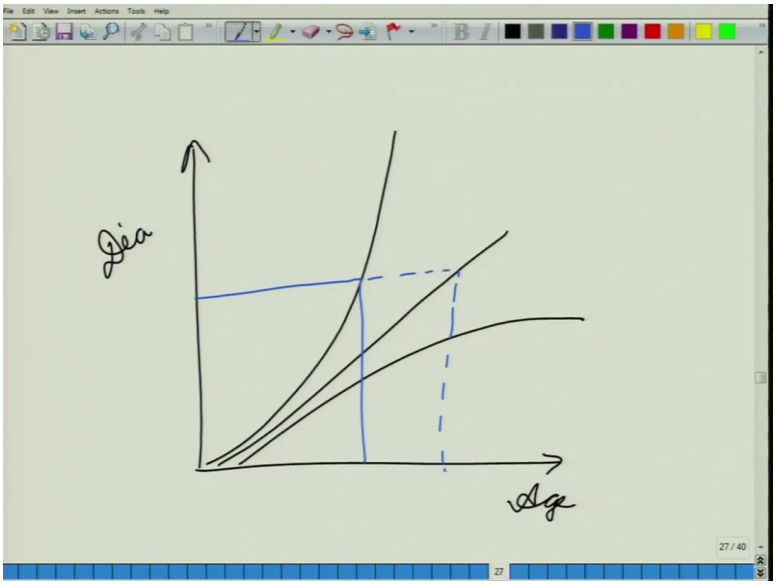

So, essentially when the age increases the diameter also increases. So, it might show a curve like this a straight curve a curve like this or So on or maybe some other shape. So, once we have plotted the age diameter curve when we get the crop diameter and then when we when we try to get the corresponding age then that is called the crop age.

So, coming back to the slides crop age is the age of the even aged crop which is derived by getting the crop diameter plotting the diameter age curve and then finding out the age for the crop diameter. So, that is defined to be the crop age. So, we shall look into these topics in further detail in the next class.

Thank you for your attention. [FL].