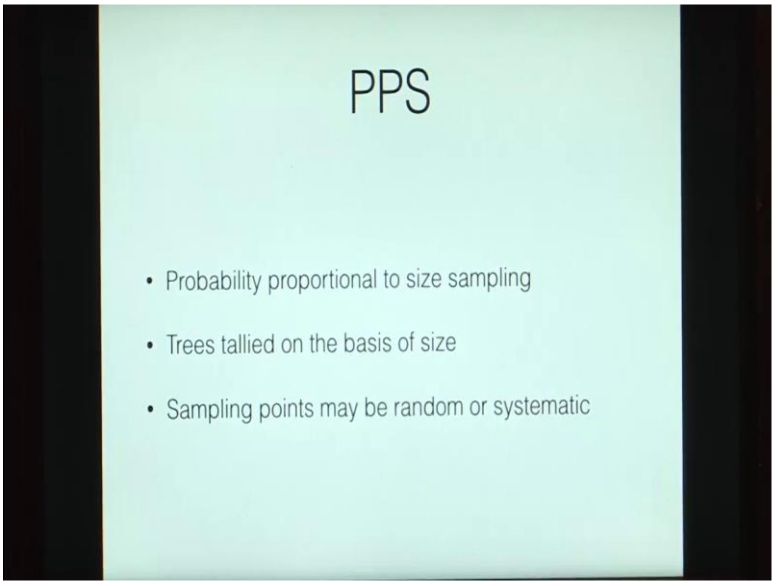
Forest Biometry
Prof. Mainak Das
Dr. Ankur Awadhiya
Department of Biological Sciences & Bioengineering & Design Programme
Indian Institute of Technology, Kanpur

Lecture – 28
Point Sampling: 1

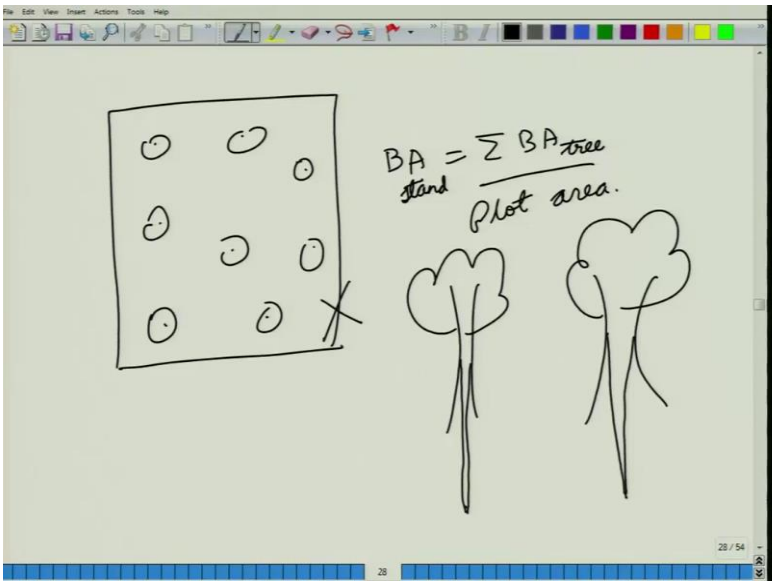
[FL]. Today we shall look at another way of calculating the basal area, which goes by the name of point sampling. So, we shall look into point sampling in this lecture. So, let us begin.

(Refer Slide Time: 00:29)



So, looking at the slides here we have PPS. So, point sampling is a way of sampling that goes by the name of probability proportional to size sampling. So, essentially the probability of a tree getting into your sample will depend on the size of the sample. So, trees are tallied on the basis of the size. So, what does that mean?

(Refer Slide Time: 00:57)

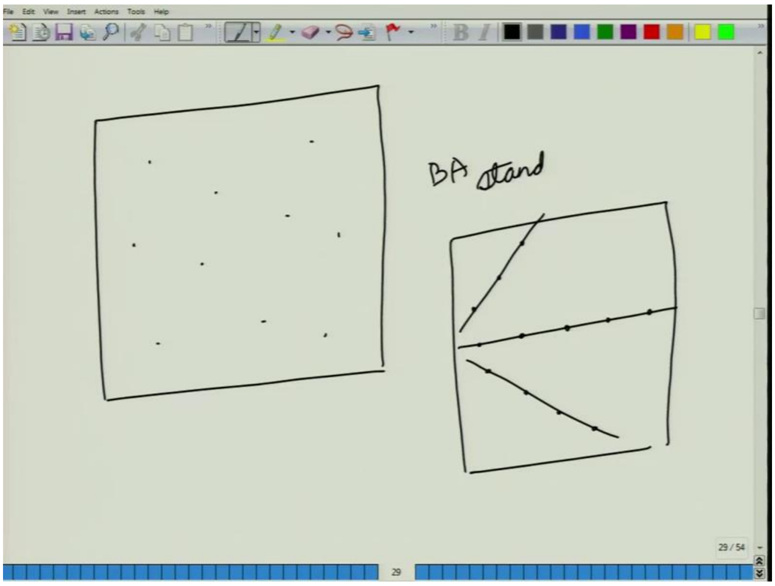


So, basically when we are talking about any sampling method, we generally do something like this. We define a sample plot then we go for all the various trees that are there in the sample plot whatever their diameters be, then we calculate the basal area as the sum of the basal areas of all the trees divided by the plot area. So, this is how we define the basal area of the stand. Now, point sampling is another way of sampling in which we do not have to define a sample plot. We just go into the field and then we look at all these trees. Now, our sample plot will be automatically generated by these trees, and it is called a probability proportional to size because the probability that your tree will be a part of your sample plot will depend on its size.

So, essentially a very small tree might not be a part of your sample whereas, a larger sized tree will become a part of your sample. So, the probability of a tree getting into your sample is dependent on its size it is also dependent on its distance. So, it is dependent on the angle that is subtended. So, essentially if you are standing here, then this is the angle that is subtended by this tree; whereas, when you are standing here, this is the angle that is subtended by this tree. So, if the angle that is subtended by a tree is greater than a critical angle, then it becomes part of our sample.

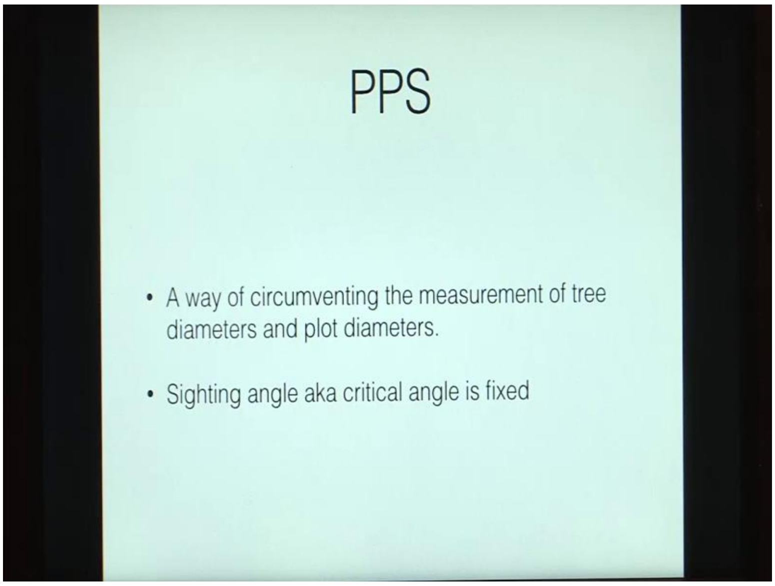
So, now coming back to the slide; here we have in probability proportional to size or point sampling trees are tallied on the basis of their size. And the sampling points maybe randomly distributed in your plot or it they may be systematically generated. What do we mean by that?

(Refer Slide Time: 02:50)



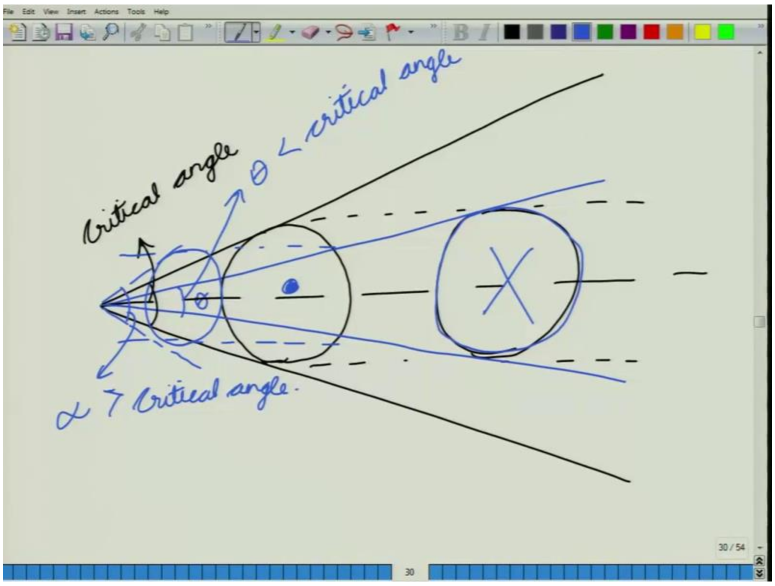
So, suppose this is our field in which we want to find out, we want to calculate the basal area of the stand through point sampling. So, how do we get as to how many samples plots have to be taken and there should they be distributed. So, we can either take our sample plots randomly distributed anywhere or we could take a systematic sampling in which we could say generate three transacts on all these transacts we would say that we would have a sample plot say at every 200 meters, so that might be a systematic sampling. So, in the case of point sampling, you could go for a random sampling point or for a systematic sampling point.

(Refer Slide Time: 03:36)



Now, coming back to the slides, the probability proportional to size or the point sampling is a way of circumventing the measurement of tree diameters and plot diameters. So, in this measurement, we do not calculate the size of the sample plot, and we do not calculate the; we do not measure the sizes of all the trees. And here we have a fixed sighting angle also known as the critical angle. And any tree that subtends an angle that is greater than this sighting angle or the critical angle will be counted.

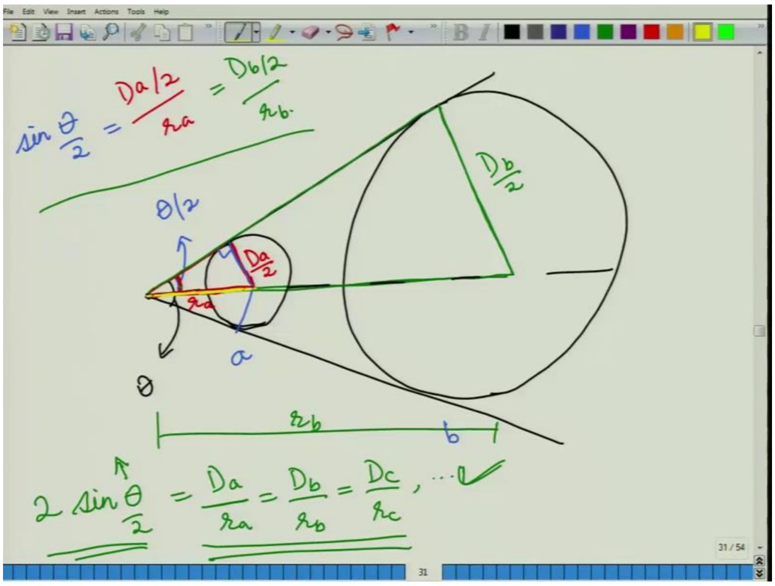
(Refer Slide Time: 04:19)



So, let us now look at the theory of point sampling. So, in the theory of point sampling, we can have a number of trees; so essentially, if we fix our angle, so considering this as the base, suppose we decide that this is our critical angle, so this is your critical angle. Now, let us look at some trees if we consider a tree here, here this tree is subtending an angle that is equal to the critical angle, but consider a similar sized tree at some other distance. So, consider this tree, now the angle that is subtended by this tree at this point will be this. So, it is a tree of the same diameter at a greater distance and now this angle is suppose we call it theta. So, here we have theta is less than critical angle.

So, in this case we are not going to consider this tree. Whereas, let us consider a tree of a smaller diameter, but which is closer by. So, let us consider say this tree. So, the diameter of this tree is less than the diameter of our original tree. So, what is the angle subtended by this tree now, this angle let us call it alpha. So, alpha is greater than the critical angle. So, this tree is counted. Any tree that subtends an angle, which is greater than the critical angle will be counted.

(Refer Slide Time: 06:11)



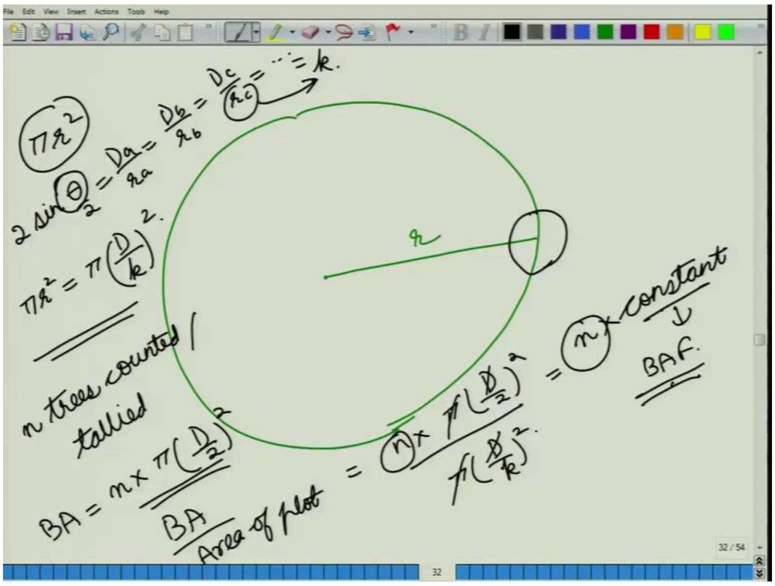
Next, for all the trees that are subtending the same angle how does the situation look like. So, this is our reference line and we have taken this to be our critical angle. Let us consider this tree. So, this is a tree of a smaller diameter and this is a tree of a larger diameter, but at a larger distance. So, both these trees are subtending the same angle. So, let us call this angle to be theta, which is our critical angle. Now, in this situation this angle is equal to theta by 2. And in this circle, we have let us call it circle a and circle b. So, now, this angle of theta by two if we have this radius of r a and considering this to be a small angle. So, we have sin of theta by 2 is equal to r a that is this.

So, we are considering this triangle now. So, this triangle is at a distance of or may be let us represent it a diameter this is D a by 2. And it is this circle of this tree is at a distance of r a from r point at which we are seeing it. So, sin of theta by 2, so this angle the sin of this angle will be equal to the height divided by the hypotenuse. So, this is equal to D a by 2 divided by r a, where r is the distance of this tree from the point of observation. Now, if we considered, so this was for the first circle or circle a.

So, now we let us look at the other circle. Let us now consider this big size circle. So, here your radius is D b by 2, and this distance to the second circle is equal to r b. So, here again this angle subtended is the same. So, sin theta by 2 will be given by the height divided by the hypotenuse which is D b by 2 divided by r b and similarly for any number of circles. So, we have the relations sin theta by 2, now multiplying all these with 2. So, we have twice of sin theta by 2 is equal to D a by r a is equal to D b by r b is equal to D c by r c and so on. So, any tree that is subtending the same angle that is equal to the critical angle will have this equation. So, its diameter divided by the distance from the point of observation will be a constant given by twice of sin theta by 2.

So, now we can vary this theta or we can say fix this theta depending on our applications. So, we can fix. So, whenever we are doing this point sampling we will fix theta and by fixing this theta, these ratios will be fixed automatically.

(Refer Slide Time: 10:13)

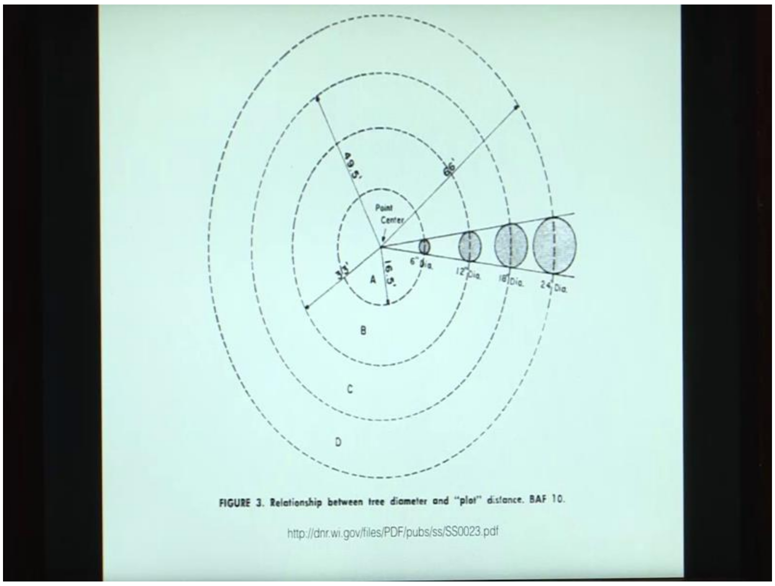


So, now let us consider a plot of radius r. So, here we have a plot of radius r, where r is your distance from your point of observation to any tree. Now, if we fix an r then we will have some trees that subtend an angle which is equal to the critical angle or is greater than the critical angle and only those trees will be counted. So, in that case the number density, so in this area of pi r square, let us use another color. So, if we consider this area of pi r square we have the ratio of twice sin theta by 2 is D a by r a is equal to D b by r b is equal to D c by r c is equal to so on. Now, in the area of pi r square, let us call this ratio to be k.

So, if we consider the area of the sample plot to be pi r square, it will be given by pi times, so here if you move r above we will get D by k its square. So, in this sample plot area, so we are considering the farthest most tree. And in this sample plot of area of pi D by k whole square if suppose n trees are tallied. So, we have n trees that are counted or here we call it tallied. So, if n trees are tallied, then your total basal area the basal area of the n trees is given by n times of pi D by 2 whole square or pi by 4 D square. Now, the total basal area per hectare that is a basal area of the stand is the basal area, but upon the area of the plot is given by the total basal area is n times pi D by 2 square whole divided by pi D by k its square. So, in this case we have n here pi and pi get cancelled, D and D get cancelled. So, it is given as n into some constant. Now, that constant is what we defined as the basal area factor

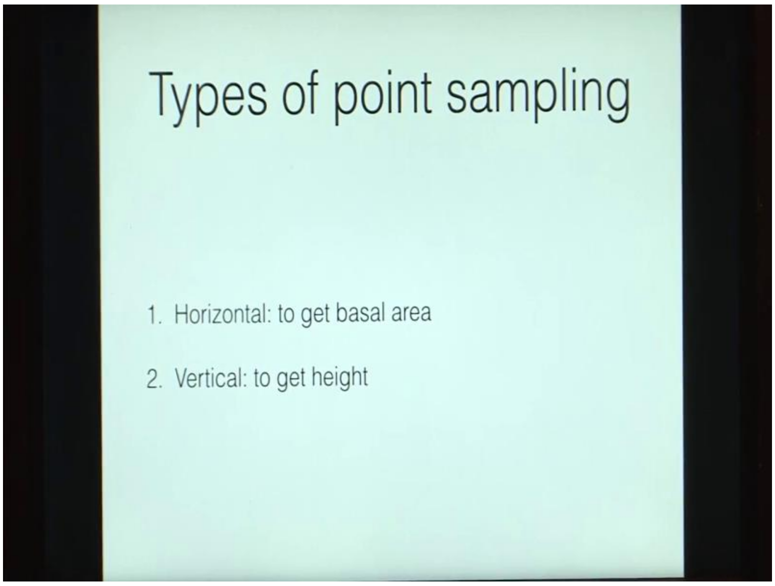
So, what do we get here, if we have fixed this basal area factor, and basal area factor is fixed by this critical angle. So, once we have derived a basal area factor, if we multiply it with the number of trees that are tallied, we will get the total basal area of the stand per hectare.

(Refer Slide Time: 12:48)



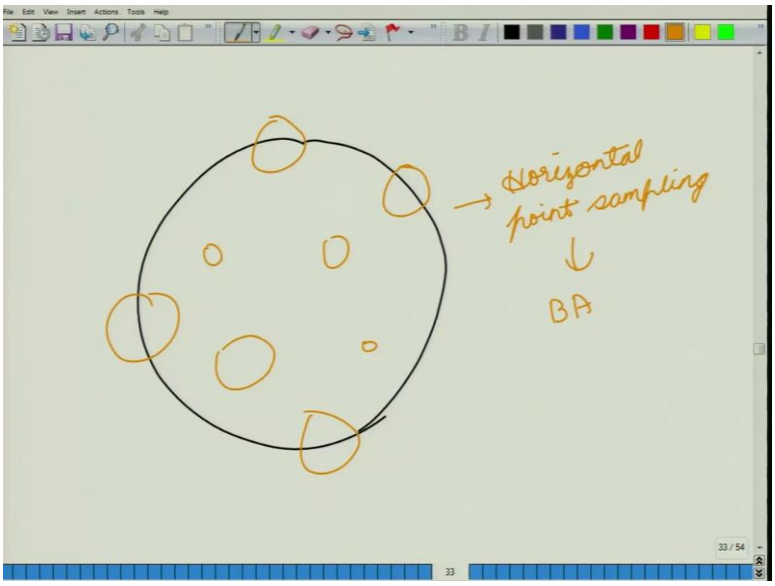
So, now looking at slides in this figure we are seeing the relationship between tree diameter and the plot distances for a fixed basal area factor. So, here also if we have fixed our basal area factor, we have fixed our critical angle and all these trees will be counted.

(Refer Slide Time: 13:09)



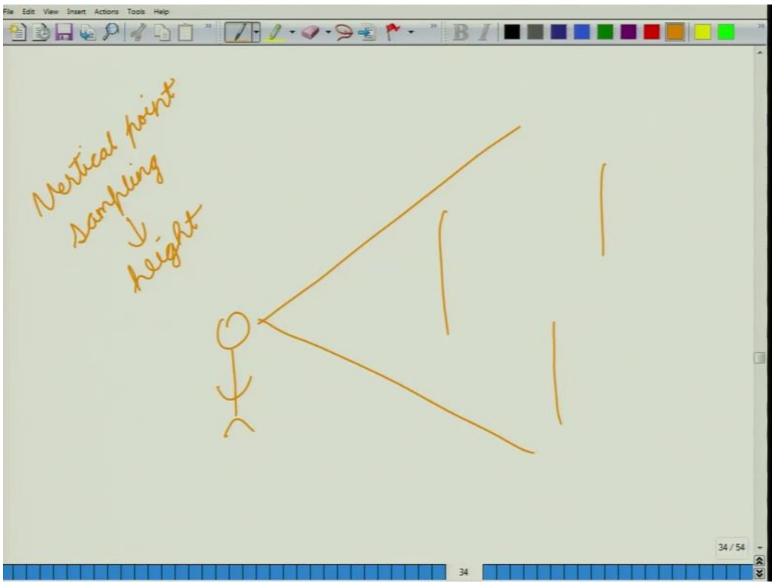
Now, there are two types of point sampling we have a horizontal point sampling in which we take our measurements at a horizontal plane.

(Refer Slide Time: 13:23)



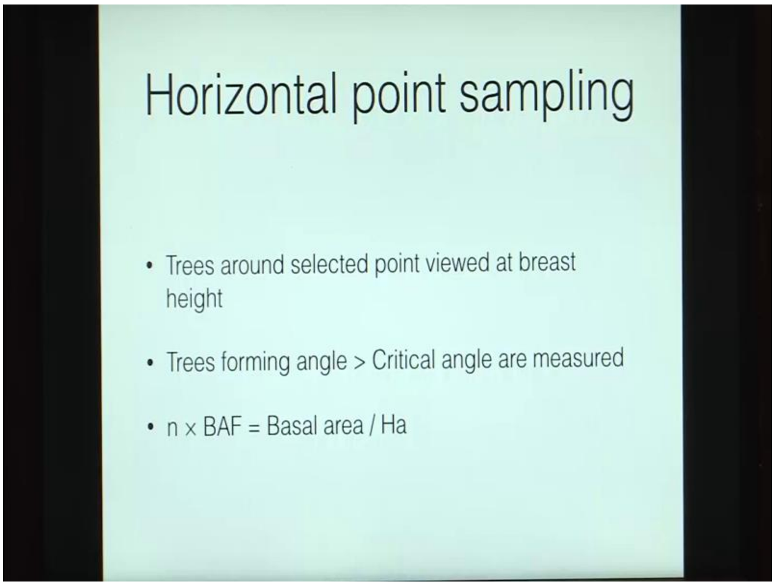
So, for instance if we fix our horizontal plane, so in that case we will be saying the cross sections of various trees of different sizes. So, when we do a horizontal point sampling, we will be getting, so when we do a horizontal point sampling we get the basal area of the stand.

(Refer Slide Time: 13:56)



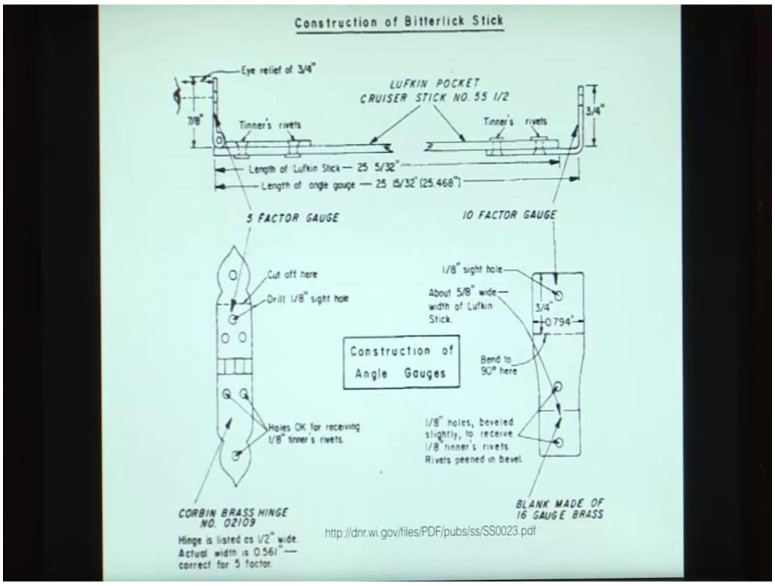
On the other hand if we do a vertical point sampling, so in a vertical point sampling will be standing somewhere in the forest and then looking at things vertically. So, here you will find trees of different heights. So, the vertical point sampling gives us the heights of the forest.

(Refer Slide Time: 14:26)



So, let us now look at horizontal point sampling, so looking at the slides now. So, in the case of horizontal point sampling we look at trees around the selected point viewed at the breast height. So, why breast height because we have taken that to be our reference height. So, when we stand in the forest, and look at different trees at the breast height, all the trees that are forming an angle that is greater than the critical angle will be measured or will be counted. And here as we have derived before the number of trees that are tallied multiplied by the basal area factor that will be determined by your critical angle and by the instrument that you are using. So, n multiplied by the basal area factor will give you the basal area of the stand per hectare. So, this is the theory of point sampling.

(Refer Slide Time: 15:17)



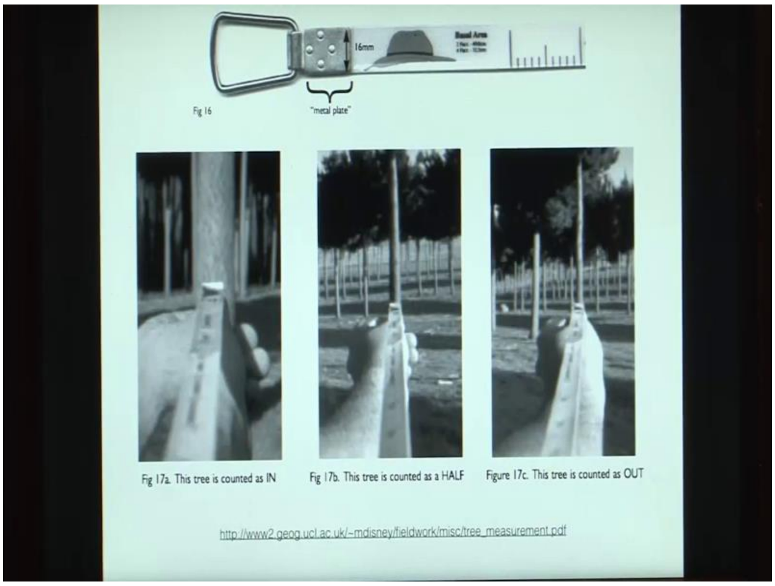
So, what are the instruments that we use to do this? So, there are a number of instruments that can be used you can use a bitterlick stick. So, Bitterlicks is the name of the scientist or the forester who first device this point sampling. So, in the case of the bitterlick stick you have a rod. So, the rod is of a fixed size and you have two ends for this. So, if you take your one end is the end from which you look at your trees; and at the other end, you have an object of a fixed size.

So, for instance if you have an object of a fixed size and you are looking from here, so anything that is subtending an angle that is greater than this angle defined by this point, and these two points will be counted; and anything that subtends a smaller angle will not be counted.

(Refer Slide Time: 16:21)

Another such device is known as a Panama angle-gauge. So, it is also very similar. So, here we can see that you have an observer who is looking through a tube, and at the end of the this tube you have an object made out of a slit. So, anything that is greater than this slit will be counted and anything that is smaller than the width of the slit will not be counted. So, these are ways of fixing your critical angle.

(Refer Slide Time: 16:51)



If you do not have any instrument then you can even use a tape to achieve the same thing. So, for instance, in this tape, we have a metal portion at the very end followed by this hook like portion. So, now, if you take this hook like portion downwards then this metal strip can be used to measure your trees. So, for instance you are keeping your eyes somewhere here and then this point is downwards. So, your holding it in your hands and you are looking at this top portion. So, this top portion is subtending an angle. And in this case this tree is subtending an angle that is greater than the critical angle because the width of this tree is greater than the width of the top.

In this case, it is equal to your critical angle because the width of this tree as seen from this distance and the width of your end of the tape is the same and here you have a tree that is subtending a smaller angle as compared to the tip of your tape. So, when you have a situation like this when the angle is greater than the critical angle you count it as one. When you have this situation, where the angle subtended is less than the critical angle, then you do not count it.

So, it is tally is zero. In this situation you take your tally as half. So, you count every other tree. So, suppose you calculated four trees then your tally will be 2.

(Refer Slide Time: 18:22)

Now, if you do not even have a tape, you can use a penny or any coin. So, if you keep it at a fixed distance so that distance could be your arms length and here is your penny. So, anything that is subtending an angle that is greater than this penny. So, for instance this tree is subtending an angle that is greater than this penny because its width as seen from this distance is greater than the width of the penny seen from this distance. So, this will be counted as one, and similarly you can have half counts or out counts.

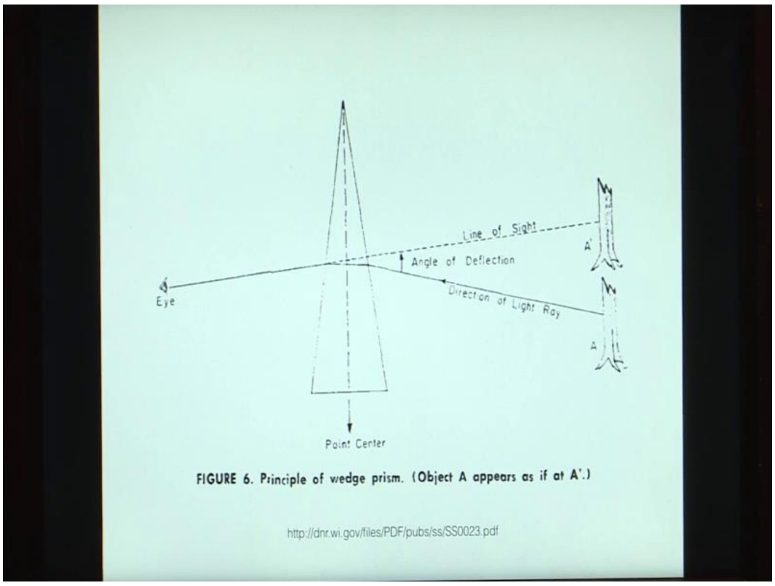
(Refer Slide Time: 18:54)

We also have some angle gauges that do the same thing. So, in the case of this angle gauge, we have three basal area factors defined by this width, this width and this width. So, here we are having three basal areas, three basal area factors, because these three are subtending three different critical angles.

(Refer Slide Time: 19:19)

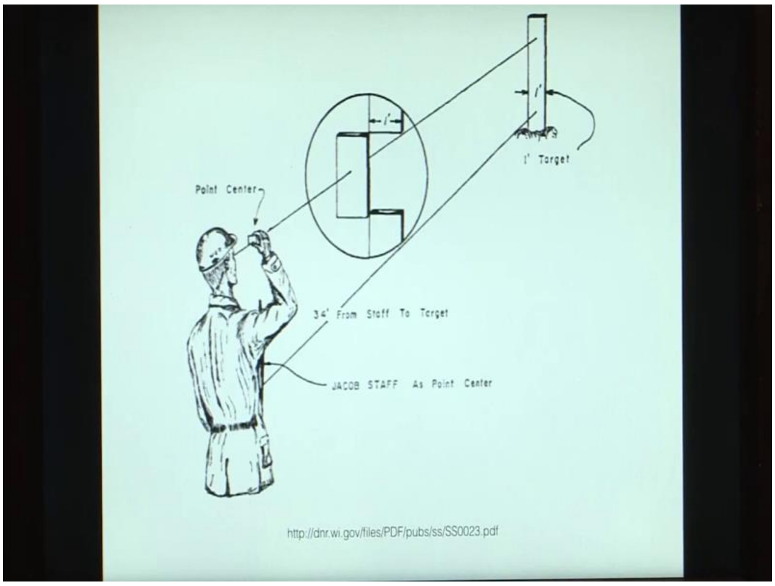
Now, how do we use these instruments? Again as this image shows you can have a full tally in which your angle subtended is greater than the critical angle you can have a half tally where the angle subtended is equal to the critical angle or you can have a zero tally in which the angle subtended is less than the critical angle.

(Refer Slide Time: 19:45)



Now, to simplify things even further, we can use a wedge prism. Now, a wedge prism is a very thin prism that leads to the deflection of an object when it is seen through the wedge prism.

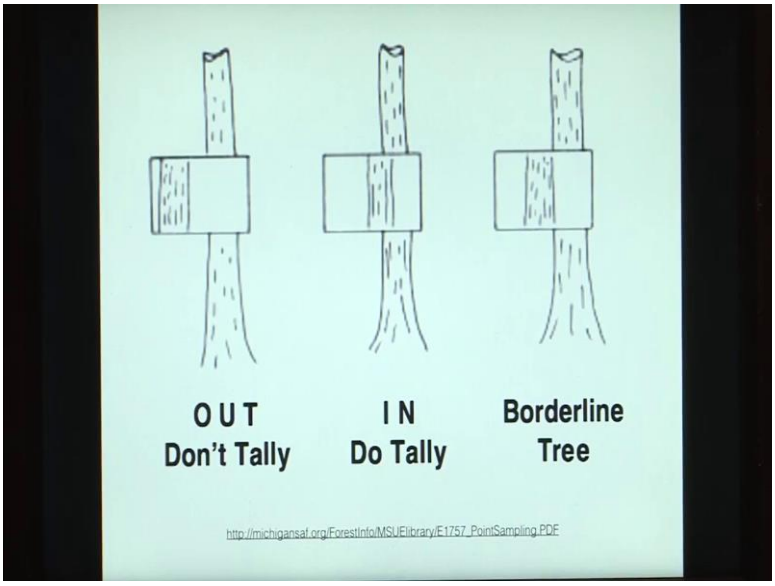
(Refer Slide Time: 19:56)



So, as this image shows, so when you look at a pole with a wedge prism so its central portion, so the portion that is being seen from the wedge prism will look at a displacement. So, now this displacement can be greater than the width of the pole it can be less than the width of the pole or it can be equal to the width of the pole; so again giving us three values for the tallies. So, if you look at this figure, so here in place of looking at the poles, we are looking at the trees in a forest.

So, you stand at one point and you look all around you with the wedge prism to see what are the trees that can be counted as a tally or a full tally a half tally or a no tally.

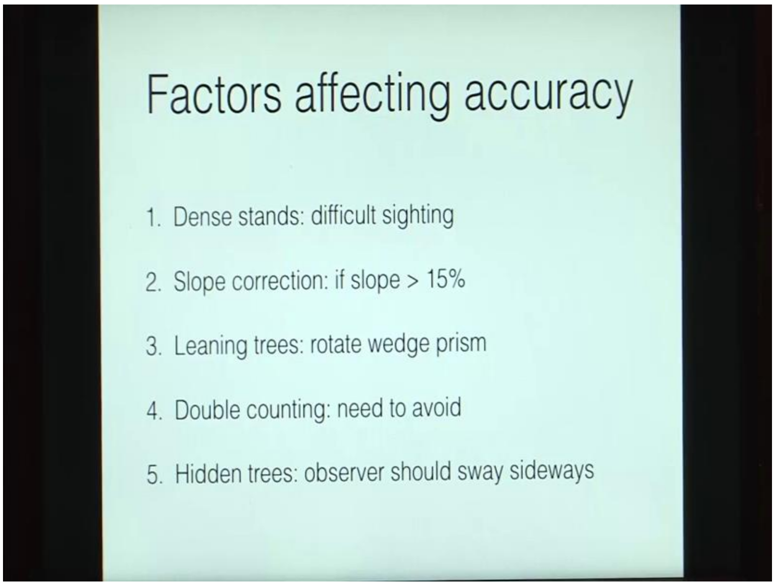
(Refer Slide Time: 20:48)



So, when you look through a through this prism here is what you will see. So, for instance in the case of this tree, so it has been displaced, but even when it is displaced then this displacement is less than the width of the tree which is why the edge this right most edge is coming within the tree itself. So, in this case, we counted as IN and this is the full tally if your displacement were greater than the width of the tree.

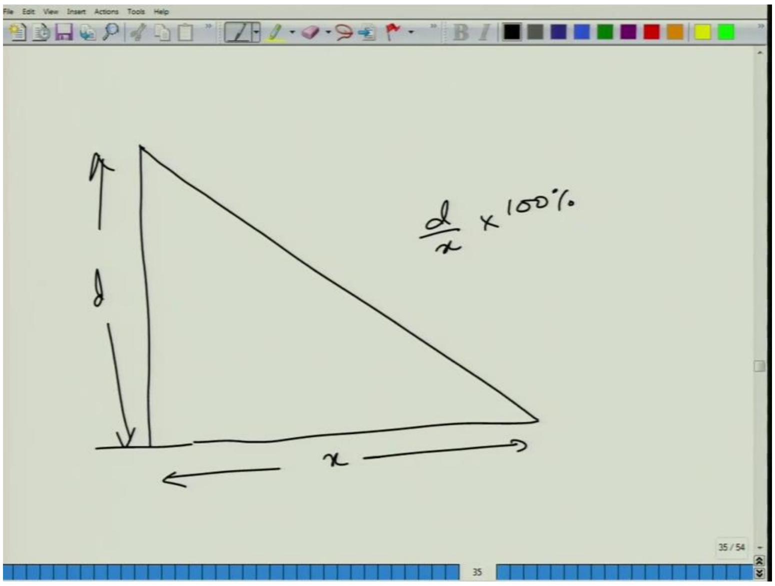
So, in that case your displaced portion will get outside of your tree in that case you will counted as an out tree in the case of an out tree you do not count. So, it is a do not tally situation. In this case where your displacement is equal to the width of your tree; so in this case the right edge is now corresponding to the left edge of the tree. So, this is a border line tree. So, in the case of a border line tree, you count it as a half. So, this is how we use a wedge prism.

(Refer Slide Time: 21:55)



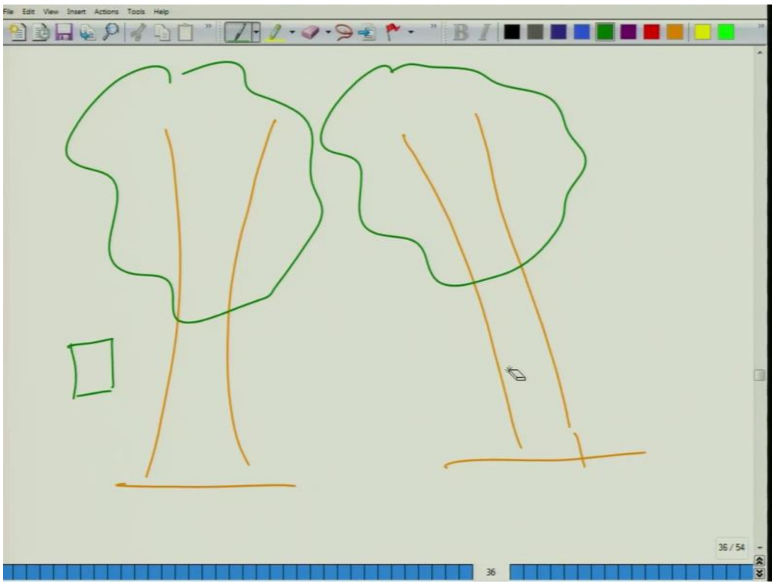
So, now what are the factors that can affect the accuracy of the point sampling? So, we will get into the examples in a while, but first of all let us look at the factors that affect the accuracy. So, in the case of dense stands it can be difficult to look at all the trees. So, in that case you might be missing out on a number of trees plus if the slope is greater than 15 percent.

(Refer Slide Time: 22:27)



So, when we say a 15 percent slope, what we mean is that suppose this is your slope. So, suppose this is your slope. What is a 15 percent slope, a 15 percent slope is if you define a horizontal then the vertical displacement let us call it d as a percentage of the horizontal movement. So, basically d by x into 100 percent is the slope in percent. So, now coming back to the slides, if the slope looking at the slide from. So, if the slope is greater than 15 percent then you might need a slope correction, then you have the case of leaning trees.

(Refer Slide Time: 23:10)

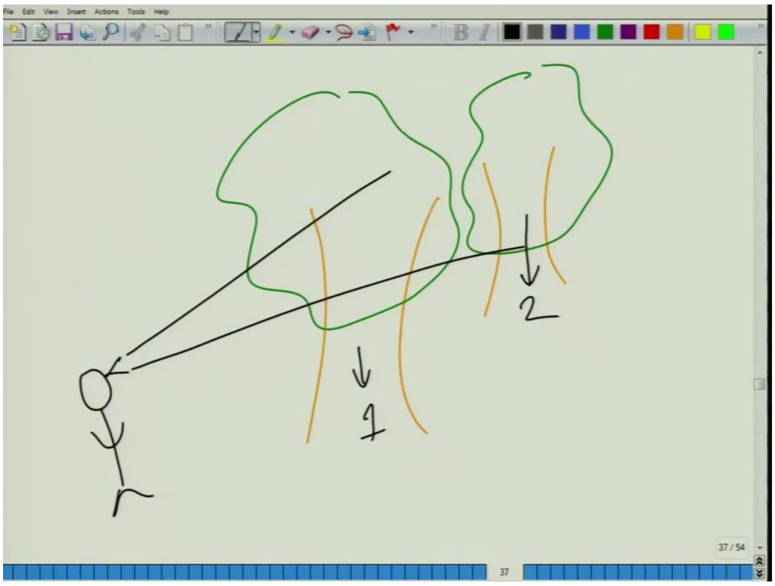


So, in the case of leaning trees what we have is in place of having a tree like this. So, in this situation you kept your prism like this, but if you have a leaning tree something like this then you need to rotate your wedge prism such that the axis of the prism and the axis of the tree should correspond to each other. Now, coming back to the slides then you need to avoid double counting. So, what do we mean by double counting? So, essentially if we have our device like this, so if you have kept it at this distance.

So, now, I am taking the width of this pen and this distance to be subtending a critical angle. So, now if I start from this point and if I go all around measuring all the trees and when I come back what about the first tree; in most cases we count the first tree twice. Once when we are starting and the second time when we have completed our rotation, so that double counting can lead to errors, so that needs to be avoided.

So, whenever you are going out for a point sampling you need to decide before and whether you will count the tree at the starting position or not. So, if you are counting your tree in the starting position then you should not count it when you come back or else if you are removing your tree in the starting position, then you should count it when you have arrived after a full rotation. So, double counting needs to be avoided.

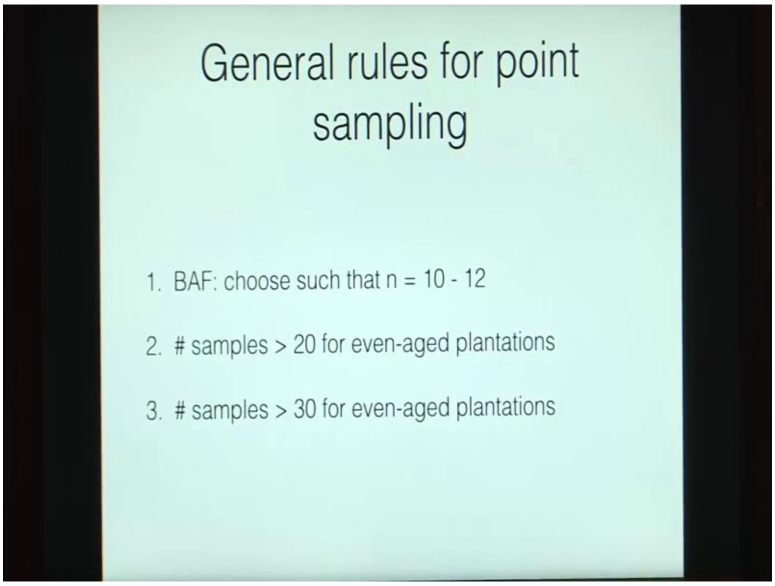
(Refer Slide Time: 24:53)



Also hidden trees can lead to errors. So, what are hidden trees. So, if we have a stand in which you have a tree here maybe you have a tree at a distance. So, this is the first tree this is the second tree and you are standing at this point and you are looking at the at the critical angle, so that are being subtended. So, now, because this tree has a large diameter, it might cause this second tree.

So, this is the first tree and this is the second tree. So, it might result into a situation in your second tree is completely obscured by the first tree. So, now coming back to the slide; in the case of hidden trees you need to sway sideways. So, what would that mean? So, suppose I am keeping my instrument like this and if I am not certain if there is another tree after this and I need to go towards a side to see if there is another tree or not.

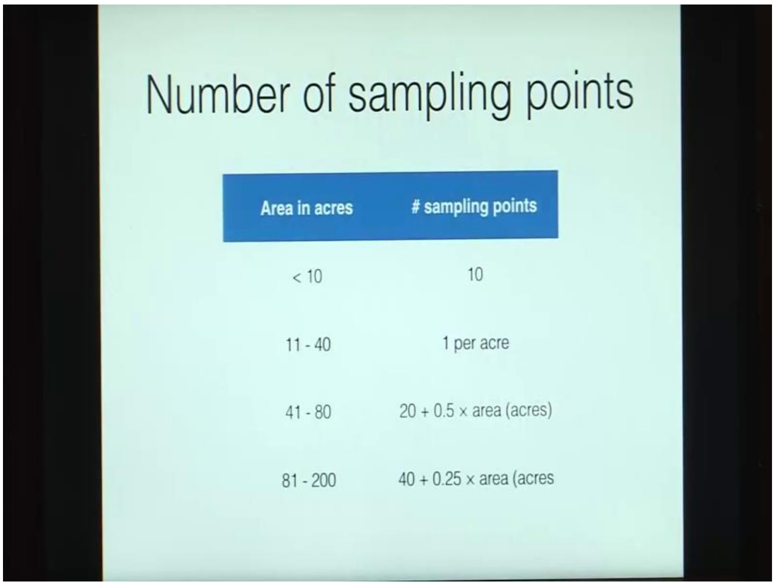
(Refer Slide Time: 25:56)



So, now let us look at some general rules for point sampling, here are these. So, remember that we can choose our basal area factor. So, essentially whether I am taking this diameter or maybe I am taking another diameter that is greater or maybe even another greater diameter such as this. So, this diameter is very much greater than this diameter. So, this the this diameter divided by this distance will be giving me a basal area factor and we choose our basal area factor in such a way that now coming back to the slides that number of trees that we tally should be between 10 to 12.

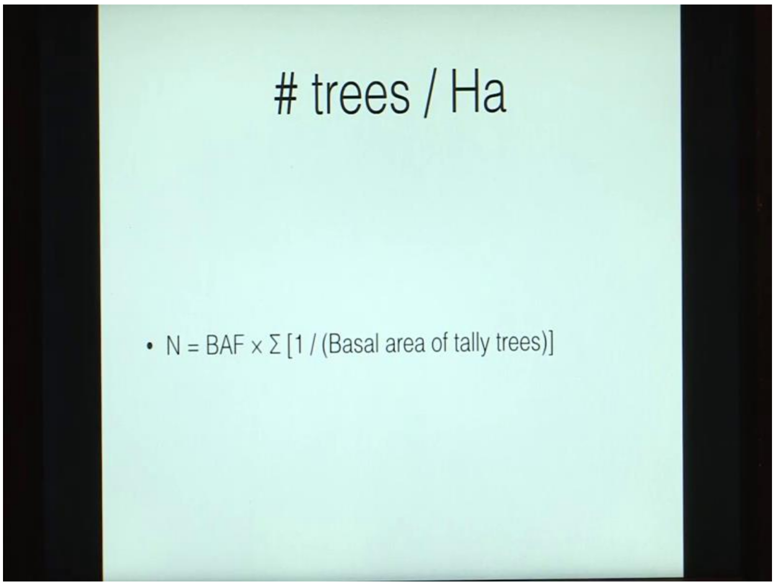
So, they should not be a very small value and they should not be a very large value 10 to 12 is the most manageable number. Number of samples that we require should be greater than 20 in the case of even aged plantations; and in the case of it should be greater than 30 for uneven aged plantations.

(Refer Slide Time: 26:58)



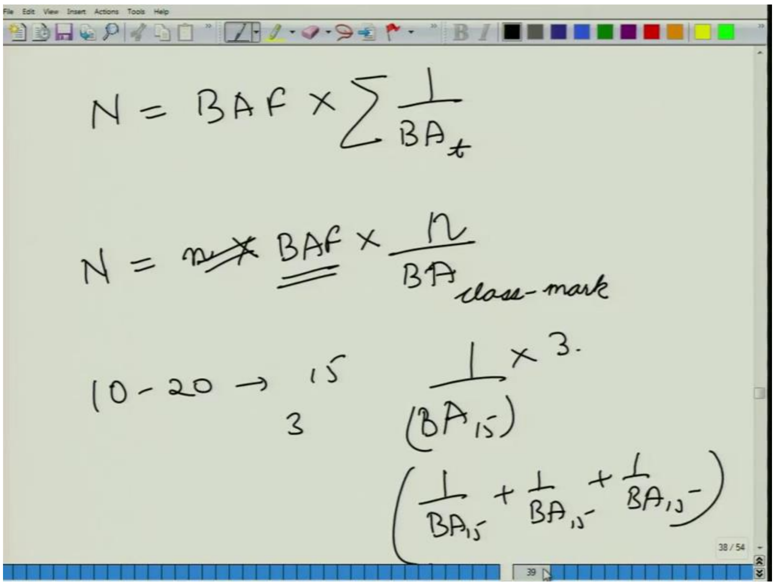
So, how many sampling points do we take if our plantation is less than 10 acres then we go for 10 sampling points; if it is eleven to 40 acres we take one sampling point per acre if we have 41 to 80 we have 20 plus 0.5 times the area in acres. And if we have 81 to 200; so if we have a very large sized forest then we take a minimum of 40 points plus 0.25 multiplied by the area in acres. So, this is the minimum number of sampling points that we must take.

(Refer Slide Time: 27:37)



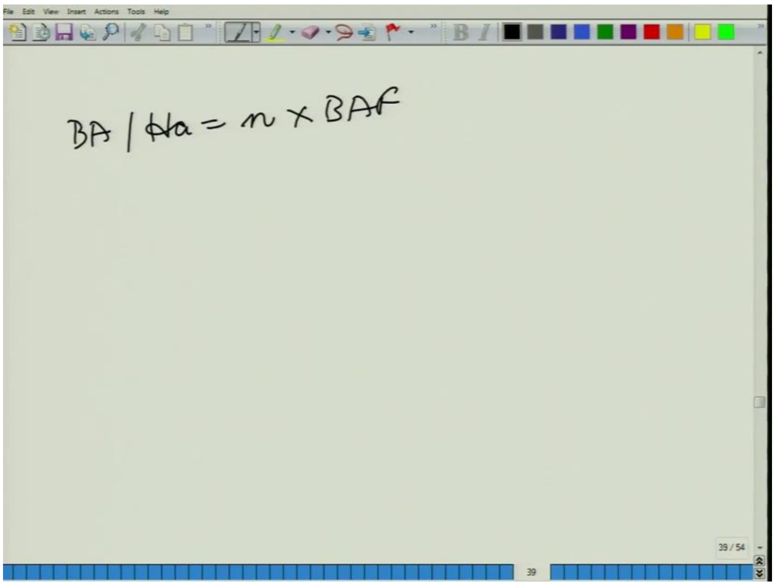
So, what are the calculations that we have from point sampling we can calculate the number of trees per hectare. So, number of trees per hectare is given by the basal area factor multiplied by the sum of the inverse of all the basal areas of the tally trees. So, we shall look in into it in greater detail when we look at some problems. So, essentially to remember for now, the number of trees N is given by the basal area factor multiplied by the sum of 1 over the basal area of the tally trees.

(Refer Slide Time: 28:06)



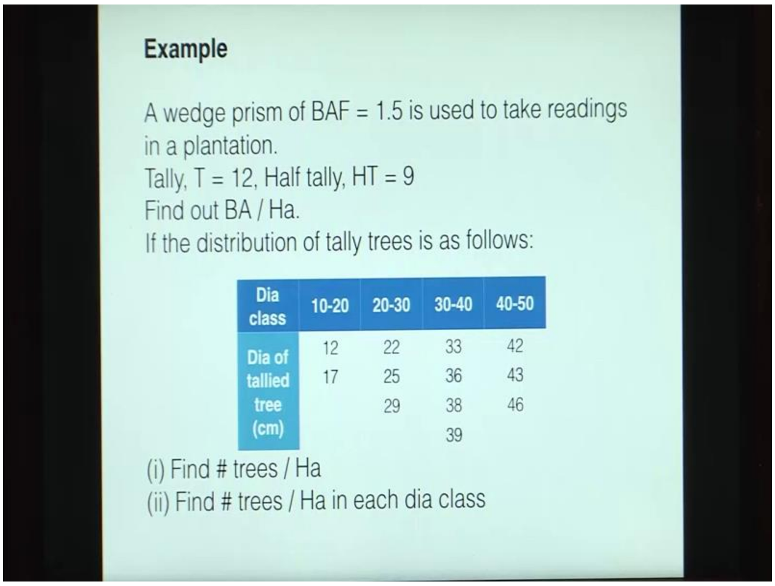
Similarly, the number of trees N a diameter class is given by n that is the number of tally trees multiplied by the basal area factor multiplied by 1 upon the basal area of the class mark. So, essentially if you have a class of say 10 to 20, the class mark is 15 and suppose we have three trees. So, we will have 1 upon the basal area for 15 multiplied by 3, which is essentially equal to 1 upon basal area 15 plus 1 upon basal area 15 plus 1 upon basal area 15. So, essentially when we take, so let us rearrange this equation. So, we multiply we put n here. So, it is basal area factor multiplied by n times 1 by BA and here we have the sum of 1 by BA. So, these are essentially one and the same to remember.

(Refer Slide Time: 29:25)



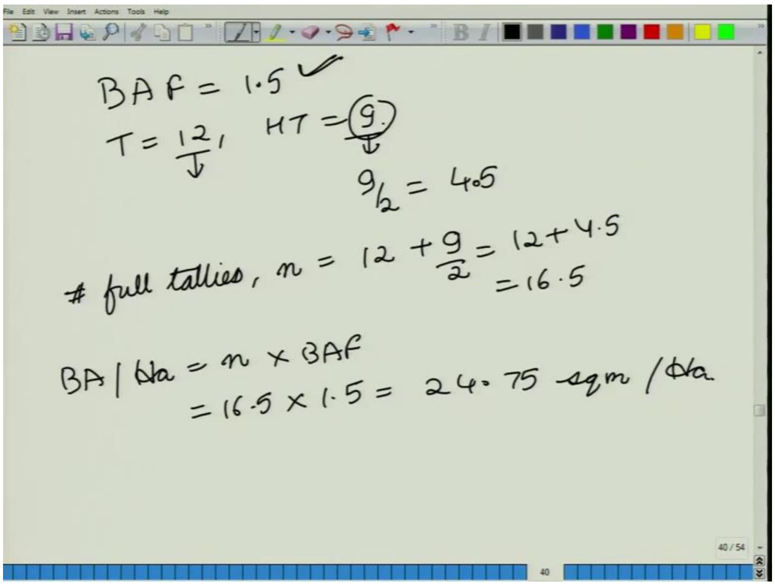
We can also calculate the basal area per hectare, which is given by the number of tally trees multiplied by the basal area factor. So, now to look at these equations in greater detail, let us solve a problem.

(Refer Slide Time: 29 :38)



So, here is the problem. There is a wedge prism of basal area factor is equal to 1.5. So, you have fixed your BAF that is 1.5 and it is used to take readings in a plantation. Now, the number of full tallies here is 12 and the number of half tallies is given to be 9. We need to calculate the basal area per hectare, so that that is the first part of the problem. So, let us solve that first.

(Refer Slide Time: 30:06)

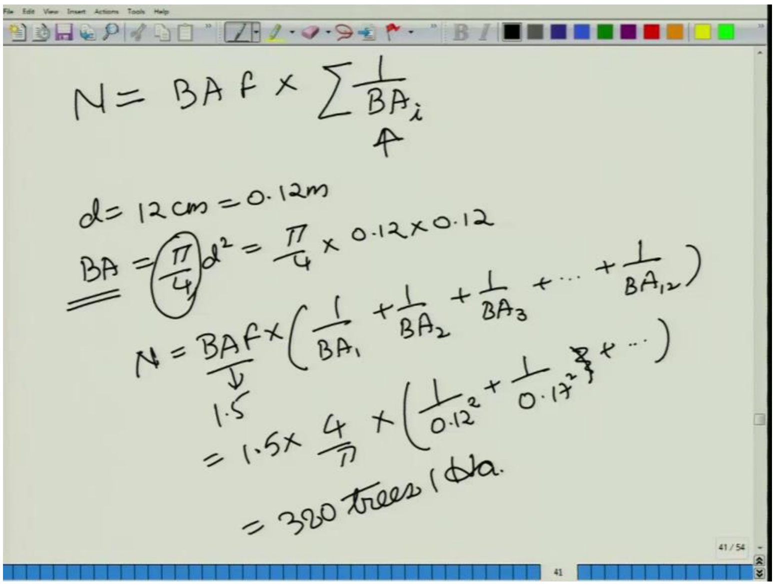


So, we are given that BAF is equal to 1.5 tally is equal to 12, and half tally is equal to 9. So, tally is the full tally, this is the half tally. So, 9 half tally will be equal to 9 by 2 full tallies or 4.5 full tallies. So, number of full tallies that we also call as n is equal to the total full tally that is 12 plus 9 by 2 is 12 plus 4.5 is 16.5, so that is n. Now, if you wanted to calculate the basal area per hectare that is given by n into basal area factor. So, it is 16.5 multiplied by basal area factors given to be 1.5 is equal to 24.75 square meters per hectare, so that is the basal area per hectare. So, this is how we calculate the basal area per hectare for a stand using point sampling.

Now, coming back to the problem, now if the distribution of tally tree is as follows, so we are given that we have a total of 12 trees. Now that 12 trees have these diameters. So, we have diameter of the tally tree. So, in this class of 10 to 20 centimeters we have one tree of 12, one tree of 17 these are the diameters of trees falling in 20 to 30 class, these are the diameters of trees falling in 30 to 40 and these are the diameters of trees falling in 40 to 50. What is the total number of trees 2 plus 3 that is 5, 5 plus 4 it is 9; 9 plus 3 is 12, which is equal to the tally number, so 12 trees.

So, now we need to calculate the number of trees per hectare and number of trees per hectare in each of the diameter class. So, how do we do that?

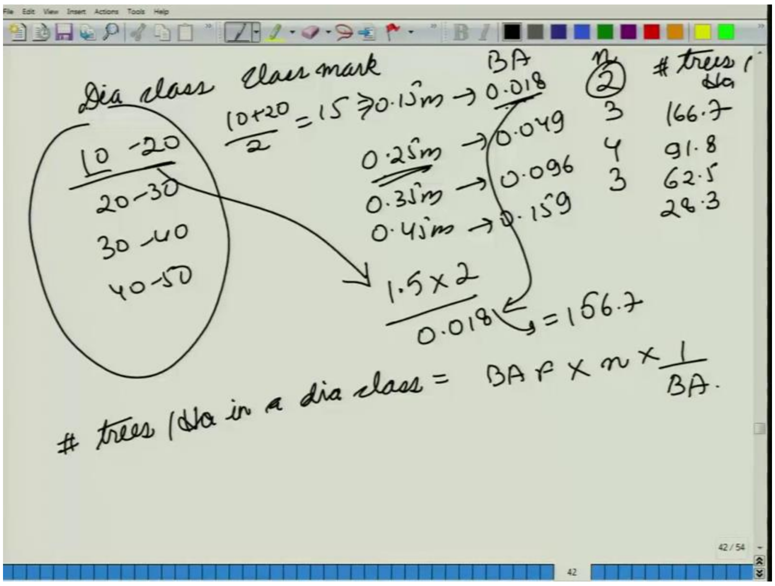
(Refer Slide Time: 32:17)



So, let us now look at the value of n. So, coming to the tablet n is given by. So, n is the total number of trees per hectare is given by basal area factor multiplied by sum of 1 over basal area of all the trees. So, in this case, we have our trees have these diameters as you can look on your screen. So, these are the diameters of the various trees we need to calculate the basal areas. So, the basal area for see in the case of a tree of d is equal to 12 centimeters is 0.12 meters your basal area will be pi by 4 d square is pi by 4 into 0.12 into 0.12. Now, that basal area you need to take an inverse of it and then put it here, and then you need to add up all the basal areas.

So, in this case, we will have N is equal to basal area factor times 1 by BA 1 plus 1 by basal area of the second tree plus 1 by BA 3 plus so on till the twelfth tree. So, if we do that if we calculated this value. So, here b a f is given as 1.5 now when we are doing this calculation we can take this pi by four outside, so that will make it 1.4 multiplied by 4 by pi into 1 by 0.12 square plus 1 by 0.17 square plus so on. So, when we calculate it, we will get 380 trees per hectare. So, this is how we use our point sampling to calculate the number of trees per hectare.

(Refer Slide Time: 34:25)

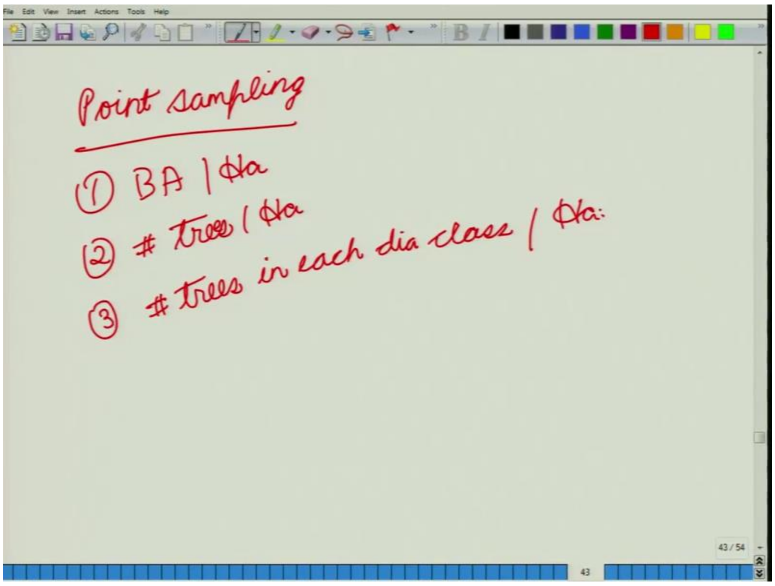


Now the next thing that we are asked, so coming back to the slide here we asked the number of trees per hectare in each diameter class. So, now here we are given the dia classes as given as 10 to 20, 20 to 30, 30 to 40, 40 to 50. So, we can find out the class mark now class mark as you remember is the lower limit plus upper limit by 2. So, it will be 10 plus 20 by 2 is 15 or will be 0.15 meters. Similarly this will be 0.25 meters,0.35 meters and 0.45 meters.

Now, consider a tree with this diameter. So, d is equal to 0.15 meter what will the basal area be basal area is given by pi by 4 d square is pi by 4 into 0.15 into 0.15 is 0.018 square meters. So, we can calculate. So, 0.15 will give us 0.018 square meters of basal area similarly this will give us 0.049 as we had calculated in a previous example this will give 0.096 and this will give 0.15 nine square meters. So, this is the basal area per tree. Now, we are also given the number of trees in each diameter class. So, if we go back to our slide here we are given that in 20 to 20 diameter class, we have two trees, here we have three trees, here we have four trees and here we have three trees that is 23 43.

So, now coming back to the tablet. So this will give us n of 2, 3, 4 and 3. So, now, number of trees per hectare. So, now, let us remove this. So, we know that number of trees per hectare in a dia class is given by BAF times the number of trees multiplied by one upon the basal area. So, for this diameter class we can find the BAF will be equal to 1.5 that is given multiplied by 2 divided by 0.018 that is the basal area that we get from here, so the number of trees per hectare in this case. So, this value comes to be 166.7. So, here we have 166.7. Similarly, for the other cases we have 91.8, 62.5, 28.3 number of trees that correspond to these diameter classes. So, this is how using point sampling we can calculate.

(Refer Slide Time: 37:25)



So, with point sampling, we have been able to calculate one the basal area per hectare of your stand, two - the number of trees per hectare in your stand, and three - the number of trees in each dia class in your stand per hectare. So, in today's class, we saw how point sampling can be used to calculate these three values. And we shall look into it in further detail in the next class.

Thank you for your attention, [FL].