Forest Biometry
Prof. Mainak Das
Dr. Ankur Awadhiya
Department of Biological Sciences & Bioengineering & Design Programme
Indian Institute of Technology, Kanpur

Lecture - 33
Volume computations in the field

[FL]. Let us now have a look at how volume computations are done in the field. So, we have already looked at how to compute the volume for a single tree, or maybe for a single log of wood, but then if we have a large stand with a large number of field how do we compute the volumes out there in the field. So, let us look at the methods. So, one of the simplest methods is to sum up all the volumes.

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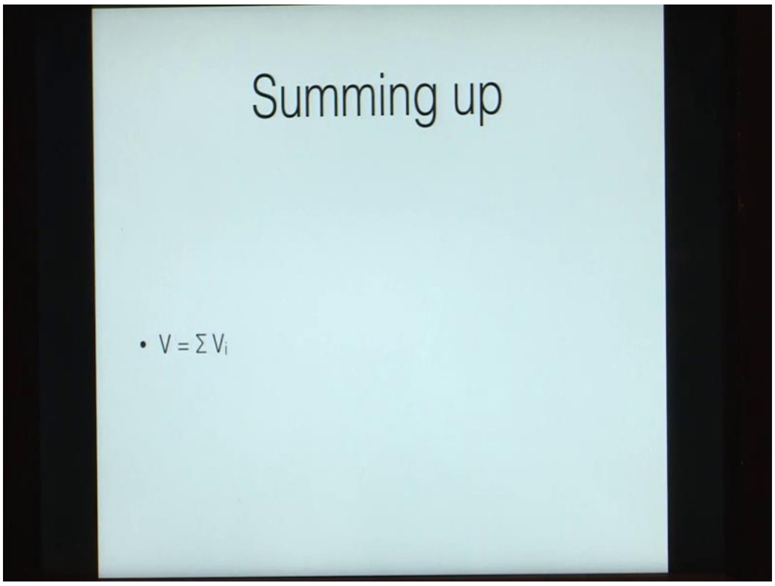

So, if you have a number of volumes you can just add them up to get the volume of the stand.

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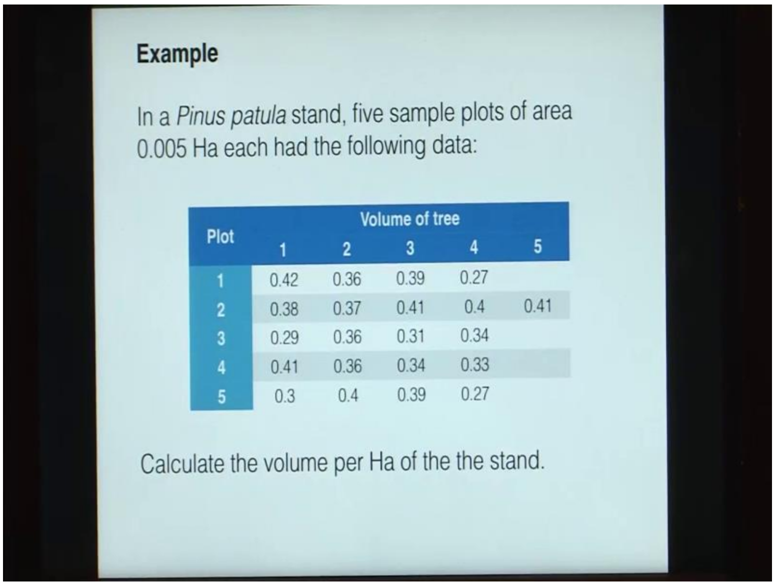

So Let us look at an example to do this. So, in is a in a pinus patula stand, 5 sample plots of area 0.005 hectares each had the following data. So, here we have 5 sample plots. So, these are sample plots 1 2 3 4 and 5, each sample plot has a different number of trees. So, the first plot has only 4 trees, the second plot has 5 trees, and the other 3 plots have 4 trees each. The volume of all these individual trees has been computed, and we are required to calculate the volume per hectare of the stand.

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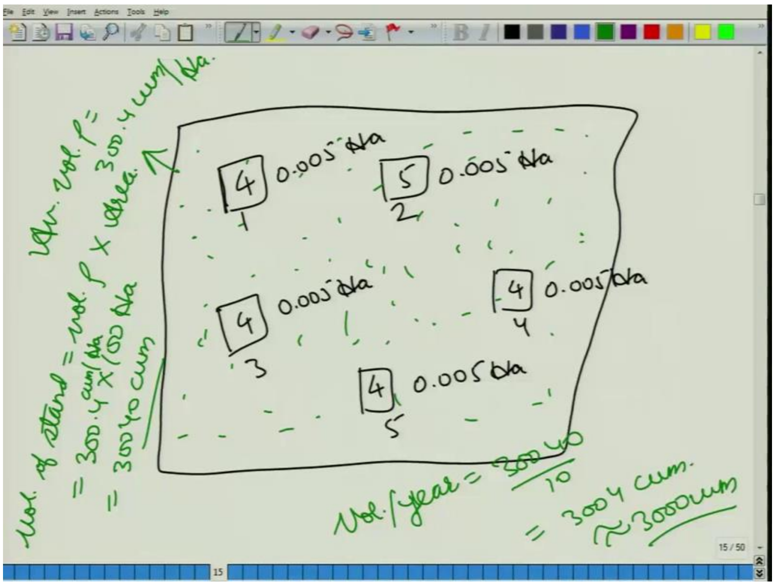

So, what have we done here? Essentially if you have a large sized stand; so if this is your complete area, you have taken just 5 sample plots somewhere. So, you have taken 5 sample plots in each of these sample plots. So, let us call these 1 2 3 4 and 5, in the first sample plot and each sample plot has an area of 0.005 hectares.

So, each sample plot has the same area. Now the first sample plot has only 4 trees, the second sample plot has 5 trees, and the other 3 sample plots have 4 trees each. Now in the first sample plot out of these 4 trees we have computed the volume of each of the tree and that is given in the question.

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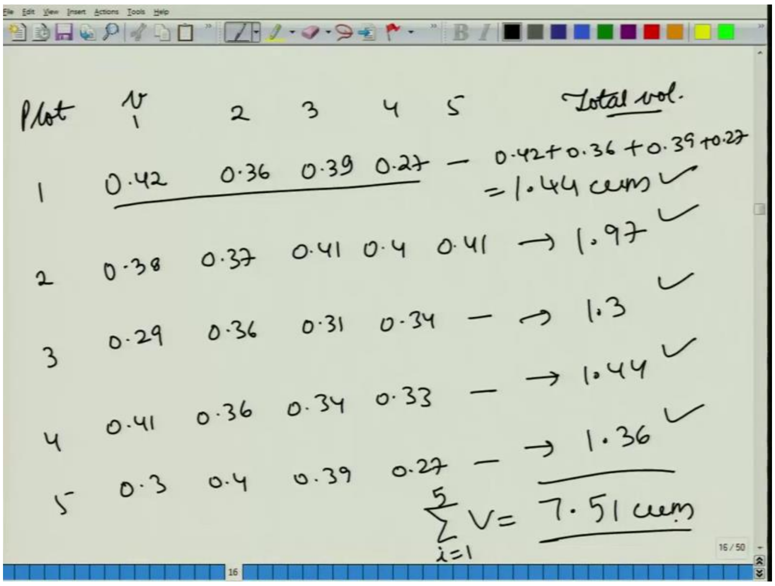

So, if we have in the plot 1 2 3 4 and 5, the volume v for tree number say 1 2 3 4 and 5 is given. So, here you have 0.42 cubic meters 0.36 cubic meters 0.39 cubic meter 0.27 cubic meter and this does not have any tree here. So, what is the total volume for sample plot one? It is given by the sum of these 4 values. So, 0.42 plus 0.36 plus 0.39 plus 0.27 which is equal to, so let us now use a calculator to do this. So, here we have 0.42 plus 0.36 plus 0.39 plus 0.27 which is 1.44. So, this is 1.44 cubic meters. Similarly in the second plot we are given the volume size 0.38 0.37 0.41.4 and 0.41. So, third one has 0.29 0.36.31.34 and this does not have any value.

Next we have 0.41, 0.36.34, 0.33 and here we have 0.3 0.4 0.39 0.27 and this does not have any value. So, we can compute the total volumes for each of these sample plots. So, in the case of the second sample plot here we have 0.38 0.37, 0.41.4 and 0.41. So, we have 1.97 as the value for the second one. So, here we have 1.97, in the third one you have 0.29 0.36.31 and 0.34 which is 1.3. So, here you have 1.3 here we have 0.41, 0.36.34 and 0.33 is again 1.44. And for the last one we have 0.3, 0.3 plus 0.4 plus 0.39 plus 0.27 which is 1.36.

So now, we have 5 sample plots and the volume of each sample plot has been calculated by adding up the volumes of each of the trees. So now, what is the total volume? The total volume of the 5 sample plots. So, here we have i equals one to 5 that is given by the sum of these values. So, we have 1.44 plus 1.97, 1.3, 1.44 and 1.36. So, that is 7.51, 7.51 cubic meter.

So now, we have total volume in 5 sample plots is 7.51 cubic meter. Now area of one sample plot is given to be 0.005 hectares.

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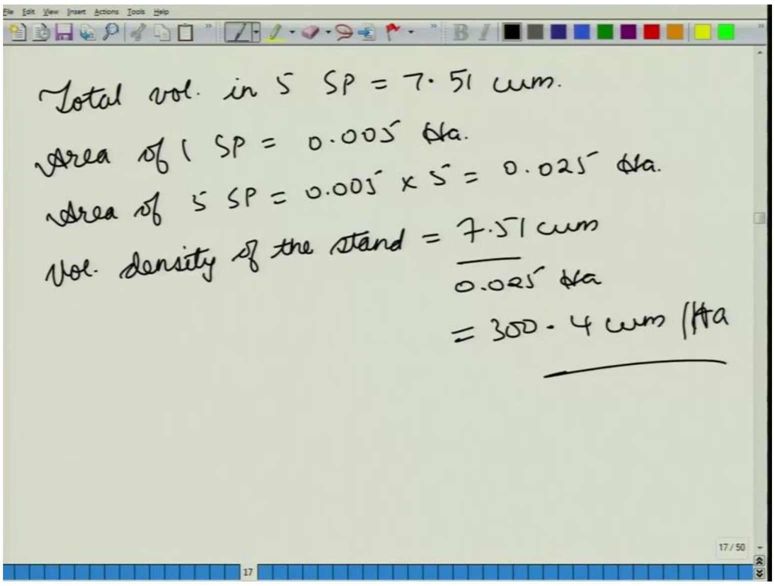

So, area of 5 sample plots is 0.005 into 5 is 0.025 hectares. So, if we wanted to find out the volume density of the stand it will be 7.51 cubic meter by 0.025 hectares. So, if we found that out we have 7.51 divided by 0.025 that is 300.4 cubic meter per hectare. So, just by summing up the volumes of the trees in different sample plots we can find out this stand density; now, when we talk about that stand density that is considered to be a constant stand density for the whole of your stand.

So, everywhere in this stand because we have taken an average of different sample plots. So, we can find that we can consider that to be the average stand density. So, the average let us call it the volume density is 300.4 cubic meter per hectare. Now suppose your whole stand had an area of suppose 100 hectares. So, in that case you can find out the total volume of the stand just by taking.

So, the total volume of stand will be the volume density multiplied by the area of this stand. So, suppose so, in this case it is 300.4 suppose our total area was 100 hectares. So, this is cubic meter per hectare. So, here we will have 30040 cubic meter. So, that would be the total volume of all the trees in the stand. How does that help us? So, suppose we wanted to harvest this stand and suppose we choose it in such a way that in that in a period of 10 years we are going to harvest this stand. So, how much could be the volume of wood that you will be extract in each year? So, that would be the total volume divided by the total number of years. So, if we considered that to be 10 years.

So, in that case we will have the volume per year will be 30040 by 10 s, 3004 cubic meter or approximately 3000 cubic meters. So, if we knew that every year we are able to harvest 3000 cubic meters. So, in that case if we wanted to know how much is the amount of profits that we are going to make out of it, or how much will be selling price of this amount of wood. So, say in the case of take the value of one cubic meter of take and go from anywhere between say 35000 rupees to 1 lakh 50000 rupees.

So, considering 1 lakh to be a central figure or a nearby central figure or let us consider 80000. So, in that case the amount of remuneration per year would be this 3000 cubic meters, multiplied by the value of one cubic meter of the wood; so when you want to convince a farmer to go into agro forestrian wood or if you want to compute the amount of remuneration that you can get out of a stand that you are managing. So, this is one easy method of finding that out.

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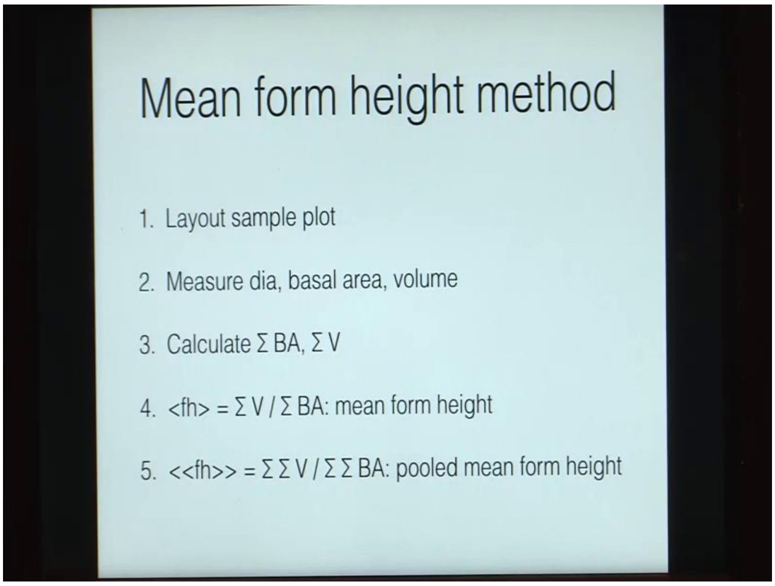

Now another way in which we can compute the volume of a complete stand is using the mean form height method. So, in the case of mean form height method these are the steps, one we layout a sample plot. So, sample plot is just as we did in the previous instance. So, we can layout a number of sample plots. Then for all the trees in the sample plot we can find out the diameter the basal area and the volume for each of the trees. So, diameter can be very easily measured using calipers or using tape.

Basal area is pi r square or pi by 4 d b h square for each tree, volume can be calculated by multiplying by the basal area with the with the height of that tree and with the form factor of that tree. So, after we have done that we can calculate the sum of the basal areas of all the trees in the sample plot and the sum of the volumes of all the trees in the sample plot.

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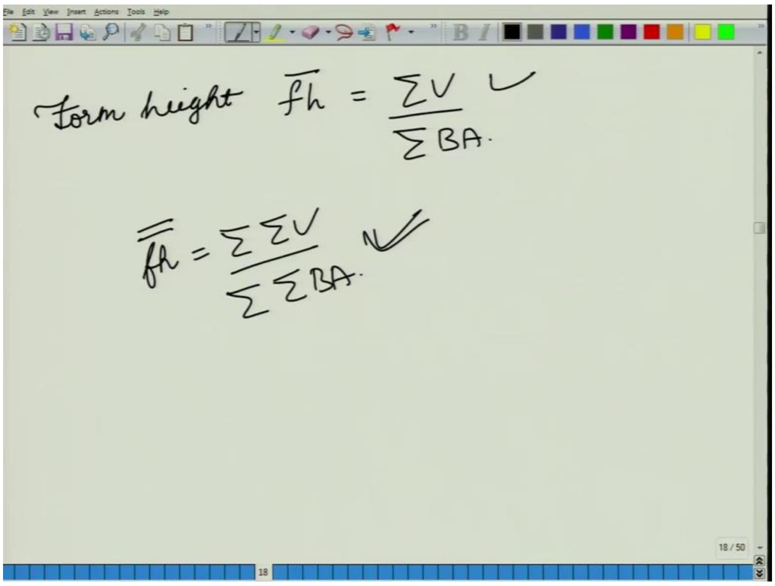

So, that can be figured out. Now what is the form height? Form height is defined like this. So, we have form height or f h average doubt. So, so this is the mean form height it is given by the sum of the volumes of all the trees divided by the sum of the basal areas of all the trees. So, essentially you can say that form height is the height of the tree multiplied by the form factor, but then we can also write it as sum of the volumes and sum of the divided by the sums of the basal areas. We also have a pooled mean form height.

So, a pooled mean form height is given by f h with 2 bars about, it is the sum of the sum of the volumes divided by the sum of the sum of the basal areas. So, for instance in this one we will calculate it for each of the sample plots whereas, the mean pool form height will be for all the sample plots combined together. So, let us now have a look at these equations in greater detail by looking at an example.

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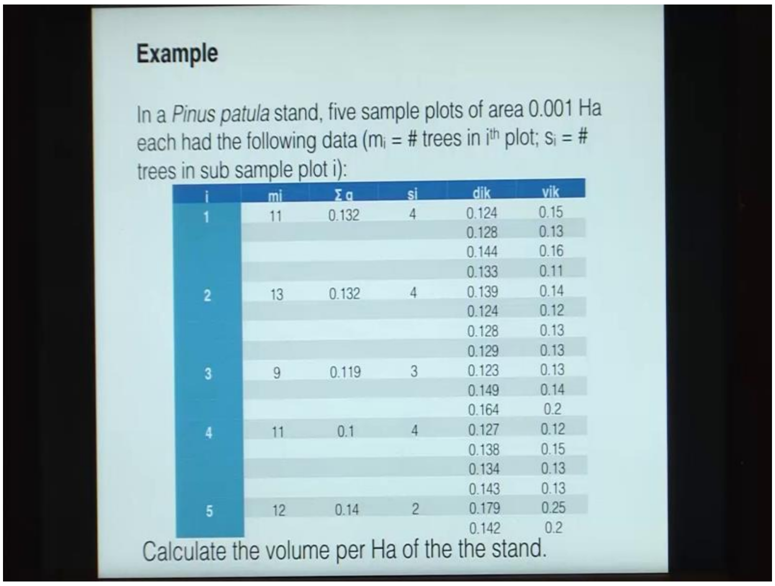

So, here it states that in a pinus patula stand 5 sample plots of area 0.001 hectare have been taken. And for each of these mi is the number of trees in that sample plot, si is the number of trees in the sub sample plot. And we are given the values and we are required to calculate the volume per hectare of the stand. So, here we have 5 sample plots 1 2 3 4 and 5. Now in each sample plot. So, in the first sample plot mi is the number of trees in the I th sample plot. So, in the first sample plot we have 11 trees.

In the second sample plot we have 13 trees in the third sample plot we have 9 trees and so on. So, this tells us the number of trees in this sample plot. Now for these trees g is the sum of the basal areas of all these 11 trees. So, when you when you take the basal area of all of these trees and you sum them up you get this value. So, here for 11 trees the basal area sum is 0.132 for 13 trees here also again it is 0.132 for 9 trees it is 0.119 and so on. Now in each sample plot you can find out a sub sample plot.

So, si tells you the number of trees in the sub sample plot i. So, in out of these 11 trees you have taken 4 trees for your sub sample plot, and for those 4 trees the diameter and the volume are given. So, here are the 4 trees 1 2 3 and 4. So, the first tree has this diameter and this volume. So, the diameter is given in meters volume is given in cubic meter. For the second tree these are the diameters and volumes for the third one and for the 4th one. Similarly for the second sample plot out of 13 trees you took a sub sample plot of 4 trees. So, out of these 13 trees for 4 trees you have measured the diameters and the volumes completely whereas, for the rest for all these 13 trees you have figured out the basal area you have figured out the sum of the basal areas of all these 13 trees.

So, for these 13 trees you have the sum of the basal area and for these 4 trees you have individual diameter and volume values. Similarly in the third 4th and the fifth plot as well. So now, how do we figure it out the volumes of these?

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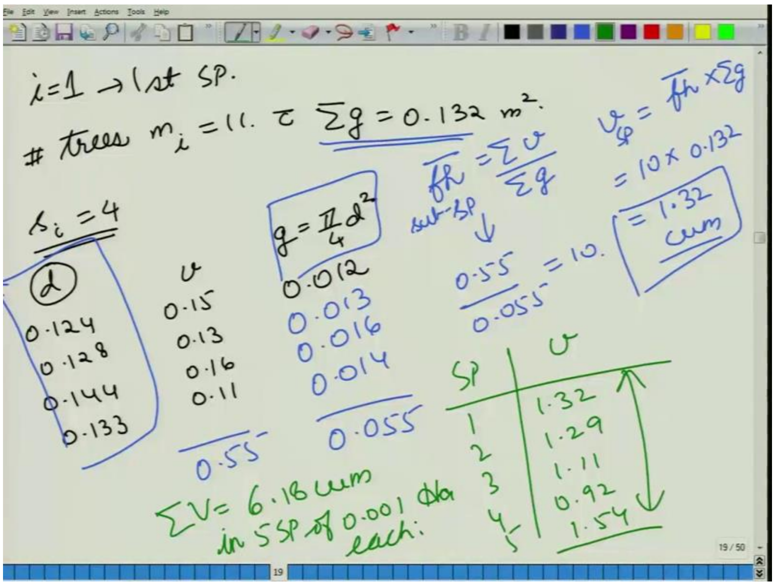

So, let us do it. So, for i is equal to one for the first sample plot, you have number of trees mi is 11 with the some total of the basal area as 0.132 square meter. Out of these you took 4 trees in your sub sample plot. For those 4 tress you have the diameter and the volume values given 0.124 0.128 144 133 and the volume is 0.15 0.13 0.16.11.

That is something that has been given to you. So, this is for each individual tree in the sub sample plot. So, given the d value you can find out the basal area of each tree. So, the basal area is given by pi by 4 d square. So, for 0.124 what will that be. So, we have pi that is 3.14 by 4 into d square 0.124 into 0.124. And you get it to be 0.012. So, here you have 0.012. And when we are computing this we are only looking at this column the column for the diameter. And we are getting the g values. For the second one you have 3.14 by 4 into 0.128 into 0.128, which is 0.013. For the third one we have 3.14 by 4 into 0.144 into 0.144. That is 0.016 and for the 4th one that is 0.133, we have 3.14 by 4 into 0.133 into 0.133, that is 0.014 by arounding it off. So, it will have 0.014. So, that is the girth that is the basal area for all of these 4 trees. Now the form height or the mean form height in this case is given by the sums of the volumes divided by The sums of the basal areas.

So, how much is the sum of the volume and how much is the sum of the basal area. So, if we did it for the volume we have 0.15 plus 0.13 plus 0.16 plus 0.11 that is 0.55 and for the sum of the basal area we have 0.012 plus 0.013 plus 0.016 plus 0.014 that is 0.055. So, the form height for the first sub sample plot will be 0.55 divided by 0.055 which is equal to 10. Now what is the volume for the first sample plot? So, this one is for the sub sample plot and this one is for the sample plot. So, the volume is given by the average form height multiplied by the sum of the basal areas.

So, it is this value. So, this is 10 into 0.132 which is equal to 1.32 cubic meters. So, for the first sample plot we got the volume as 1.32 cubic meters. Now we can repeat this step for all the other sample plots as well. So, for the sample plots 1 2 3 4 and 5 we have got the volume values as 1.32 and for the other ones if we repeat the same thing these are the values that we will get. So, what is the sum total of the volume in all the 5 sample plots combine? So, that will be the sum of these values which is 1.32 plus 1.29 plus 1.11 plus 0.92 plus 1.54 that is 6.18.

So, it is 6.18 cubic meter in 5 sample plots of 0.001 hectare each. Now if you want to find out the volume density of this stand.

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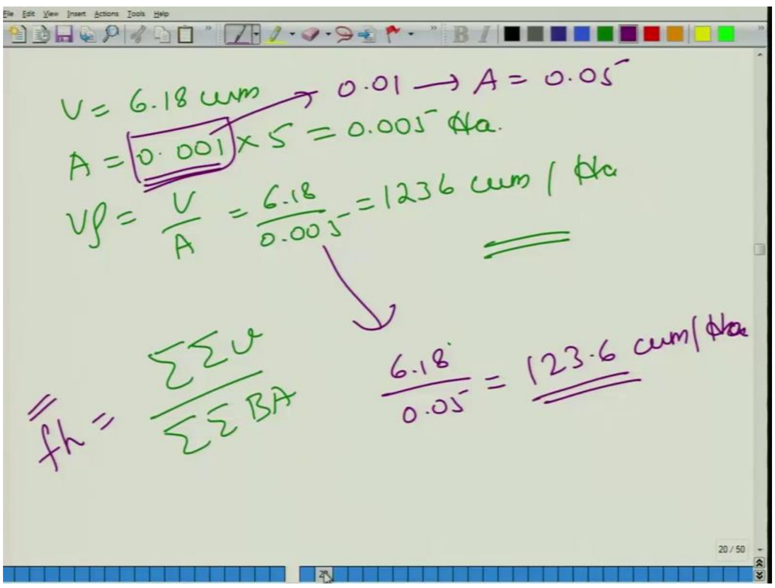

So, how do we find it out? So, the volume of 6.18 cubic meter is in an area of 0.001 into 5 is 0.005 hectares. So, the volume density will be volume by area is 6.18 divided by 0.005. So, we get it as, so we divide it by 0.005 1 2 3 6, we have 1 2 3 6 cubic meter per hectare. So, these are the value that we will get. Now we can also do the same thing for the mean pool form height.

So, in the case of the mean pool form height what we will be doing is we will be taking the sum of the sum of volumes divided by the sum of the sum of the basal areas. In this case we used the sum of the volumes divided by the sum of the basal areas. So, here we did it for one sample plot if we did the same thing for all these trees together then we will get the mean pool form height. And we can use that as well to get our total volume for this stand.

So, this is one way of computing the volume by using form heights. Let us now look at another Method which is known as the regression method of computing the volumes.

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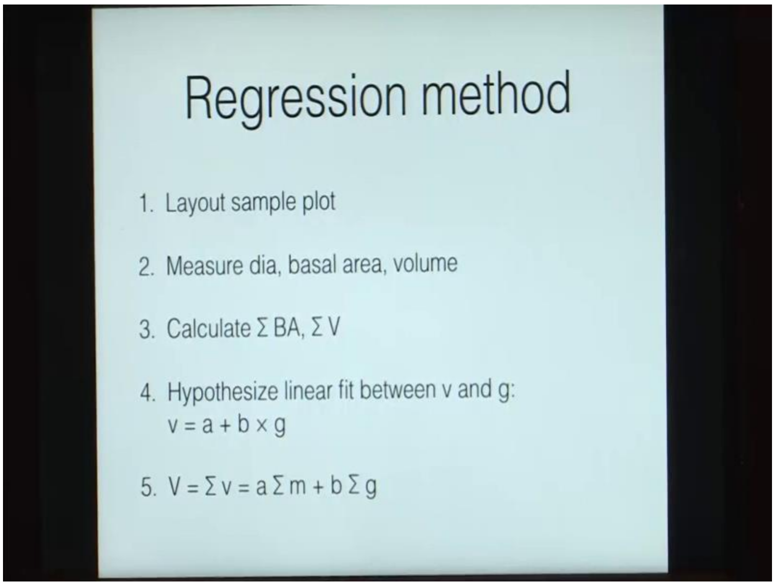

So, when we are using a regression method we do the same thing we layout a sample plot. We measure the diameter the basal area and the volume. We compute the sum of the basal area and the sum of the volume for each of the sample plots. After that we hypothesize a linear fit between volume and the basal area. So, here we make this linear equation volume is equal to a which is a constant plus b which is another constant multiplied by the basal area. So now, b will be approximately equal to the form height and a will be another constant here.

So, once we have this equation we can use it to compute the total volume of the stand by multiplying a with the total number of trees and multiplying b with the sum of the basal areas of all the trees, that are out there in the stand.

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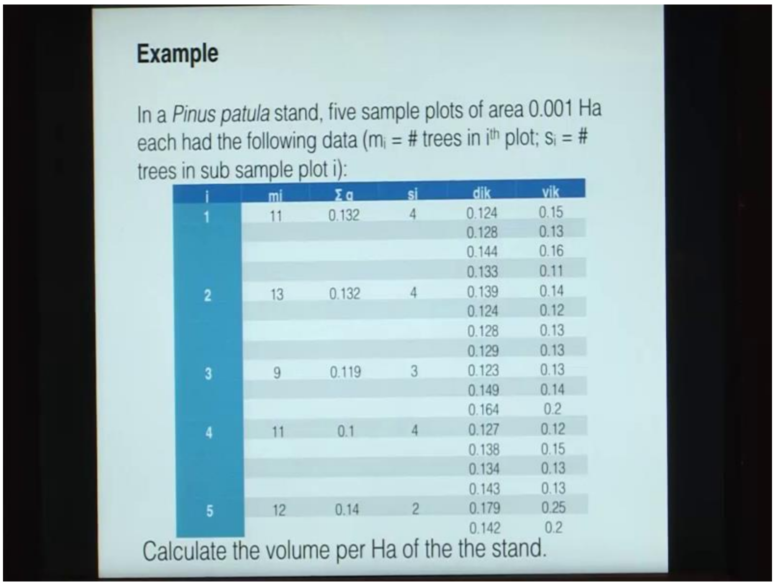

So, how do we do that? So, let us look at this example once again. So, here we have these trees in which the diameter and the volumes are given we had computed the basal areas of each of these trees by using the equation pi by 4 d square.

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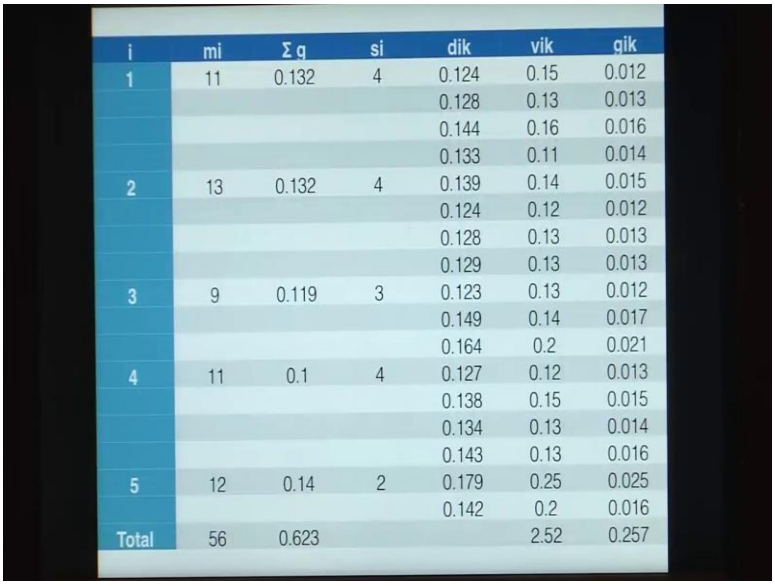

i	mi	Σ g	si	dik	vik	gik
1	11	0.132	4	0.124	0.15	0.012
				0.128	0.13	0.013
				0.144	0.16	0.016
				0.133	0.11	0.014
2	13	0.132	4	0.139	0.14	0.015
				0.124	0.12	0.012
				0.128	0.13	0.013
				0.129	0.13	0.013
3	9	0.119	3	0.123	0.13	0.012
				0.149	0.14	0.017
				0.164	0.2	0.021
4	11	0.1	4	0.127	0.12	0.013
				0.138	0.15	0.015
				0.134	0.13	0.014
				0.143	0.13	0.016
5	12	0.14	2	0.179	0.25	0.025
				0.142	0.2	0.016
Total	56	0.623			2.52	0.257

So, if we wrote another if we expanded this table. So, we are already given the diameter values and the volume values. And we can compute this gik. So, gik is in the same way as we computed earlier. So, if we go to the tablet once again. So, these are values that we had computed for the first sample plot 0.012.

So, 12 13 16 and 14. So, coming back to the slides these are the values that we have written here. So, 12 13 16 and 14 and similarly we have done it for all the other trees as well. So, for all of these diameters we have computed the basal area.

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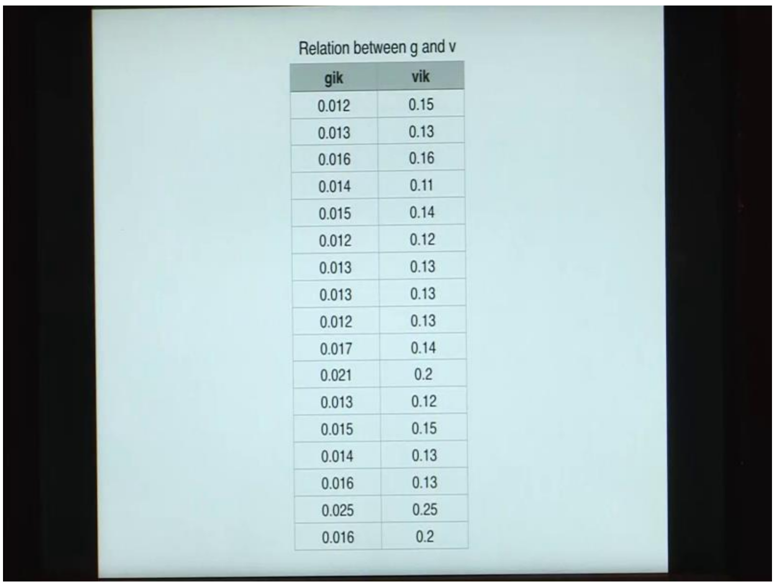

Relation between g and v

gik	vik
0.012	0.15
0.013	0.13
0.016	0.16
0.014	0.11
0.015	0.14
0.012	0.12
0.013	0.13
0.013	0.13
0.012	0.13
0.017	0.14
0.021	0.2
0.013	0.12
0.015	0.15
0.014	0.13
0.016	0.13
0.025	0.25
0.016	0.2

So now we are given the volumes of these trees and we are given the basal areas of these trees. So, how do we now compute the regression equation? So, we need to find out a regression equation between both of these variables the gik and the vik. So, this is how we are going to do it. So, here we have these values of gik and vik. And we need to find out a regression equation. So, if you remember your class on the graphical ways of presenting data there we had talked about the scatter plots. So, let us now make a scattered plot between gik and vik. So, this is the scattered plot.

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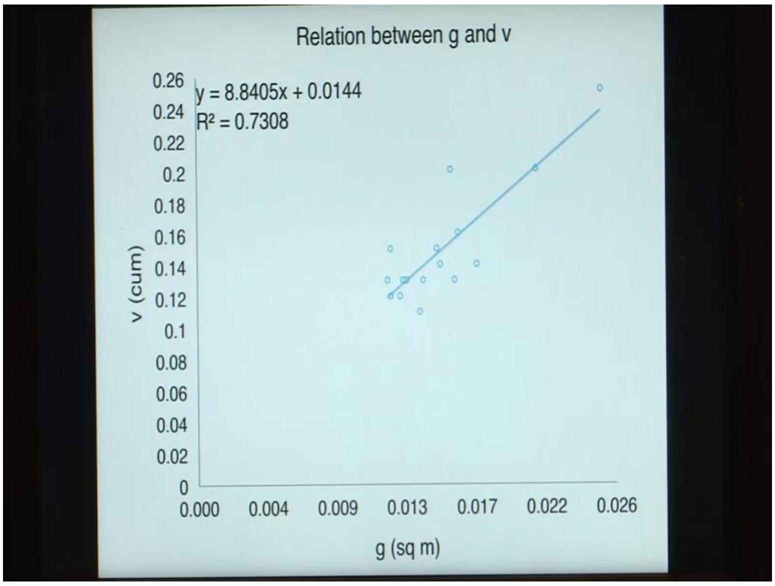

Here, so let us change the access. So, on the y axis and we do not need any grade lines. So now, here we have the volume and here we have the basal area. And all these locations are telling us the values. So, for instance if we looked at this value. So, this is 0.025 and 0.025. So, we are talking about this value and here we have it on the plot, similarly if we have If we look at this point or let us look at this point 0.016 and 0.2. So, here we have the value 0.016 and 0.2.

Let us now look at this 0.021 and 0.2 here we have right the twelfth value is 0.21 and 0.2. So, essentially we have taken these values we have plotted it as the basal area. So, let us try to 10 the term of g, and here the volume is written as v. So, we are we are plotting all the g values versus the v values. And these are the values that this is the plot that we get. So now, let us remove these values, and now let us put a trend line here. So, let us put a linear trend line and ask it to give us an equation.

So, this is the equation that we are getting. So, the y value is the volume value. So, we are saying that the volume is equal to 8.8405 times the basal area. So, volume divided by the basal area would be the form height. So, essentially the form height that we are getting here is 8.84. Now if we went back to the tablet. So, if we look at the tablet we had computed this form height and it was 10. Now coming back to the slides here we are getting a form height of 8.84. And this is the place where this straight line is going to cut the axis. The r square value tells us the spread of these points along this trend line.

So, essentially this is 0.73. So, it tells us that there is some degree of spread. So, for instance this point is very much far away from the linear fit that we have computed. So, we can use this formula.

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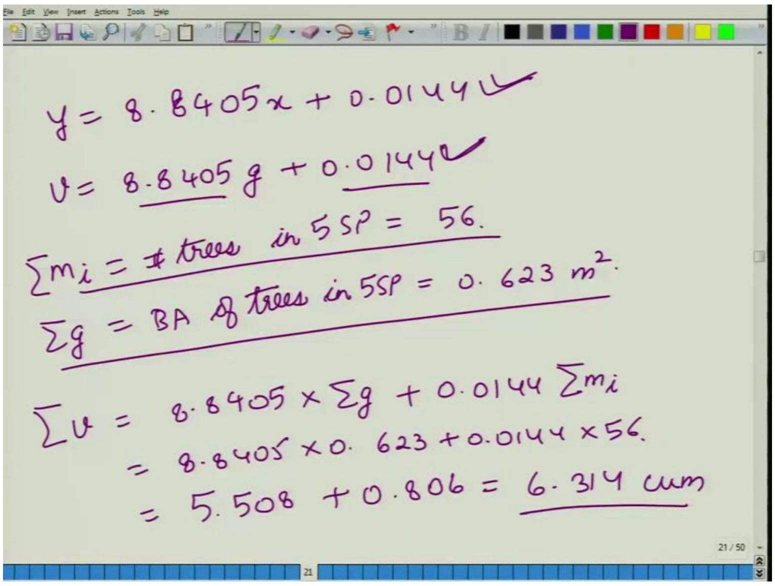

So now coming back to the tablet, we had received a formula of y is equal to 8.8405 x plus 0.0144. Now here the y value was the volume value. So, volume is 8.8405 multiplied by the basal area plus 0.0144 is the regression equation that we will get in this case. So now, coming back to the slides. So, we took these values of g and v then we plotted them together to get this curve and to get this regression equation.

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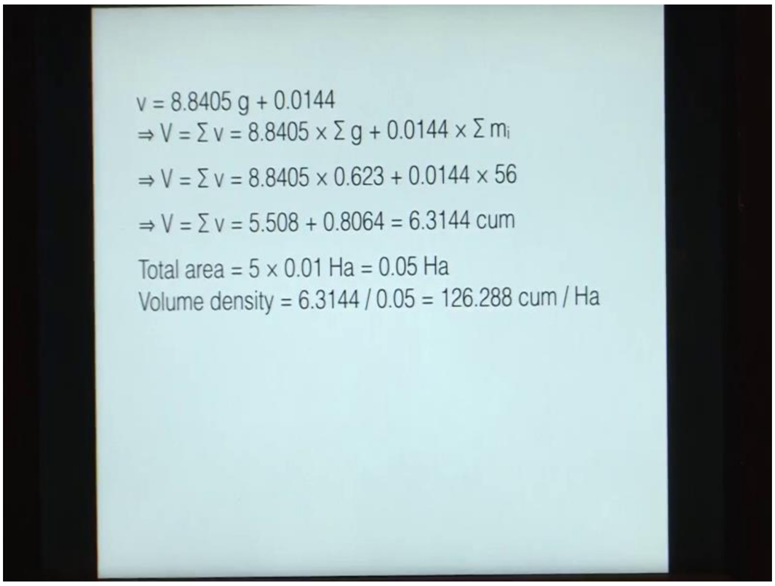

So, this is our regression equation y is equal to a 0.8405 g plus 0.0144. Now if we look back at the question. So, in the question here we were given the number of trees. So, in the first sample plot we have 11 trees in the second sample plot we have 13 trees and so on. So, we can find out the total number of trees by adding up all these trees. Similarly we are given that for these 11 trees the total basal area is 0.132, for these 13 trees it is again 0.132 for these 9 tree it is 0.119.

So, if we compute it the total basal area for all of these trees we will get it by the sum of these values. So, essentially what we are getting, is now coming back to the tablet. So, we are given all the mi values. So, the sum of the mi values is the total number of trees in 5 sample plots which is 56 and the total basal area of So, this is the total area total basal area of trees in 5 sample plots we got it as 0.623 square meters.

So now, if we use this equation to find out the total volume; so we are using this equation. So, we are given v. So, we want to calculate sum of all the v's. So, that will be given by 8.8405 multiplied the sum of g. So, sum of g is this value plus 0.0144 multiplied by the sum of the mi values. So, this is the sum of the mi values. So, how do we get? What do we get? Here we have 8.8405 into 0.62 3 plus 0.0144 multiplied by 56. So, how much is that? So, here we have 8.8405 multiplied by 0.623 which is 5.507 or surrounding it of 5.508. So, we have 5.508 plus 0.0144 into 56. So, that is 0.806. So, this is 6.314 cubic meter. So, we have this total volume of 6.314 cubic meter in 5 sample plots. And we are given that the area of each sample plot is 0.01 hectares.

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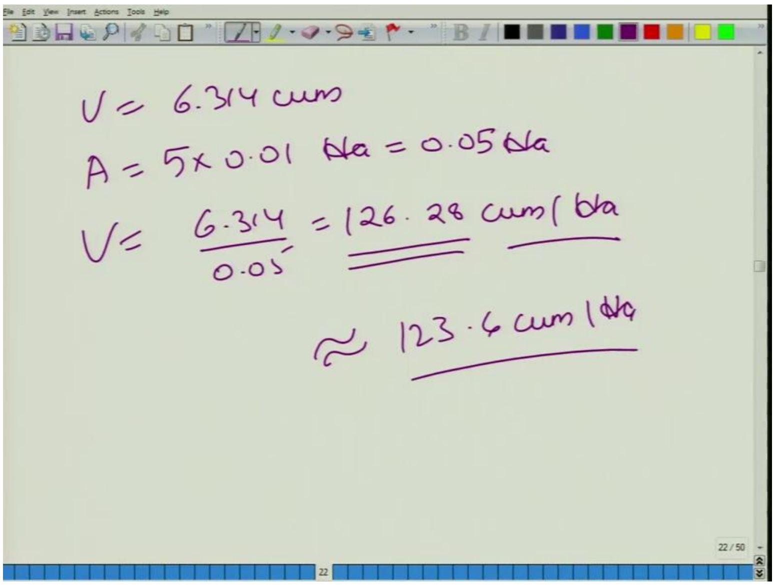

So, the volume is 6.314, 6.314 cubic meter in an area of 5 into 0.01 hectares which is 0.05 hectares.

So, what is the volume density that we will get here? It will be 6.314 divided by 0.05 which is equal to 126.2 8 cubic meter per hectare. Now remember that in the previous question we had computed the same thing. So, here we had the area of a sample plot is 0.001. So, if we use the value of this question 0.01 then we will have area is equal to 0.05. And we will have this volume figure is 6.818 by 0.05 that will be 123.61 23.6. So, in the in the current problem we have changed the areas of each of the sample plots. So, here we have 1 23.6 cubic meter per hectare, when we are finding it out by using the form height.

When we are using the regression equation we are getting 123 point 126.28 cubic meter per hectare. We saw which is very close to the value we got before of 1 23.6. So, remember that all of these equations will give you slightly different values, because all of these are based on different concepts. So, in the case of a regression equation that is the most perfect fed that you can get from all of these data, but now looking back at the curves, here we can see that all of these points are not exactly following on the trend line.

So, some of these points are very far apart some are at some distance and some lie on the linear fit line. So, which is given to us by this r square values. So, that is the spread of these values; so now, because all of these values do not exactly lie on the trend line. So, that is why the values that we will get.

So, coming to the tablet now. So, the value that we will get in the first case and the value that we will get in the second case will be slightly different. However, both of these are close together. So, we can use either of these methods to compute the volume density of the stand. So, that is all for today.

Thank you for your attention. [FL].