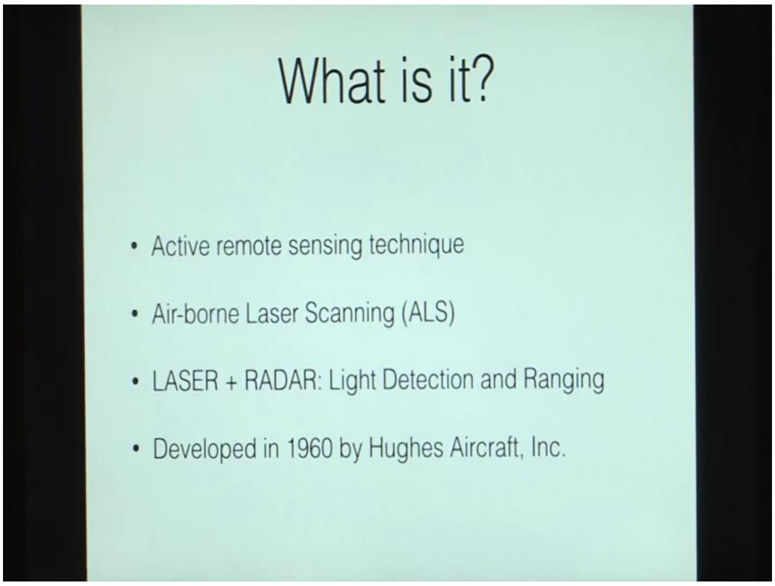
# Forest Biometry

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

## Lecture – 40
## Recap – 2

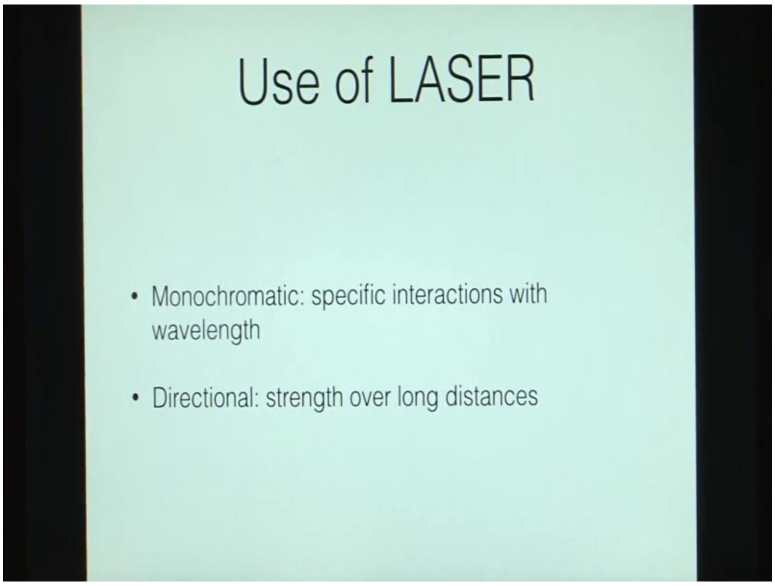
[FL], today will go through the second leg of revision session. So, we looked at Lider which stands for light detection and ranging. So, it is (Refer Time: 00:26).

(Refer Slide Time: 00:28)



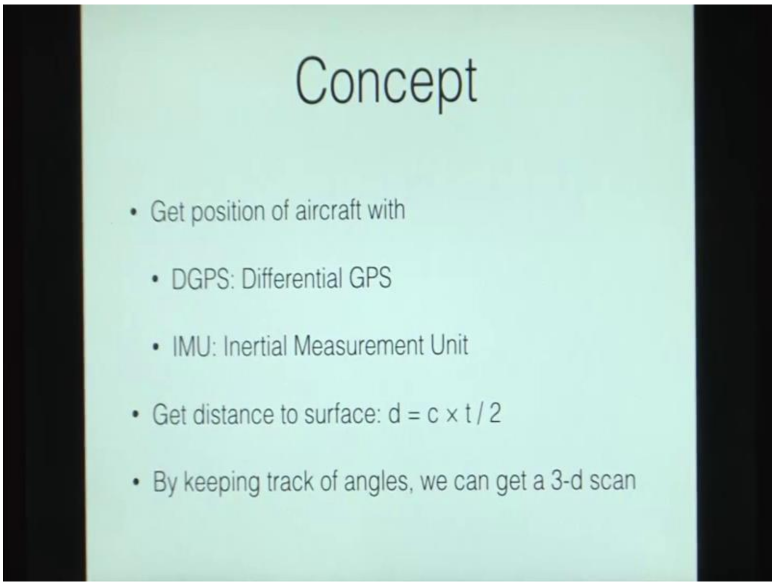

When we discussed it, we found out that it is an active remote sensing technique that is also known as air borne laser scanning or air less. So, it is combination of laser plus radar. So, it uses a laser light in the same way that radar uses radio signals.

(Refer Slide Time: 00:45)



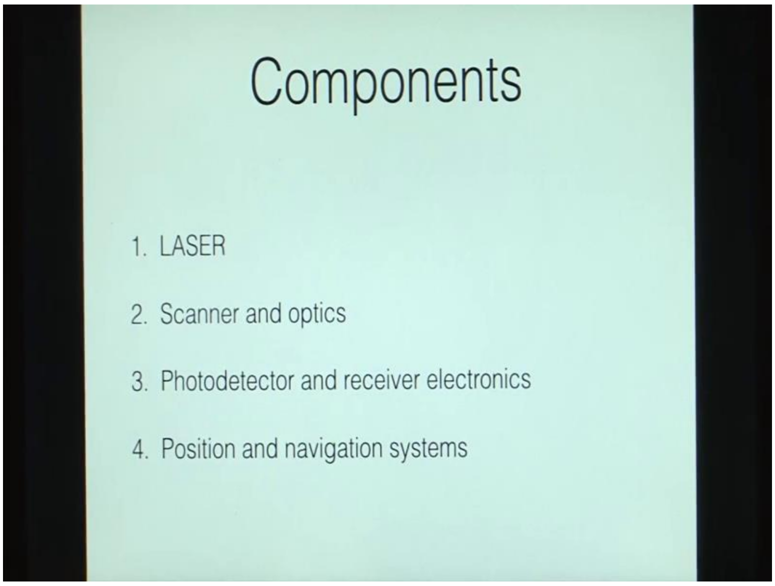

We use laser because it is monocratic and it is directional we looked at its concept.

(Refer Slide Time: 00:49)



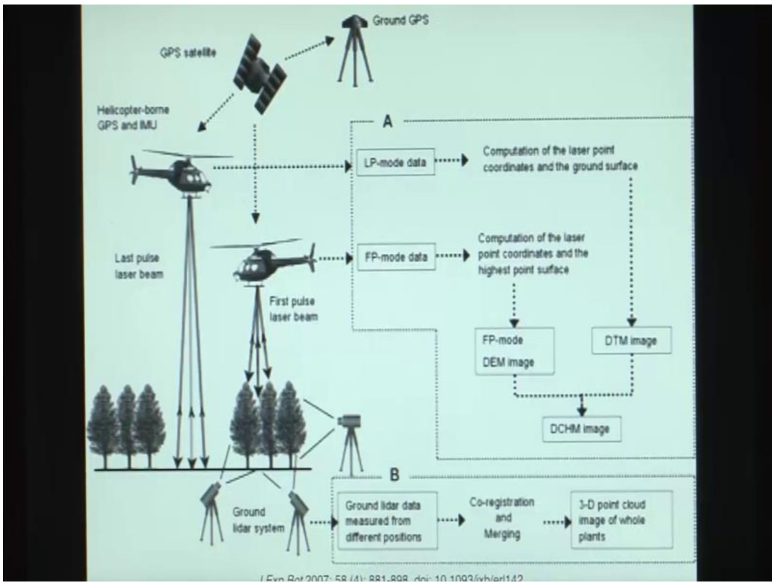

So, we need to know the exact position of the air craft using differential GPS and the inertial measurement units, and then we get distance to the surface as we did in the case of arrange finder. So, d is to equal to c into t by 2 and by keeping track of angles we can get a 3-d scan.

(Refer Slide Time: 01:09)



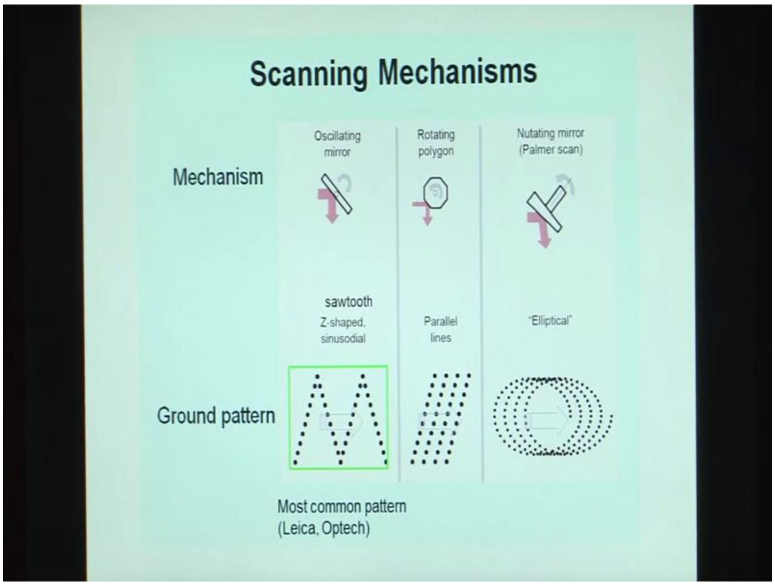

So, there are 4 components of a Lider we have laser scanner and optics photo detector and receiver electronics and the position and navigational systems.

(Refer Slide Time: 01:19)



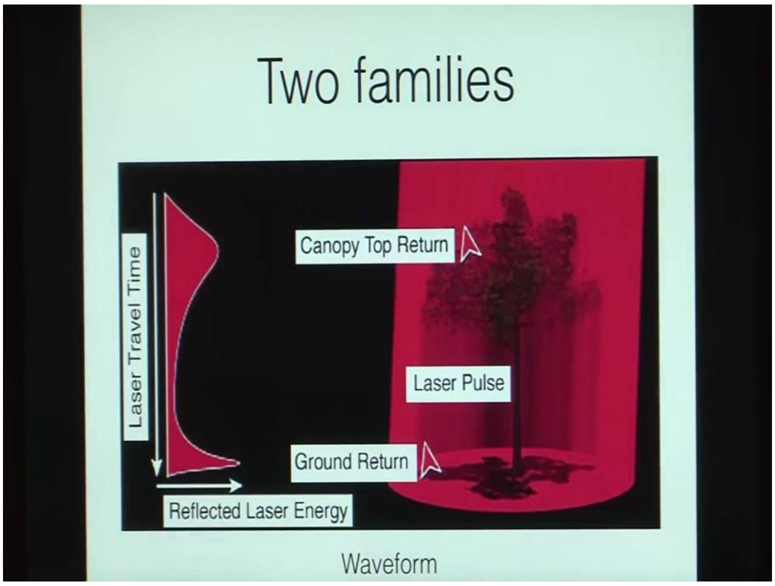

So, this can be used on a satellite or this can be used on a helicopter or this can be used on the ground.

(Refer Slide Time: 01:26)

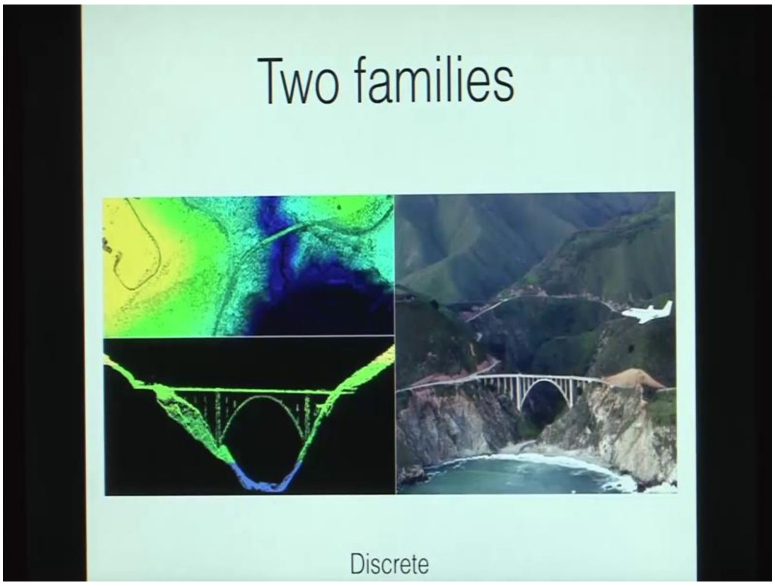



Then we looked at different scanning mechanisms. So, we can have an oscillating mirror rotating polygon or a nutating mirror which will give us different kinds of ground patters.

(Refer Slide Time: 01:37)

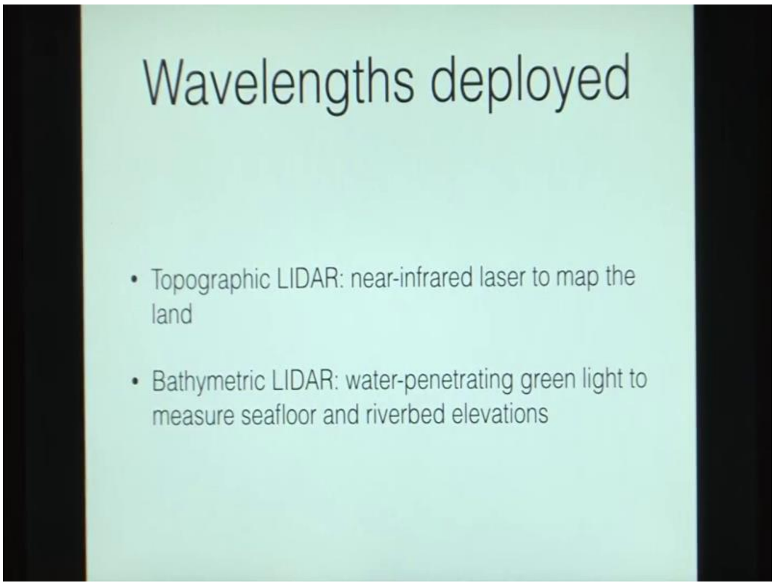


(Refer Slide Time: 01:42)




There are two families of Lidar. So, they go by the name of way form Lider and discrete Lidar.

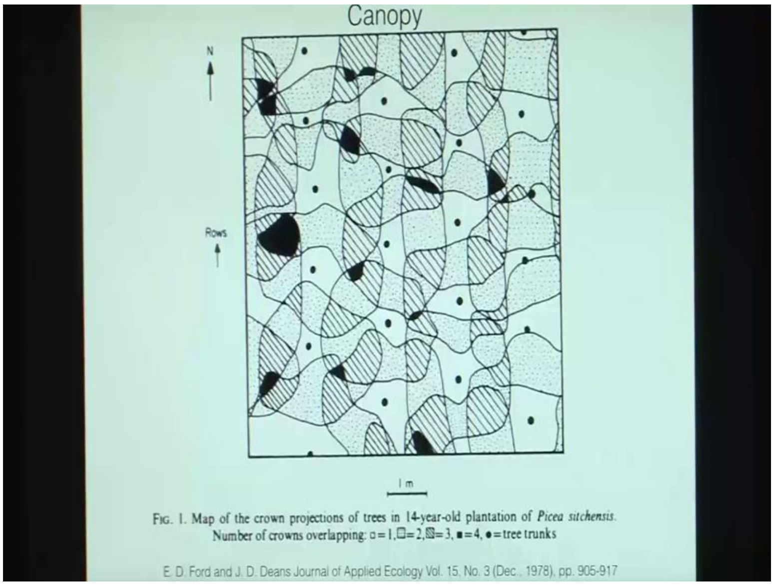
(Refer Slide Time: 01:45)




We also looked at the wavelengths that are deployed that can also lead to a classification of Lider into topographic Lider that uses an near infrared lasar or a bathymetric Lider that uses water penetrating green light to measure the seafloor and the riverbed elevations.

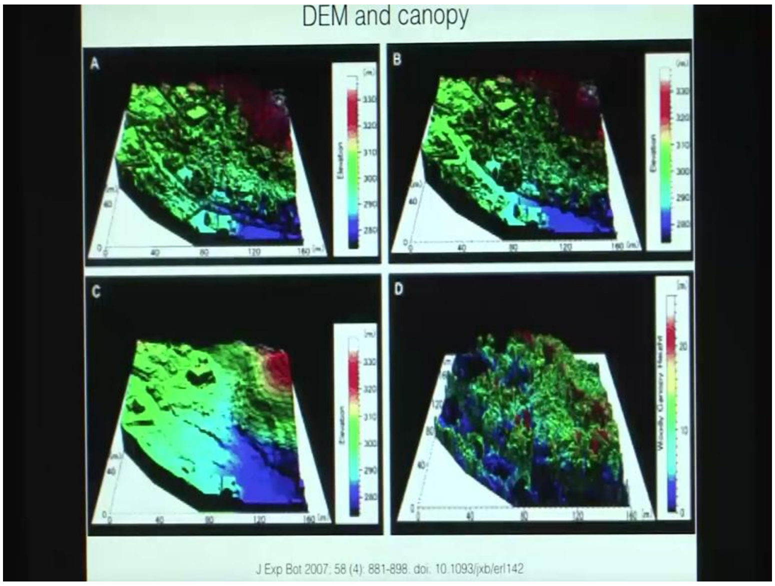
So, what is the use of Lider in forestry?

(Refer Slide Time: 02:03)



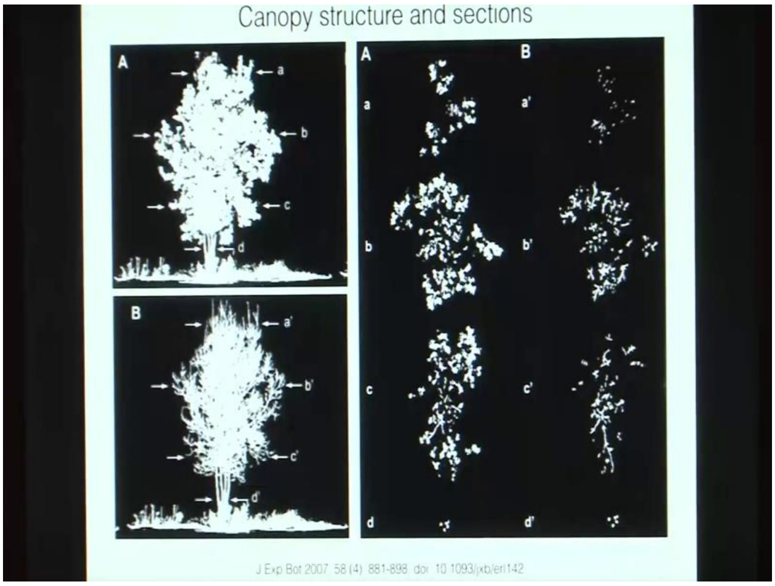

So, in the case of forestry we need to know information about the canopy cover.

(Refer Slide Time: 02:09)



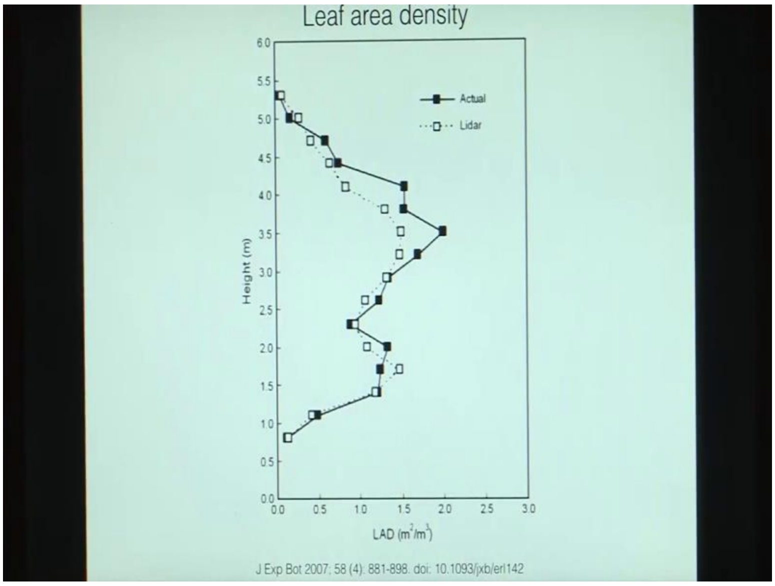

So, in the case of Lider we can get this a digit elevation model of the land.

(Refer Slide Time: 02:16)



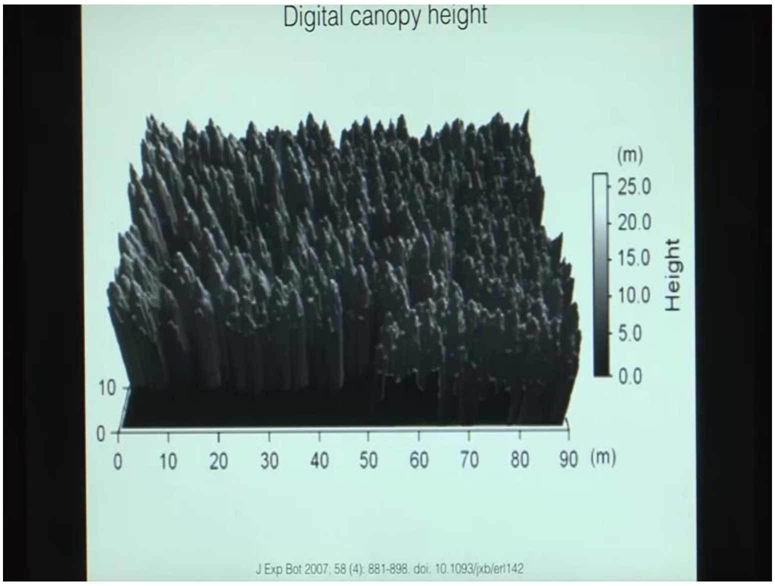

We can get the canopies. So, we can even get canopy structure. So, in the form of cross sections at different at different points or different heights, we can get the height of the tree.

(Refer Slide Time: 02:24)



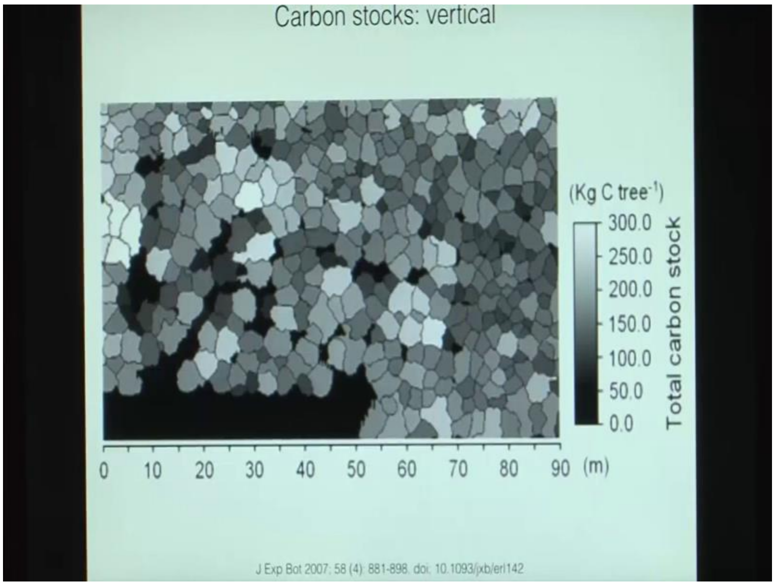

We can get the leaf area density using Lider, we can digitally calculate the canopy height of all different trees.

(Refer Slide Time: 02:30)




We can compute all these information together to get carbon stocks. So, this figure tells how much kg of carbon is there in each of these trees.

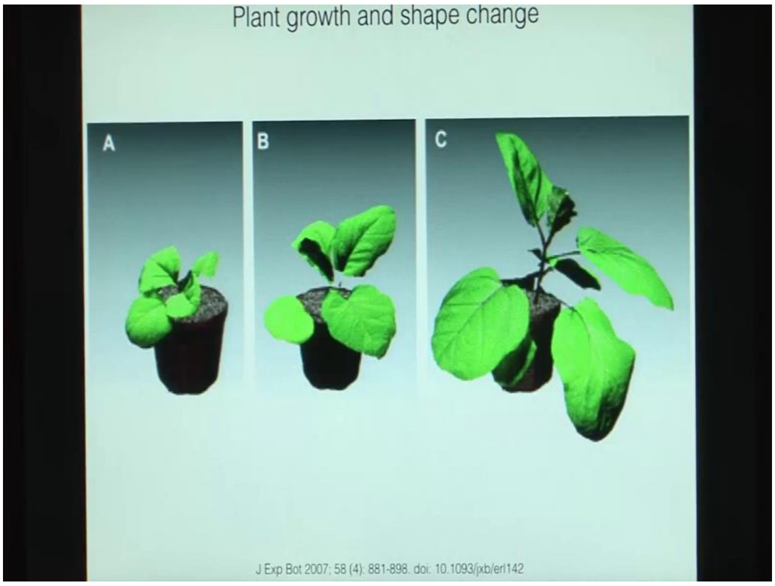
(Refer Slide Time: 02:32)




We can also use a Lider horizontally. So, we can also get carbon stocks in horizontally.

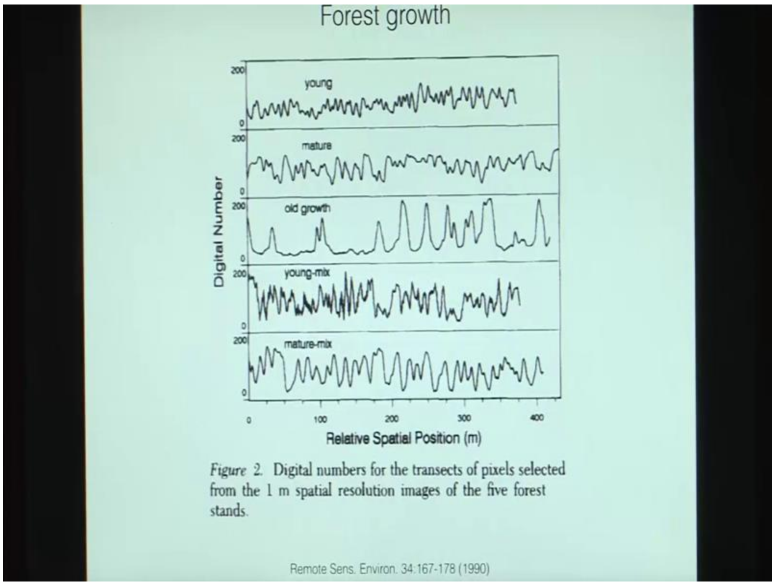
(Refer Slide Time: 02:43)


(Refer Slide Time: 02:49)



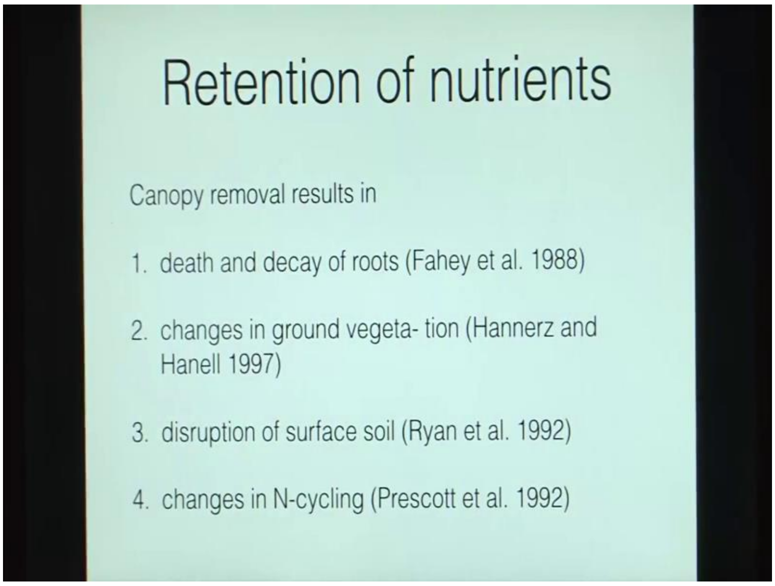

We can use it to study the plant growth and shape change, and also the growth of forest, so whether it is a young crop a mature crop an old crop or a mixed of these.

(Refer Slide Time: 02:52)



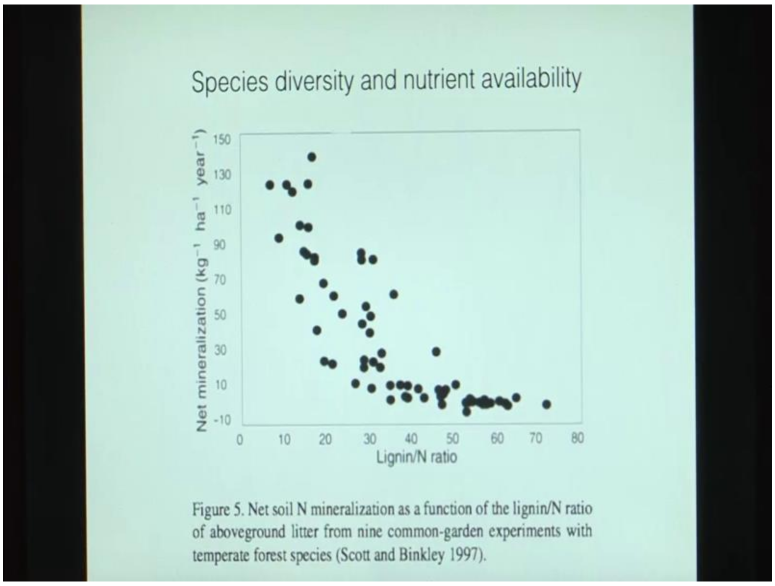

Next we looked at canopy attributes.

(Refer Slide Time: 03:05)



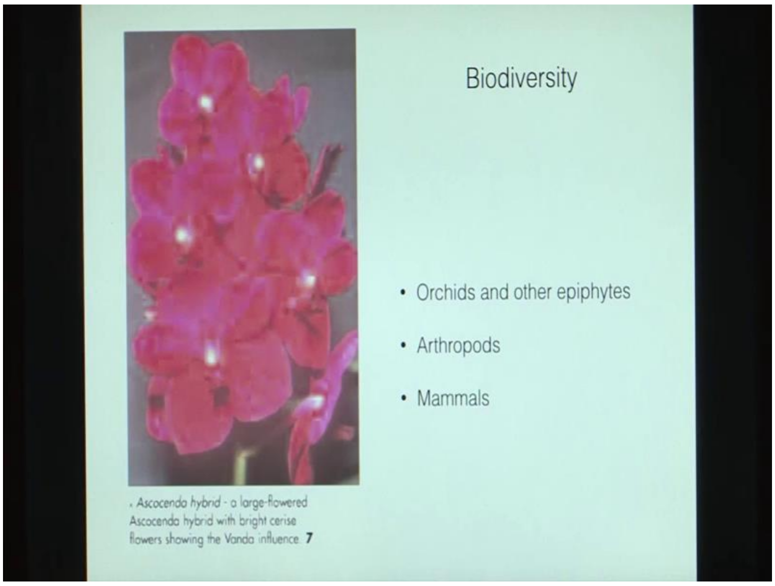

So, in the case of canopy they are very important because the size of a canopy will give you the amount of photosynthesis, that is going on in a tree and it also is important in the case of nutrient cycling and so on.

(Refer Slide Time: 03:20)



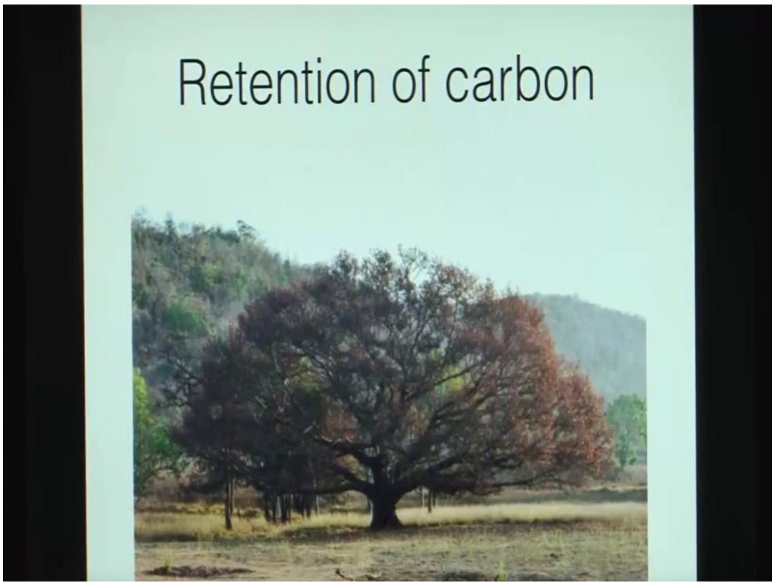

So, species diversity nutrient availability bio diversities.

(Refer Slide Time: 03:26)



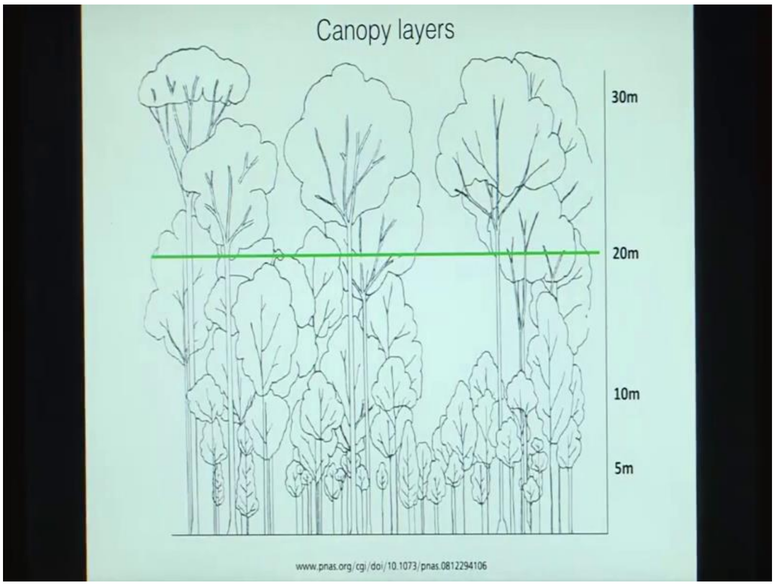

So, for instance orchids and are epiphytic plants that grown on top of trees. So, the required canopy, there are some arthropods there are some mammals such as the sloth. So, sloth only lives in the canopies then canopy also is important for the retention of carbon.

(Refer Slide Time: 03:38)



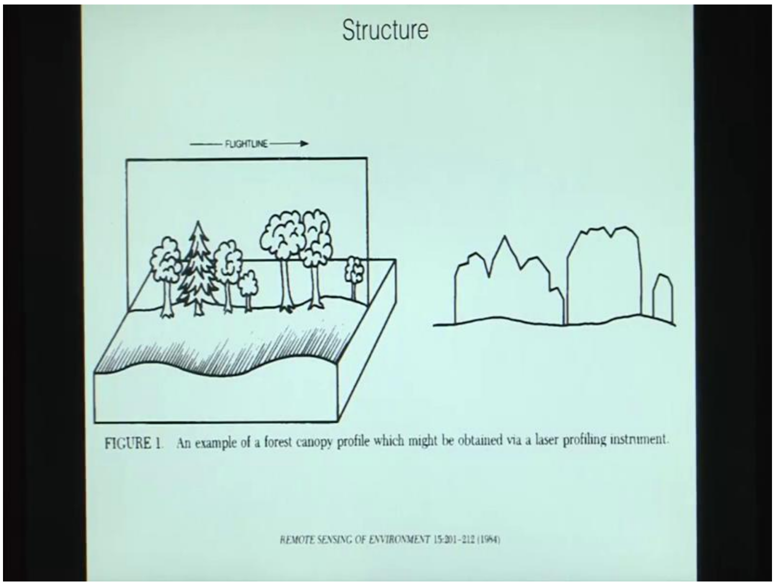

So, we looked at canopy parameters like canopy diameter and the canopy length or the crown length, this can be used to calculate the canopy volume and biomass, then we also looked at the canopy covering canopy closure.

(Refer Slide Time: 03:55)



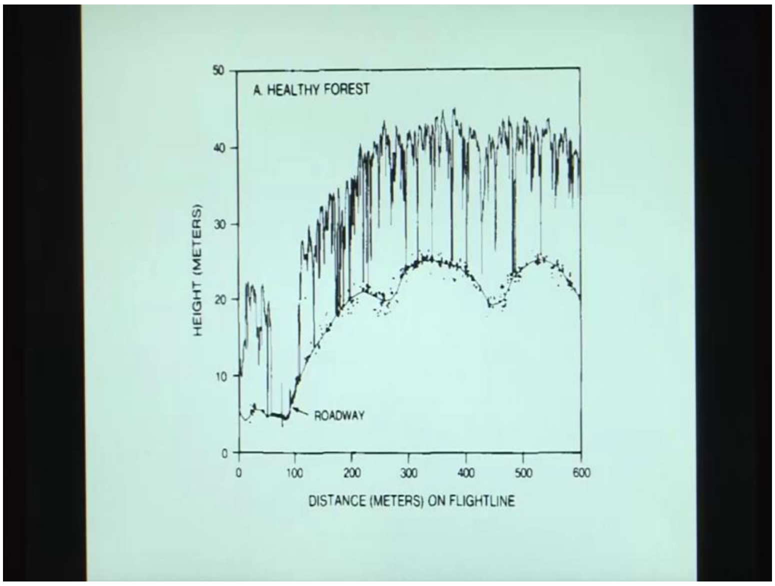

So, we can define canopy layers.

(Refer Slide Time: 03:59)



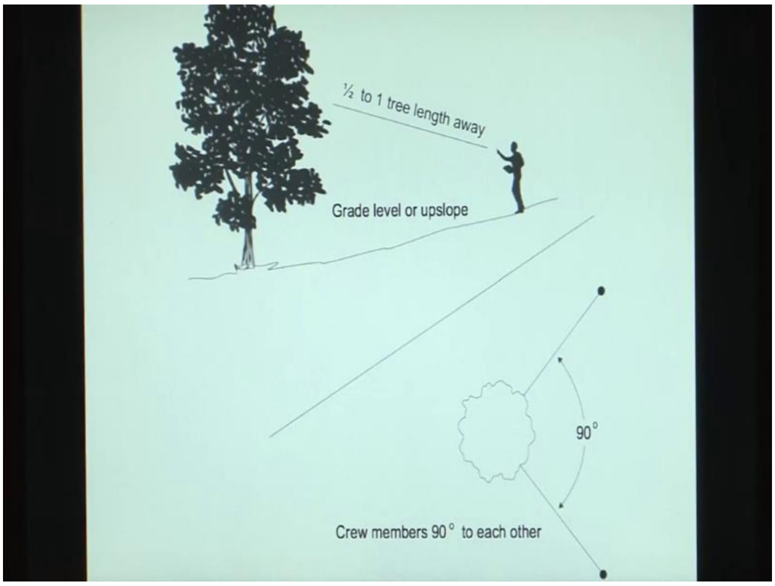

We can find out the structure of the canopy.

(Refer Slide Time: 04:01)



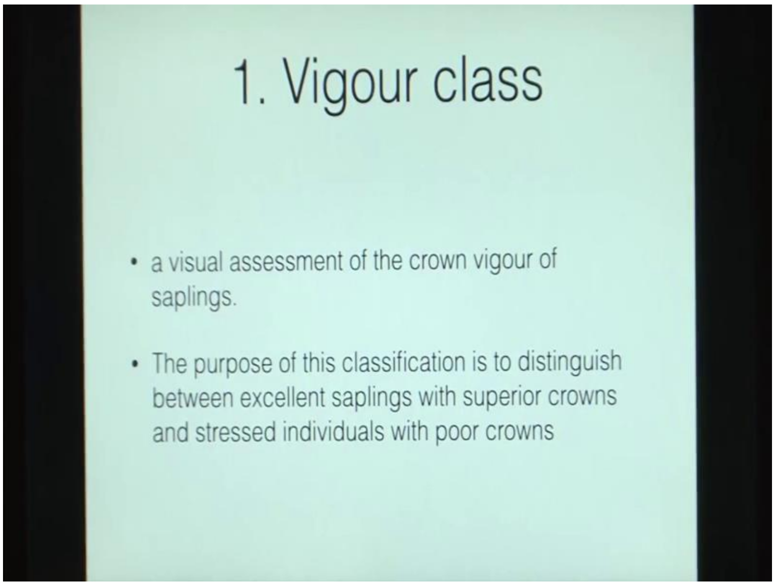

So, this can tell us whether you whether the forest is healthy or whether it is a sparse forest or it is a heavy defoliated forest, and we can even use Lider to study the canopy.

(Refer Slide Time: 04:13)



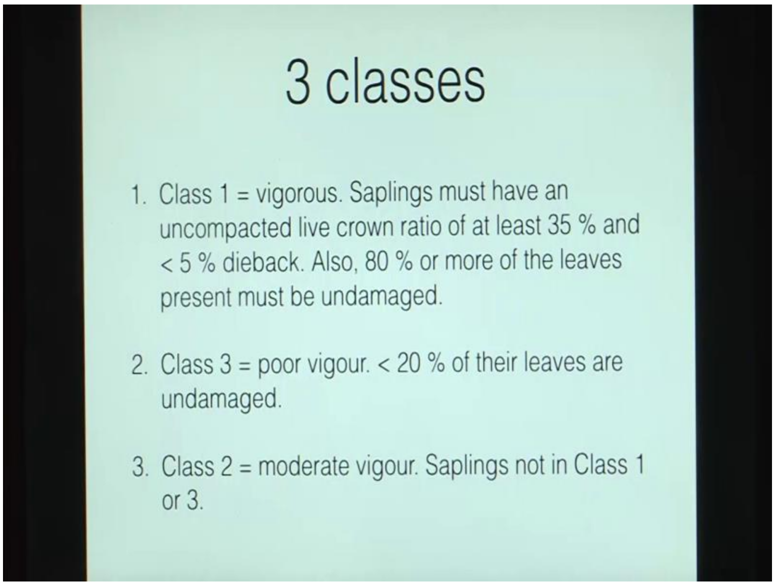

Now, in the case of canopy we also looked at, how do we look at a canopy so, we stand. So, half to one tree length away and then if there are two observers, then they should stand at ninety degrees to each other.

(Refer Slide Time: 04:25)



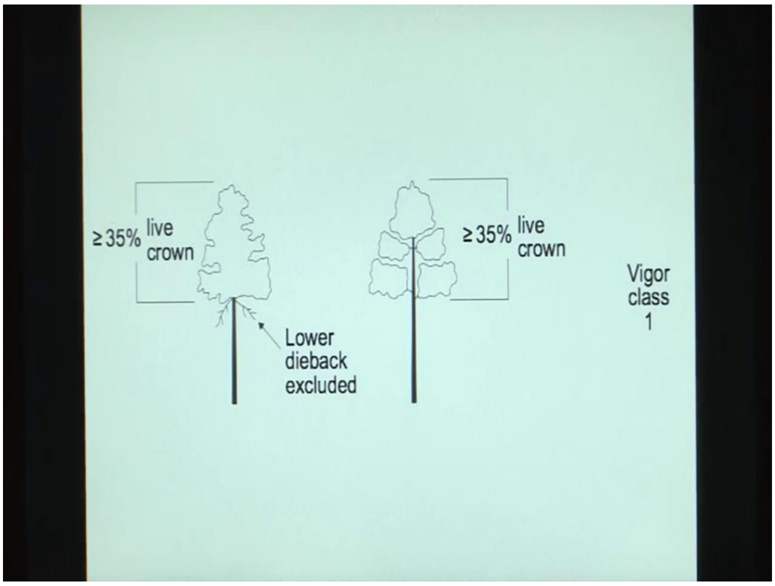

We looked at vigor class. So, what do we mean by vigor class it is a visual assessment of the crown vigor of saplings, with this we defined three kinds of vigor classes.

(Refer Slide Time: 04:37)



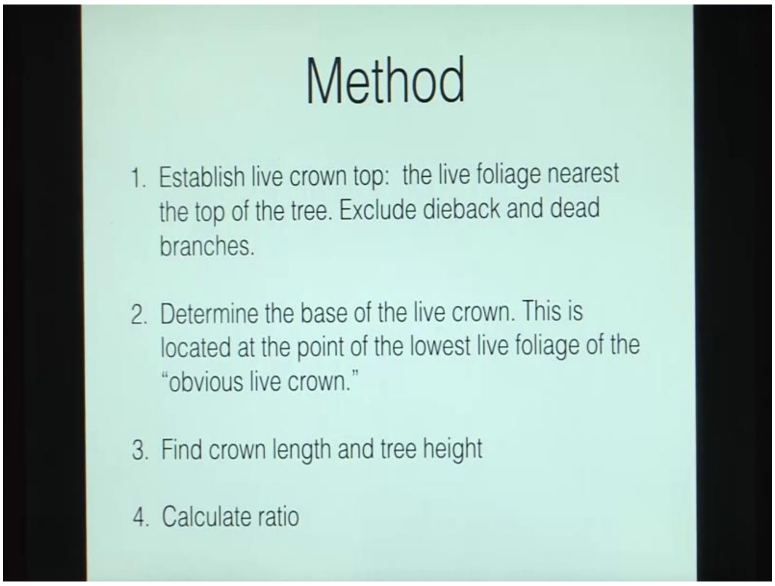

So, class one was the most vigor class. So, in this case samplings must have an uncompacted live crown ratio of at least 35 percent, and less than 5 percent dieback and 80 percent or more of the trees present must be undamaged.

(Refer Slide Time: 04:52)




So, in this case the samplings will have a vigorous growth, then we also defined a poor vigor in which less than 20 percent of the trees of the leaves are undamaged. That is more than 80 percent of the leaves are damaged that does not fall in the first or the third vigor class is called a moderate vigor class or class 2, then we also looked at the uncompacted crown ratio.

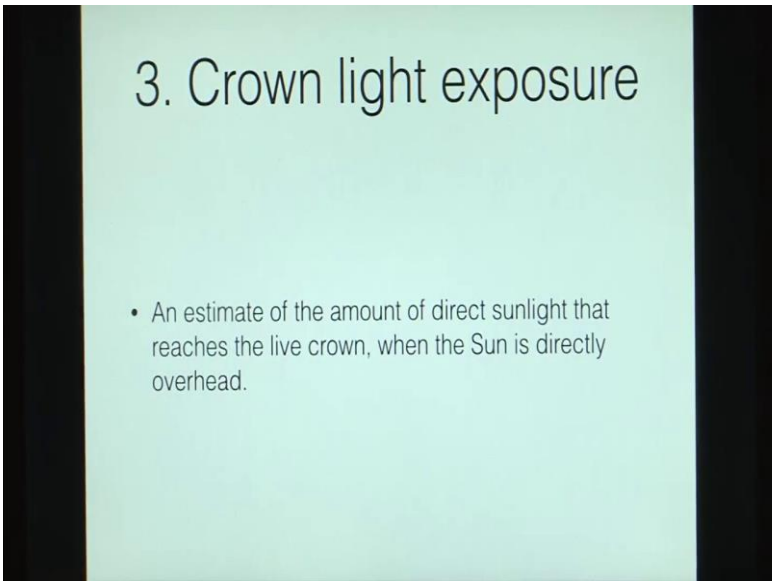
(Refer Slide Time: 05:12)




So, to find out the uncompacted crown ratio we first established the live crown top, then we determine the base of the live crown.

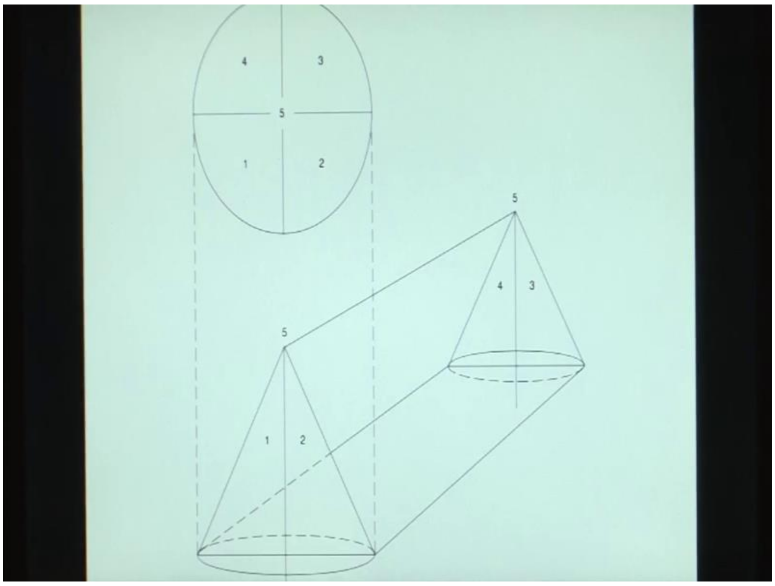
So, with both of these we can find out the crown length, then we can find out the height of the tree as we have already seen and then we can calculate the ratio.

(Refer Slide Time: 05:31)

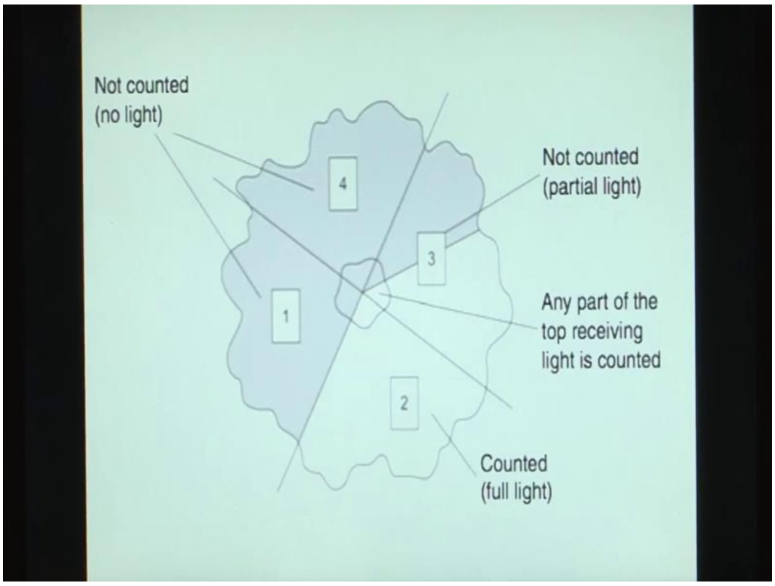


Then we also looked at crown light exposure. So, that is an estimate of the amount of direct sunlight that reaches the live crown when the sun is directly overhead. So, in this case we defined units of 0 to 5.

(Refer Slide Time: 05:42)



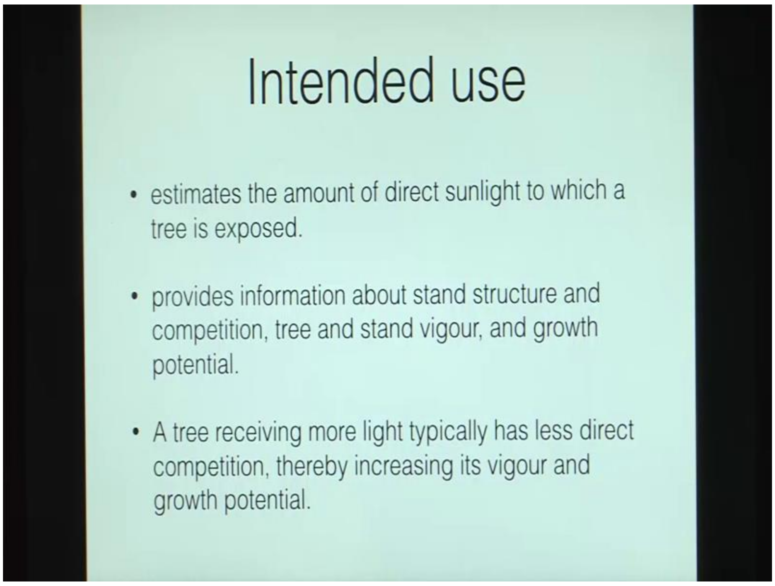

(Refer Slide Time: 05:45)




So, we looked at our canopy in the form of cones, and we divided it into four sections horizontally and one section that covers the top portion.

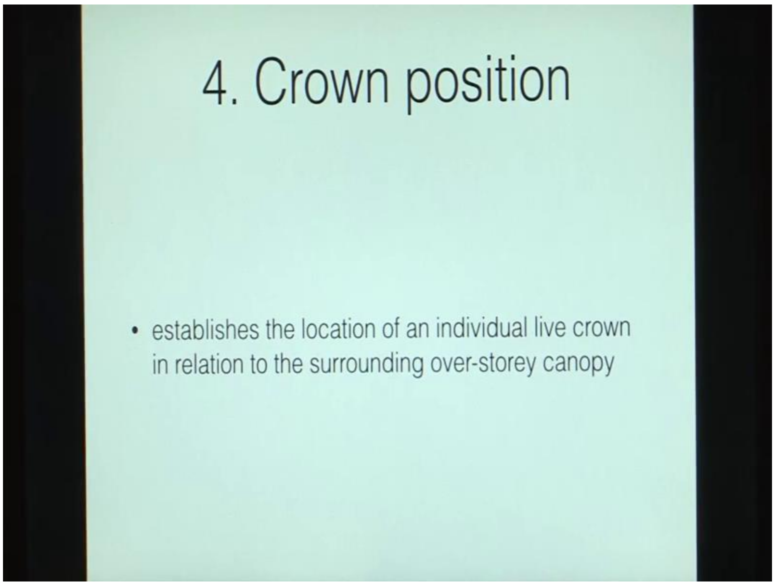
So, if any of the horizontal sections receives 100 percent light, only then it is counted if it is a receiving partial light or no light then it is not counted and if in the case of the this stock portion, if any part of it is receiving light then it will be counted.

(Refer Slide Time: 06:11)



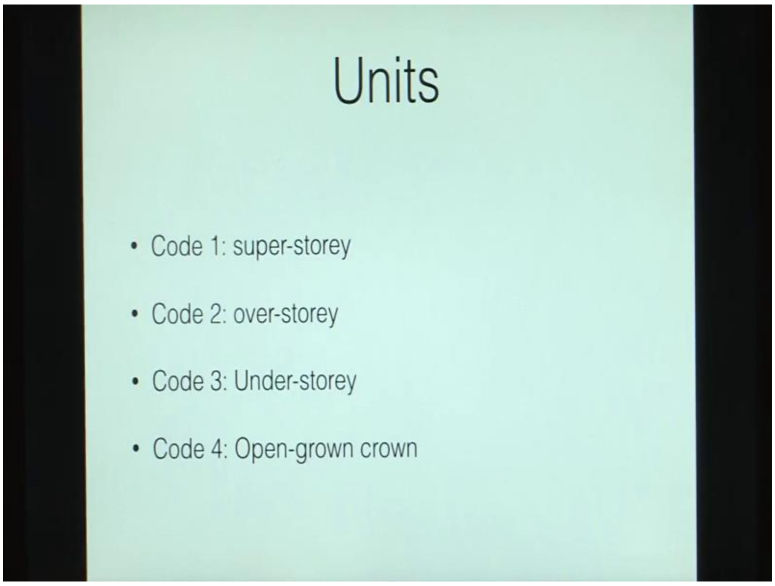

So, it gives us an estimate of the amount of direct sunlight to which the tree is exposed. So, that will give you give us the amount of photosynthesis, that it will under grow and the amount of competition and the stand structure that our forests have.

(Refer Slide Time: 06:26)



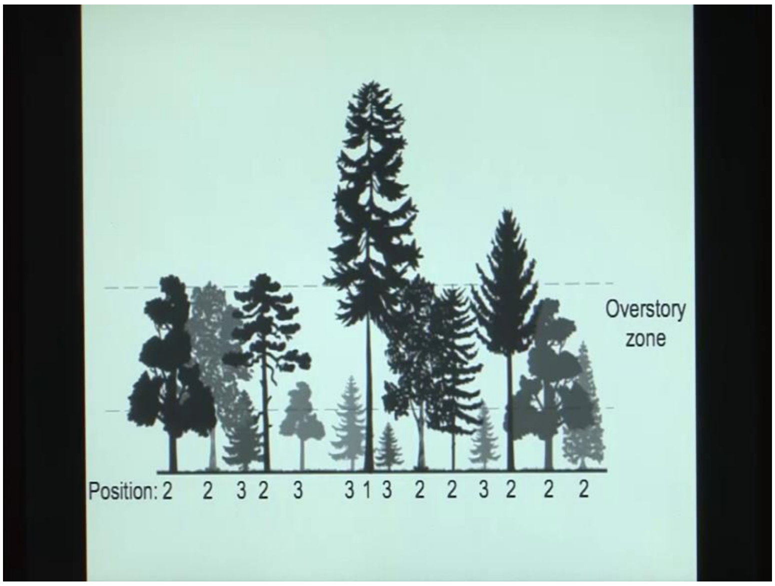
Next we looked at crown position which establishes the location of an individual live crown, in relation to the surrounding over canopy.

(Refer Slide Time: 06:33)




So, here we defined four codes that is super story over story under story and the open growth crown.

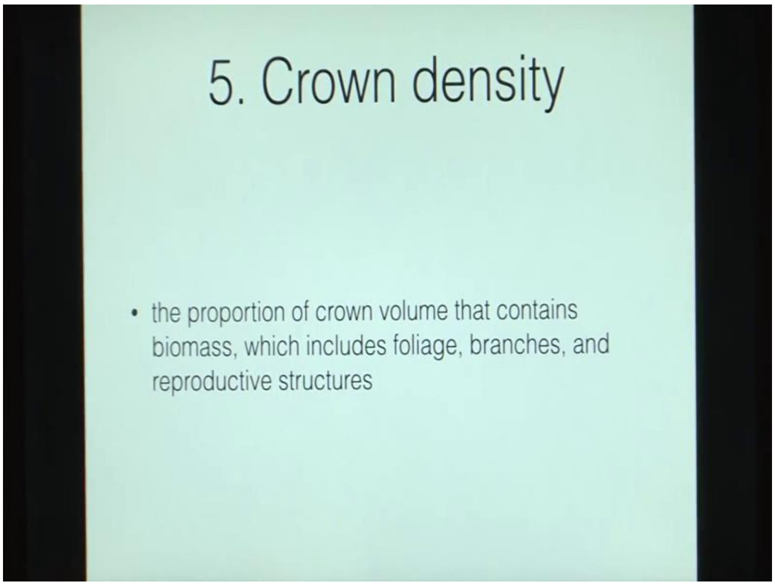
(Refer Slide Time: 06:41)




So, in this case we first go for the average height, which will give us an over story zone then we find out 50 percent of that height and that can be used to classify our trees into 1, 2 or 3 and in cases when our trees are grown very separate from each other, and there is no competition there is an open canopy then we give it a code of 4.

Next we looked at some other canopy attributes including crown density.

(Refer Slide Time: 07:10)

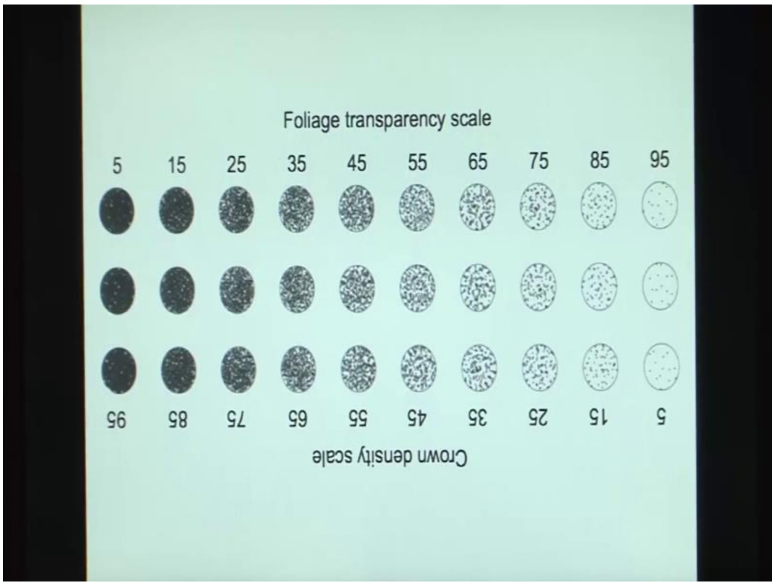



So, crown density is the proportion of crown volume that contains biomass including foliage branches and reproductive structures.

(Refer Slide Time: 07:19)

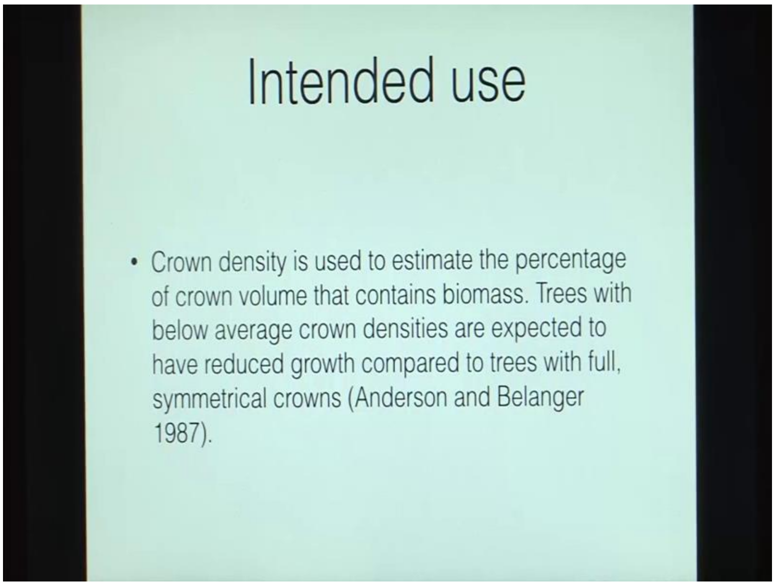
So, we saw that we can figure out its crown density by using by first making out the shape of the canopy and then using some cards.

(Refer Slide Time: 07:30)




So, these are the foliage transparency scale cards or the crown density scale cards.

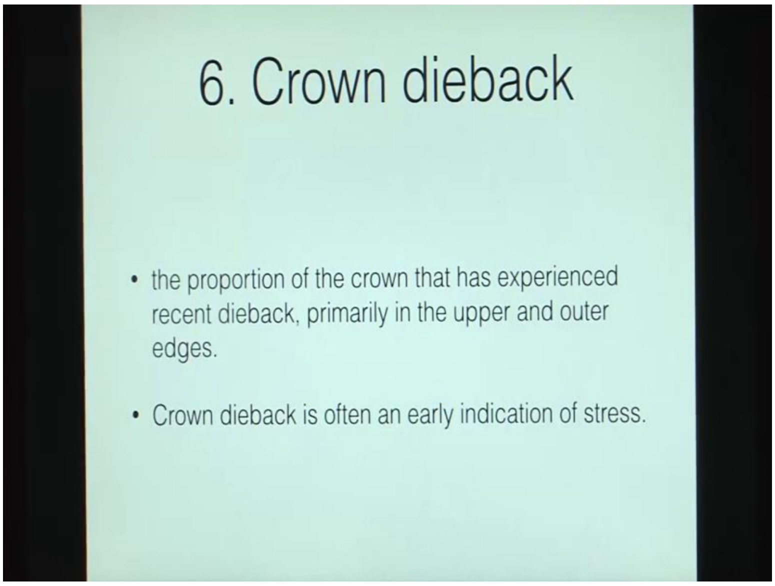
(Refer Slide Time: 07:35)




So, it gives us the percentage of crown volume that gives that contains biomass.

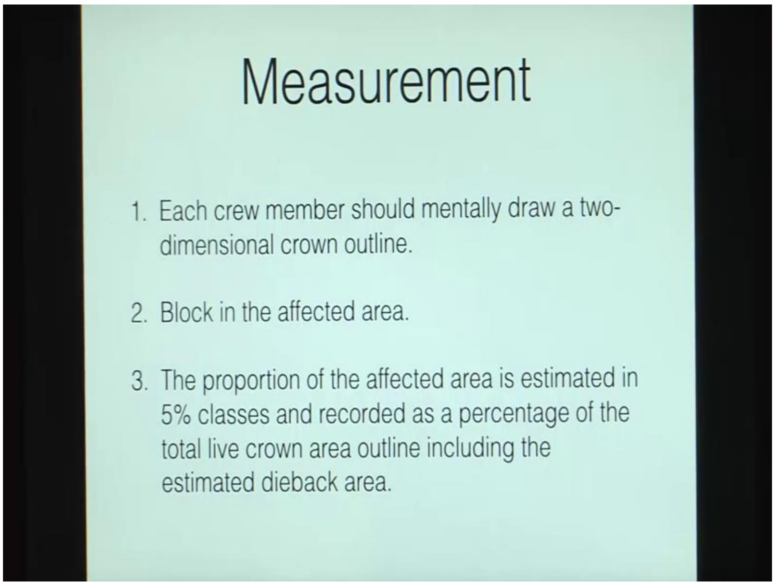
Next we looked at crown dieback.

(Refer Slide Time: 07:44)

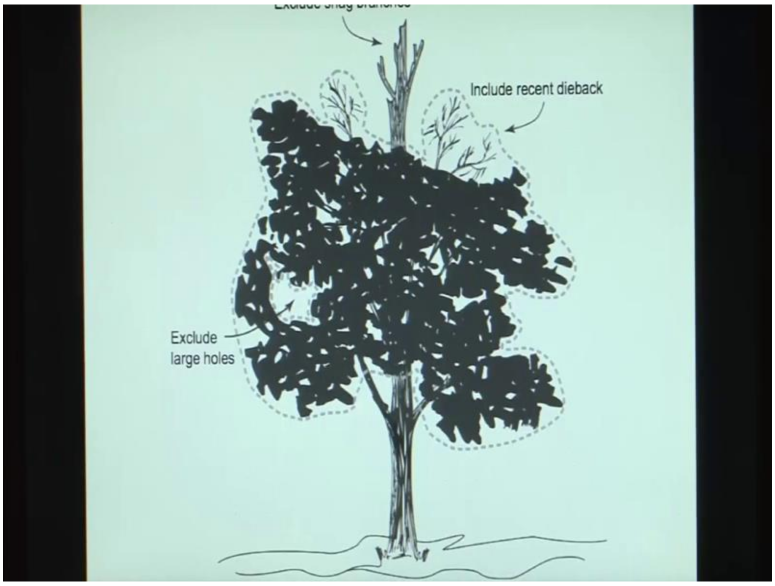



So, which is an early indication of stress and we recorded in 5 percent classes from 0 to 100.

(Refer Slide Time: 07:51)

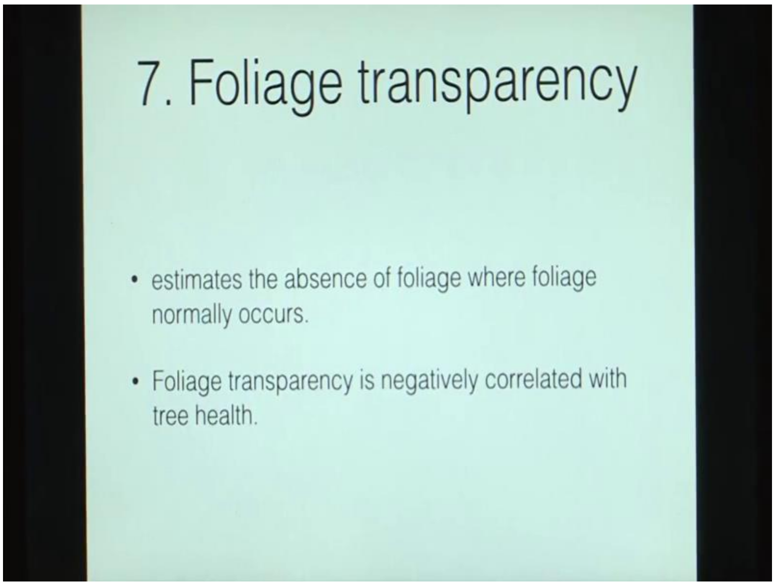


(Refer Slide Time: 07:56)



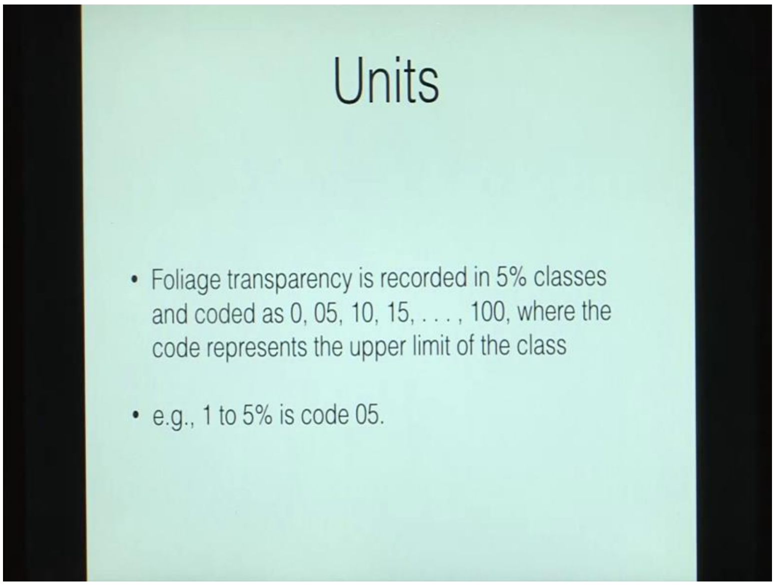

Now, in this case we drew a crown outline blocked the affected area and then figured out how much is the dieback.

(Refer Slide Time: 08:00)




Next we looked at foliage transparency, which gives us the absence of foliage where a foliage should normal have occurred and it is negatively correlated with tree health. So, if your crown does not have enough foliage. So, in that case it will appear transparent. So, all the light that is hitting the crown, will be able to pass through and in that case your tree will not be having enough amount of photosynthesis and so, it is a health will also be poor.

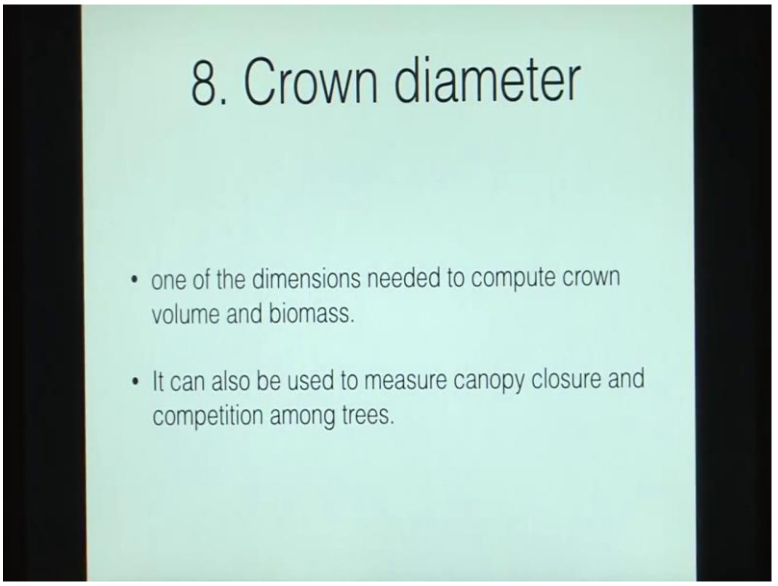
(Refer Slide Time: 08:29)




(Refer Slide Time: 08:32)

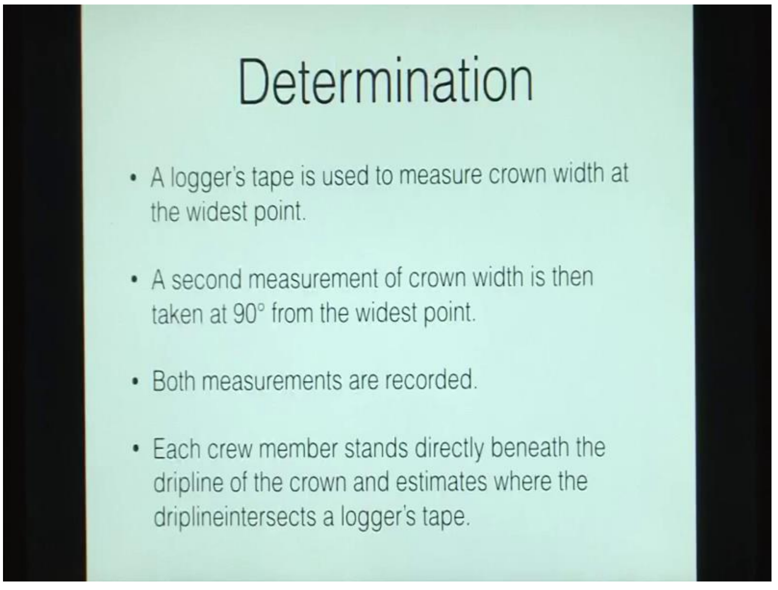

Here also define it in five percent classes, and we use our foliage transparency cards to determine the amount of foliage transparency.

(Refer Slide Time: 08:40)



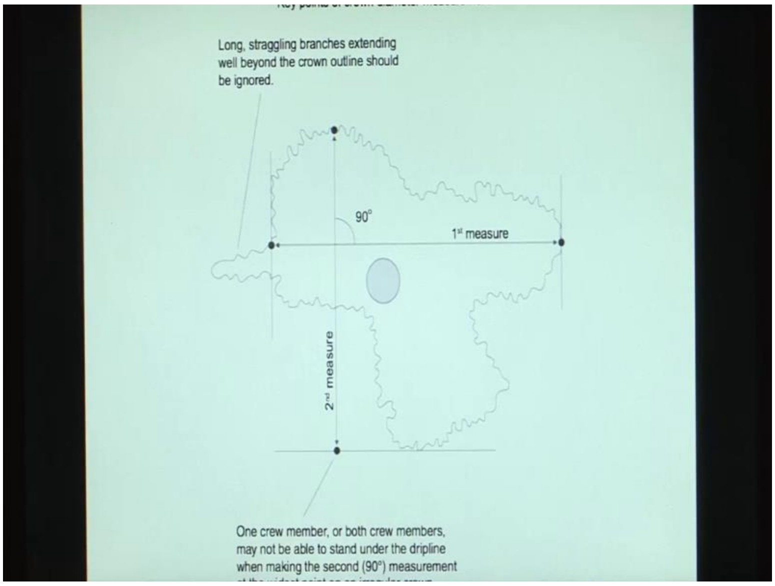

Next we also looked at a crown diameter.

(Refer Slide Time: 08:44)



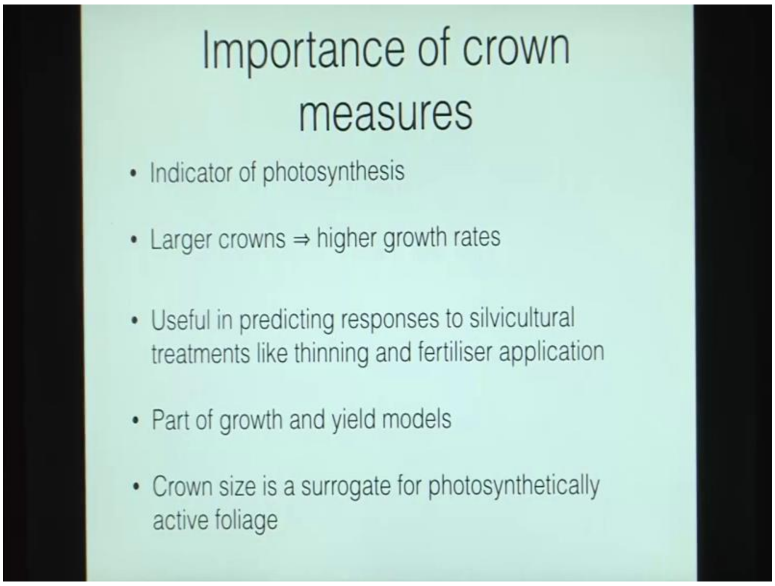

So, in the case of a crown diameter we can take two measurements, and with those two measurements.

(Refer Slide Time: 08:48)



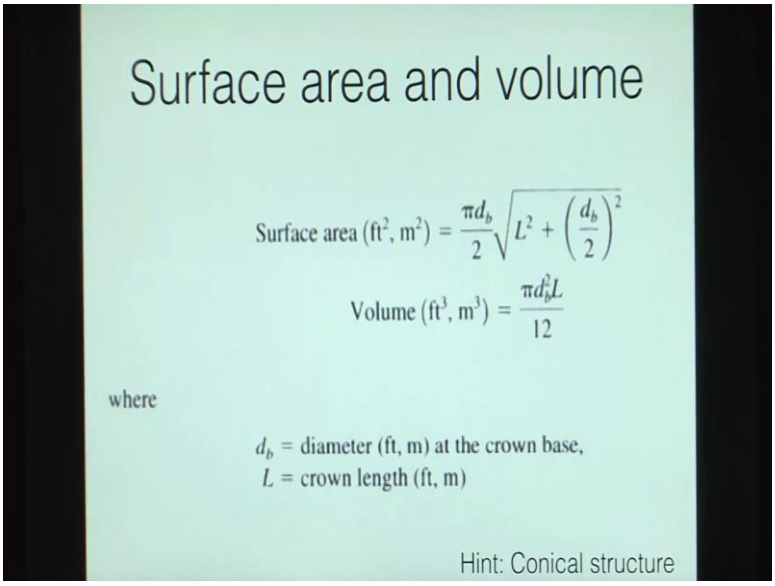

We can keep both those diameters as the crown diameter values.

(Refer Slide Time: 08:53)




Now, we looked at the importance of crown measures. So, they are an indicator photosynthesis, larger crowns will give us higher growth rates, they are useful in predicting responses to silvicultural treatments like thinning and fertilizer application they are part of growth and yield models, and the size is a surrogate for or it is a proxy for photosynthetically active foliage.

(Refer Slide Time: 09:20)

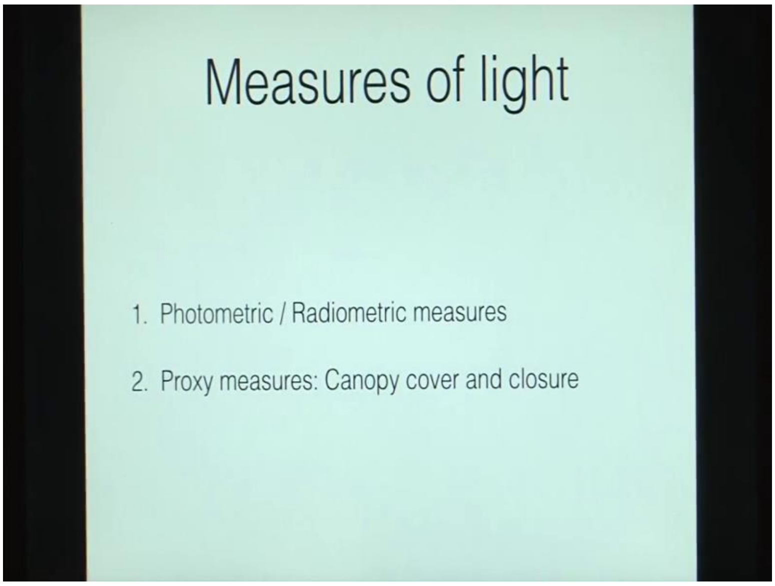



So, we also looked at crown width and the surface area and volume determination of a crown which is done by considering our crown to be having a conical shape. So, these of the on the surface area and the volume are the equations of a cone. Next we looked at canopy cover and closure. So, we defined both of these terms.

(Refer Slide Time: 09:39)

So, inside a forest the amount of light can vary depending on the amount of a canopy that is there. So, canopy will prevent light from reaching the bottom portions of the forest.

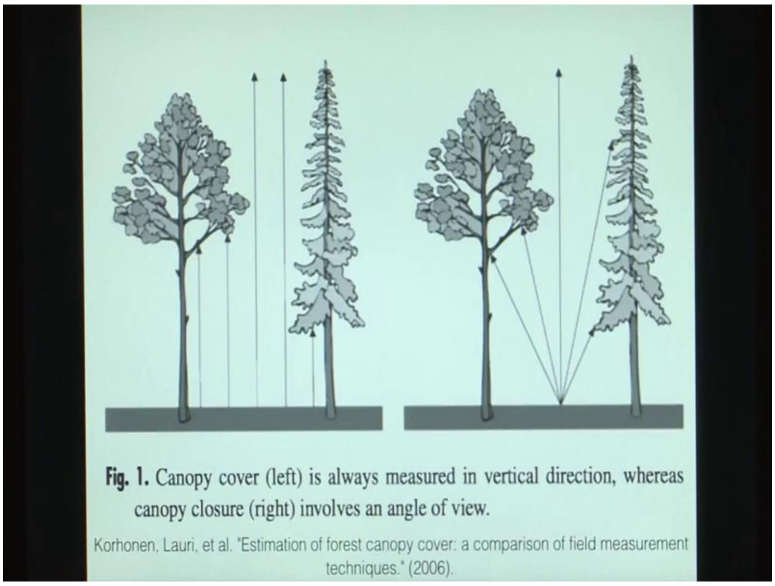
(Refer Slide Time: 09:52)




And we can measure light using a photometric or a radiometric measure and also by using a proxy measures such as canopy cover and closure.

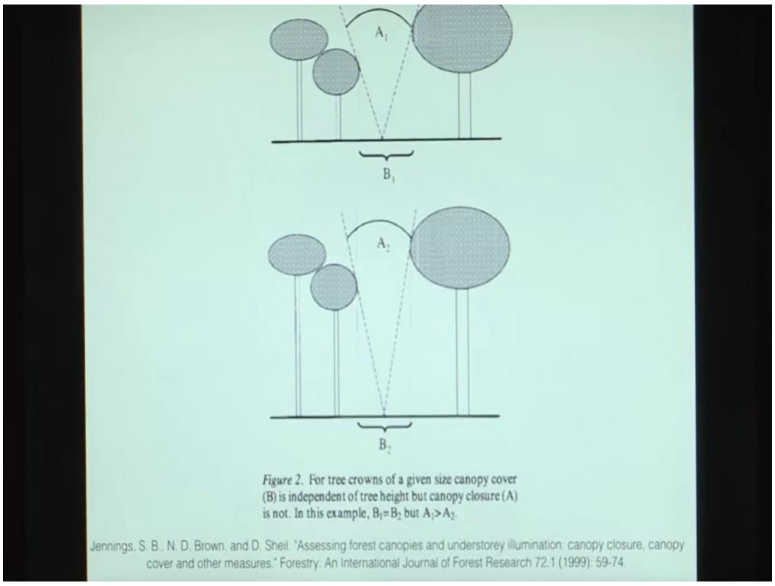
So, we looked at a demonstration of how we can use a photo resistor to measure the amount of light that is coming to a point.

(Refer Slide Time: 10:06)



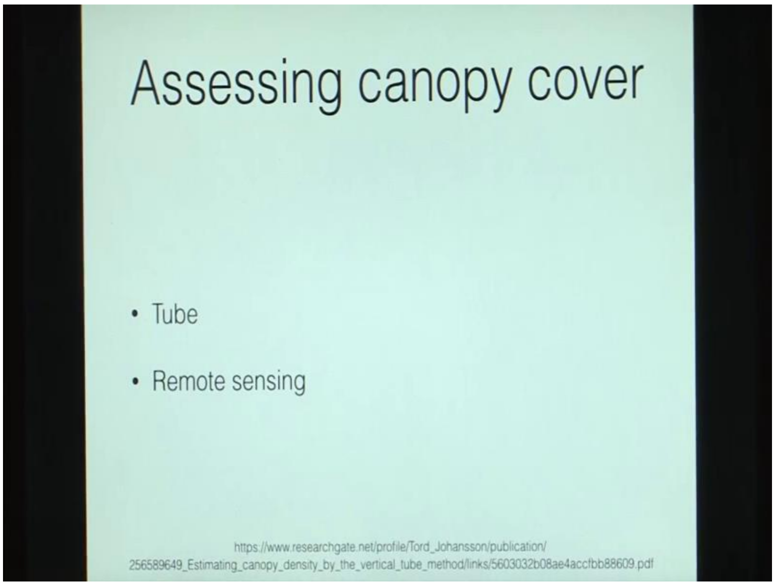

Then we looked at canopy cover. So, canopy cover is seen from the top. So, it looks at the projection of all the canopies if they are done on the ground. So, what proportion of the area is being covered by these projections will give us the canopy cover, where as in the case of canopy closure we take this bottom point and from that point we take a reading from all the directions and the proportion of the points that are covered by the canopy or that see a canopy there will give us the canopy closure.

(Refer Slide Time: 10:42)




So, in the case of canopy cover it varies with the height; in the case of canopy cover height is immaterial, but in the case of canopy closure height plays a very important role.

(Refer Slide Time: 10:53)

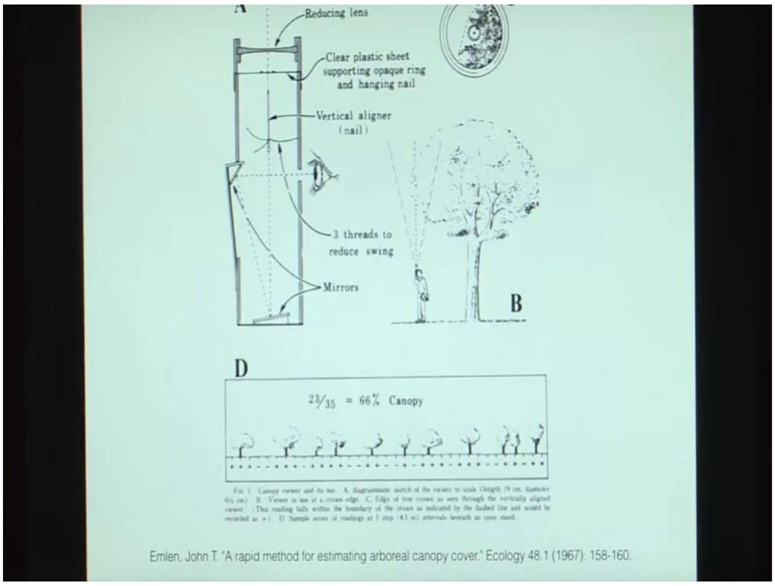



So, canopy cover can be assessed by using a tube or by using a remote sensing.

(Refer Slide Time: 10:58)


So, we looked at these tubes.

(Refer Slide Time: 11:00)

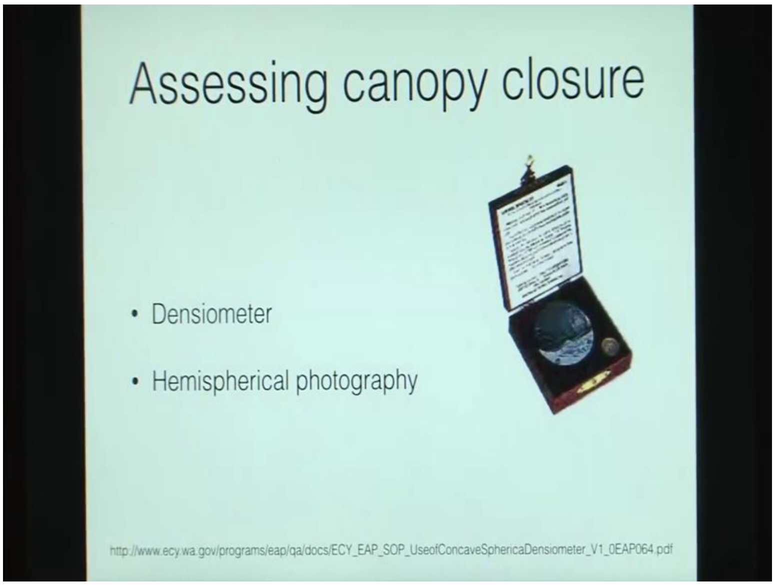



So, essentially they are periscopes, that can give us what is thin on the top or we can use remote sensing to for instance.

(Refer Slide Time: 11:07)

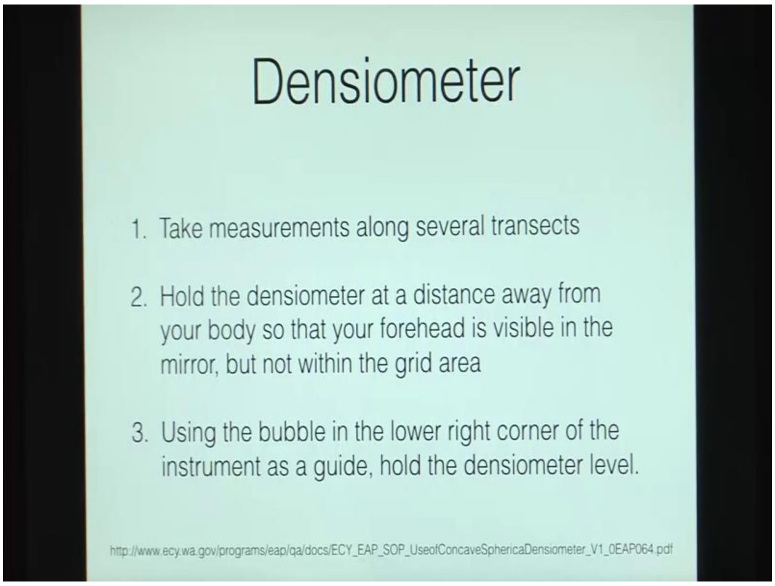

We can use photography or even Lider, to find out the areas that do not have a canopy.

(Refer Slide Time: 11:18)



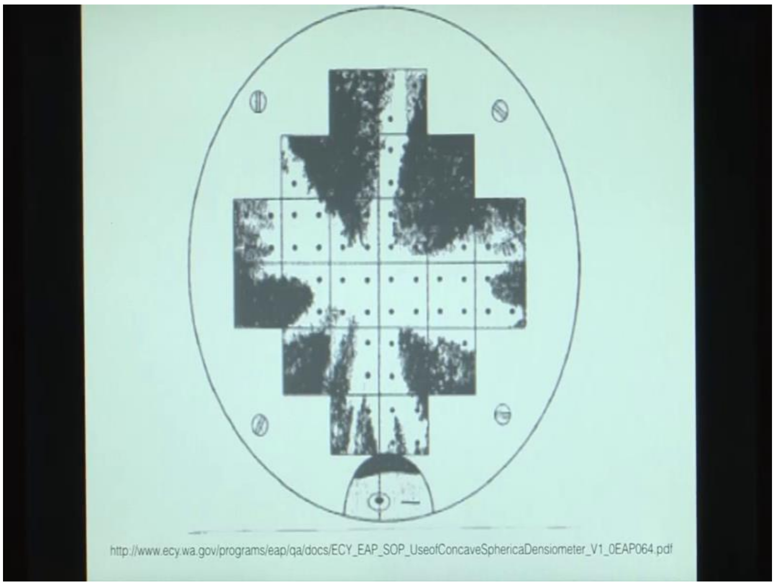

And in the case of canopy closure, we can use a densitometer or hemispherical photography.

(Refer Slide Time: 11:24)



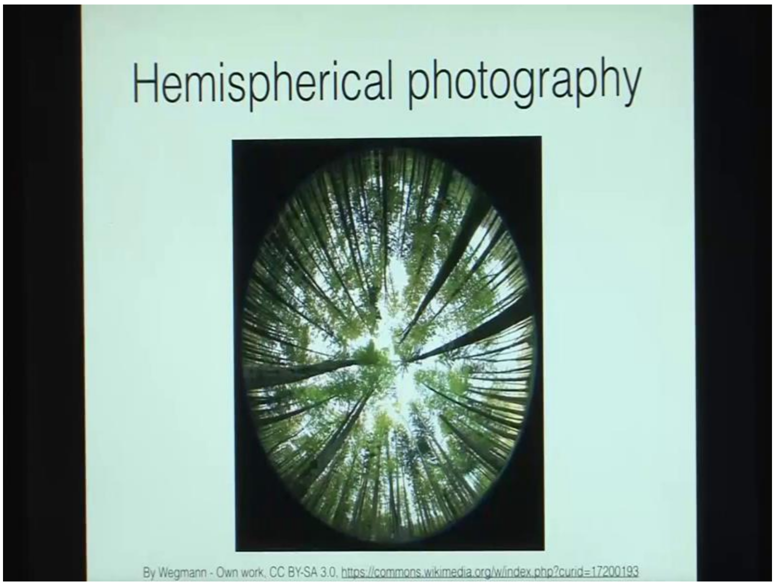

So, we looked at what a densitometer is, and it has 96 points and those 96 points can give us an estimate of the amount of canopy closure.

(Refer Slide Time: 11:30)




So, all of these, so it is divided into 24 grids, all these grids have 4 points and any point on which you can see a canopy is counted and then that value is divided by 96 and then converted into percentage to give us the canopy closure.

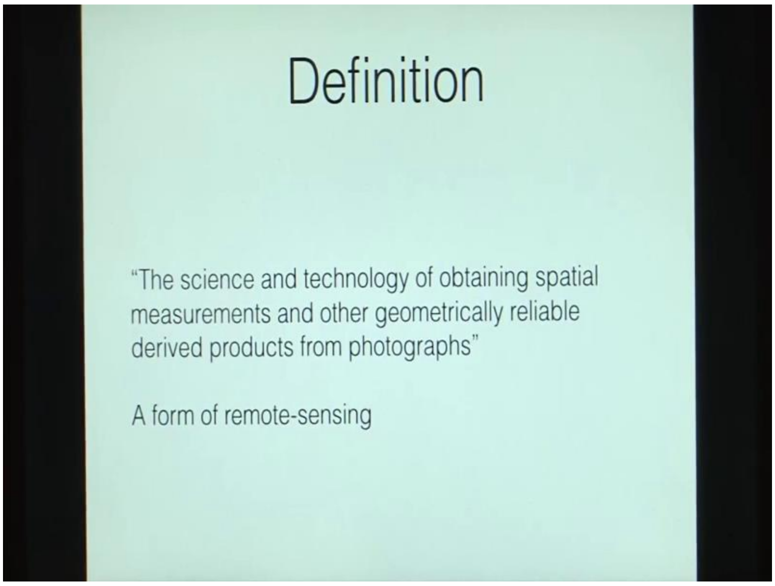
(Refer Slide Time: 11:52)




Then we also saw this hemispherical photography, which uses a fisheye lens or a very extreme wide angle length. So, here we can see what portion of the view is covered by the canopy and that can also give us the canopy closure.

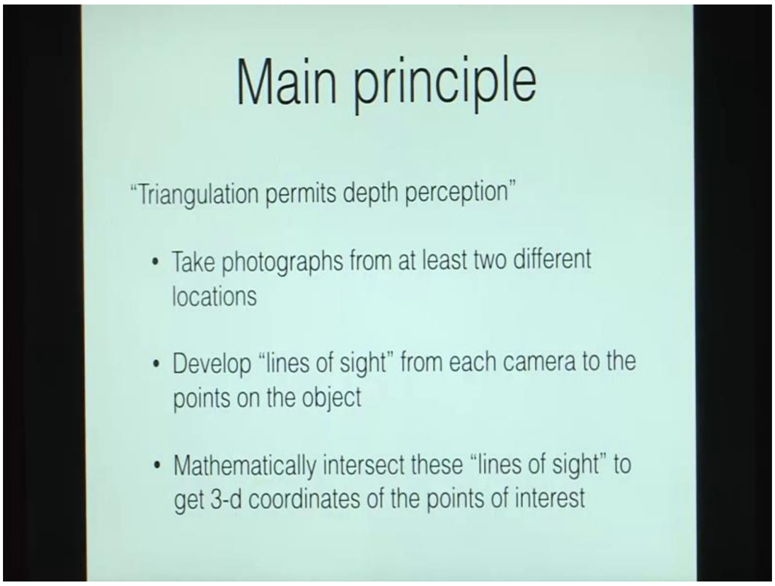
Next we looked at photogrammetry.

(Refer Slide Time: 12:10)



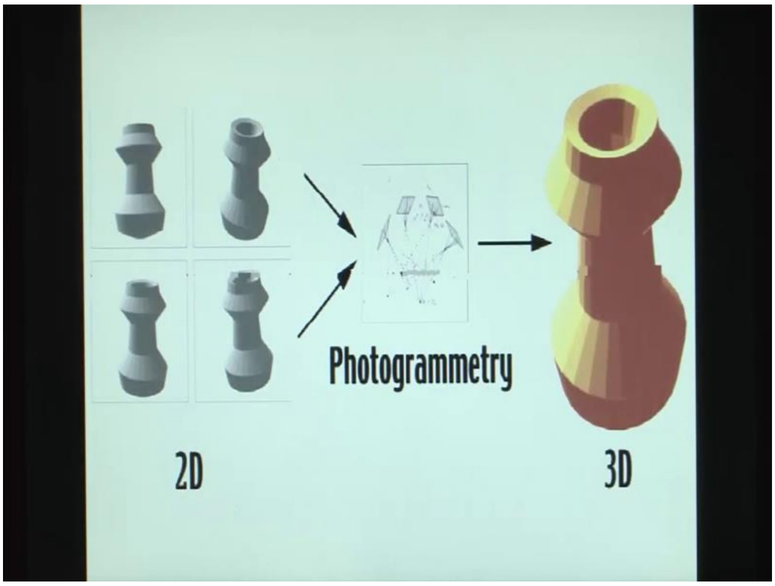

So, photogrammetry is the is a form of remote sensing that utilizes the science and technology of obtaining special measurements, and other geometrically reliable derived products from photographs.

(Refer Slide Time: 12:23)




So, the main principle of photogrammetry is that triangulation permits depth perception.

(Refer Slide Time: 12:27)



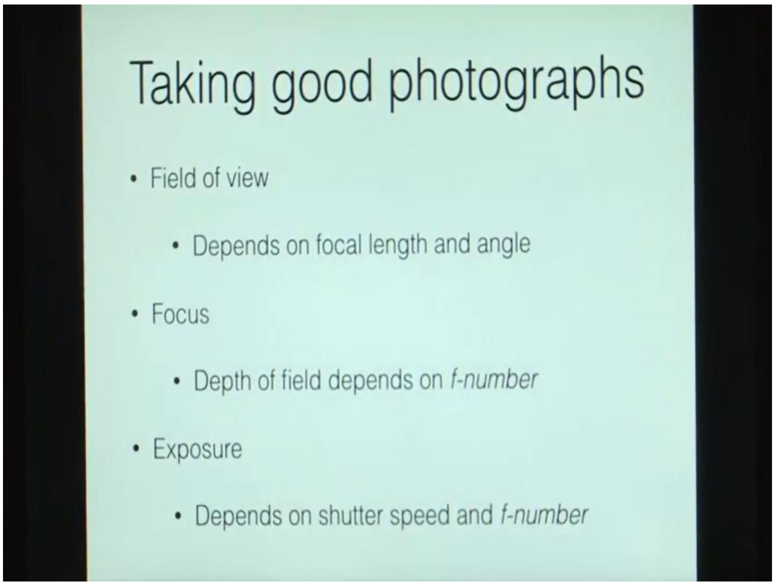

So, essentially we are taking multiple images of an object and then we are using photogrammetry, to convert it into a three dimensional information.

(Refer Slide Time: 12:36)


So, photogrammetry is used for metric applications and interpretive applications. So, we can measure some parameters from a photograph or we can use our photograph, to interpret something meaning what is actually there in the photograph.

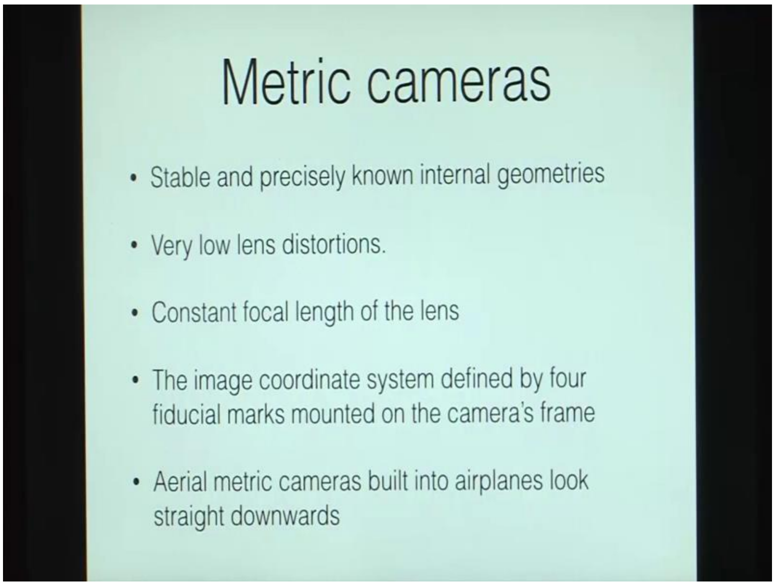
So, for instance in this picture if we say that that it is showing us a canopies of different trees. So, that is an interpretive usage of photogrammetry whereas, if we use it to calculate the crown closure then it will be a metric application.

(Refer Slide Time: 13:08)



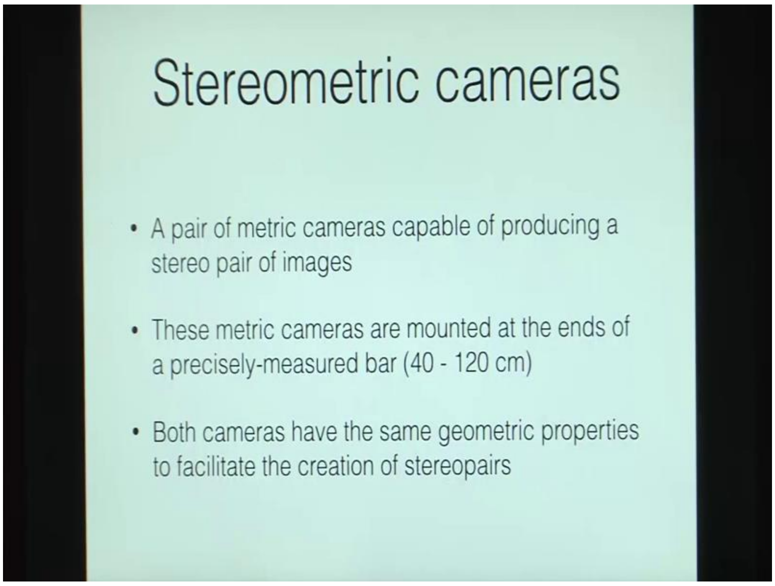
Then we looked at how do we take good photographs. So, we looked at how field of view focuses in exposure data mine what sort of photograph will get.

(Refer Slide Time: 13:17)



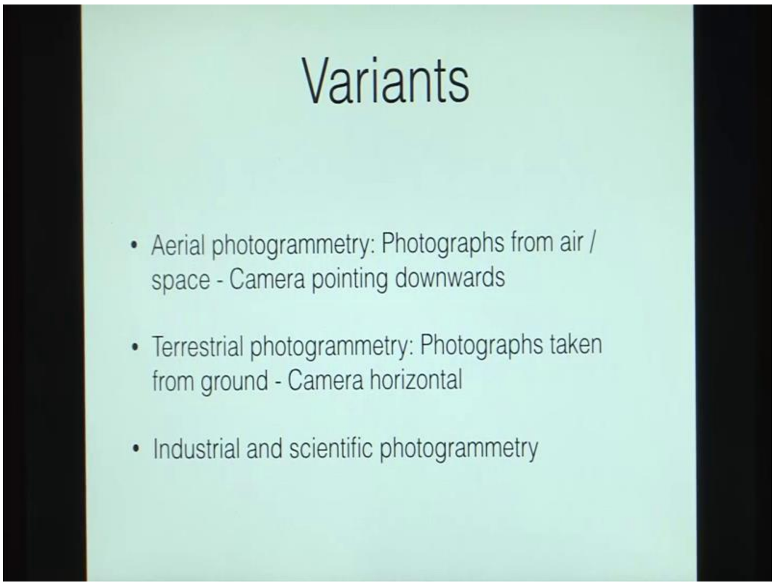

We also looked at metric cameras in which all the parameters of the camera are very well defined, there are very low less distortions and a constant focal length.

(Refer Slide Time: 13:27)



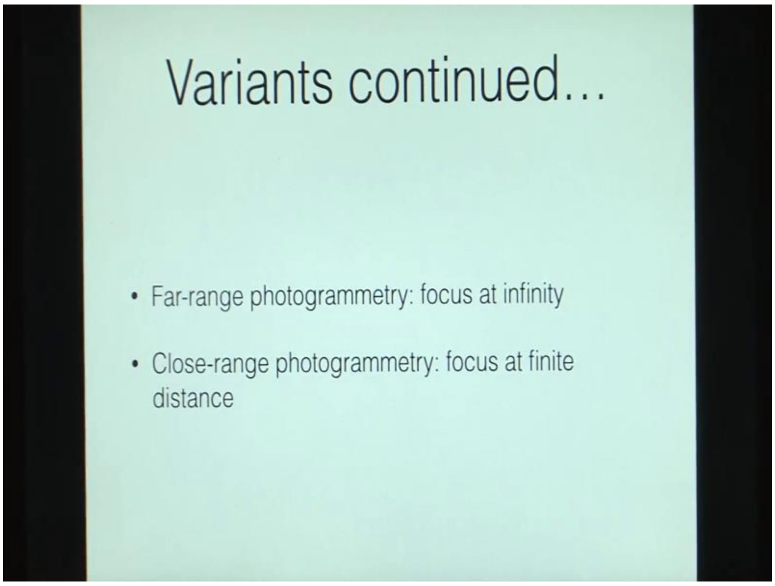

We also looked at stereo metric cameras in which we have two metric cameras, that are attached to the ends of a precisely measured bar to produce a stereo pair of images.

(Refer Slide Time: 13:38)



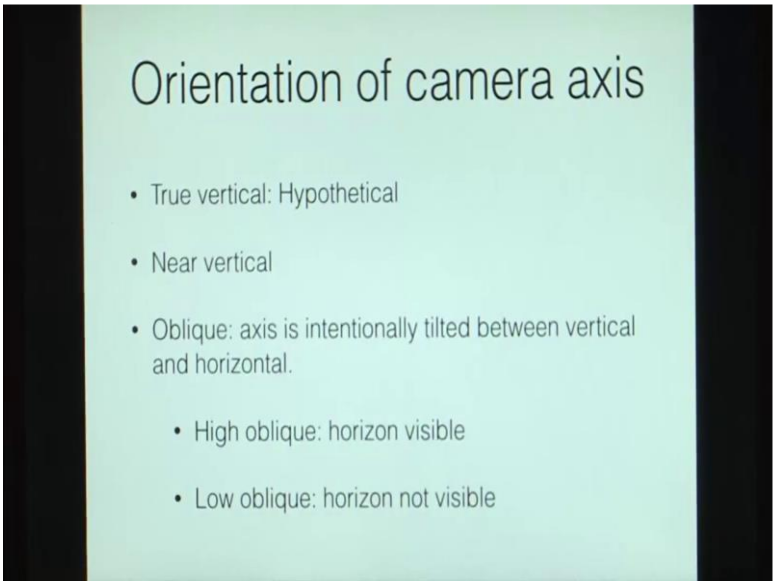

Then we looked at variants of photogrammetry. So, these include aerial photogrammetry terrestrial photogrammetry and in industrial and scientific effect photogrammetry depending on where are we taking this pictures, whether we are taking it from the air way or whether we are taking it from the ground or whether we are using it in an industrial or scientific fashion.

(Refer Slide Time: 14:01)



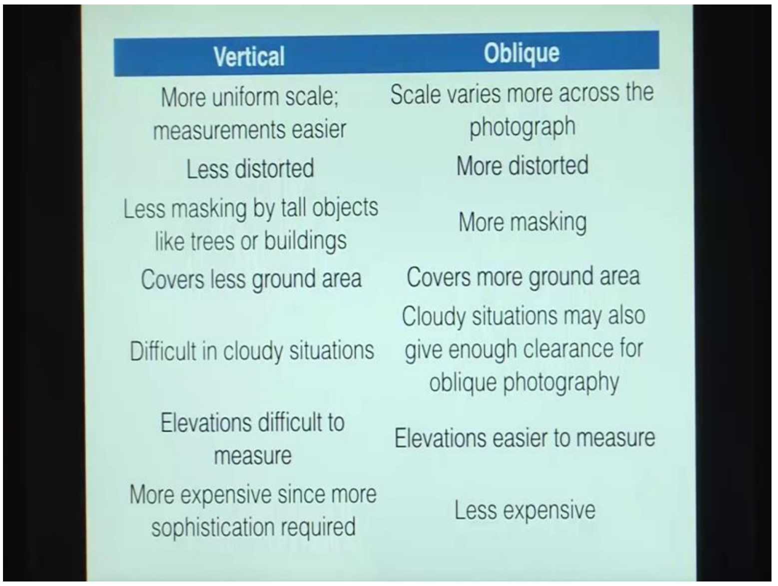
Then we also looked at far range photogrammetry and close range photogrammetry. So, in the case of far range photogrammetry, the focus is at infinity in the case of close range photogrammetry the focus is at a finite distance.

(Refer Slide Time: 14:16)



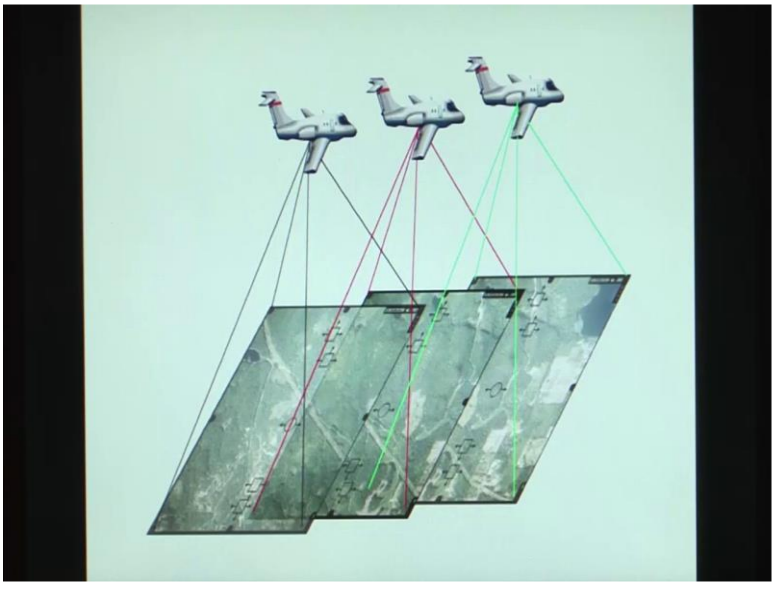

Then based on the orientation of the camera axis, we defined true vertical photogrammetry near vertical and oblique photogrammetry. Now in the case of oblique we again divided it into high oblique and low oblique; in the case of high oblique we can see the horizon in all the photographs, in the case of low oblique we cannot see the horizon.

(Refer Slide Time: 14:33)



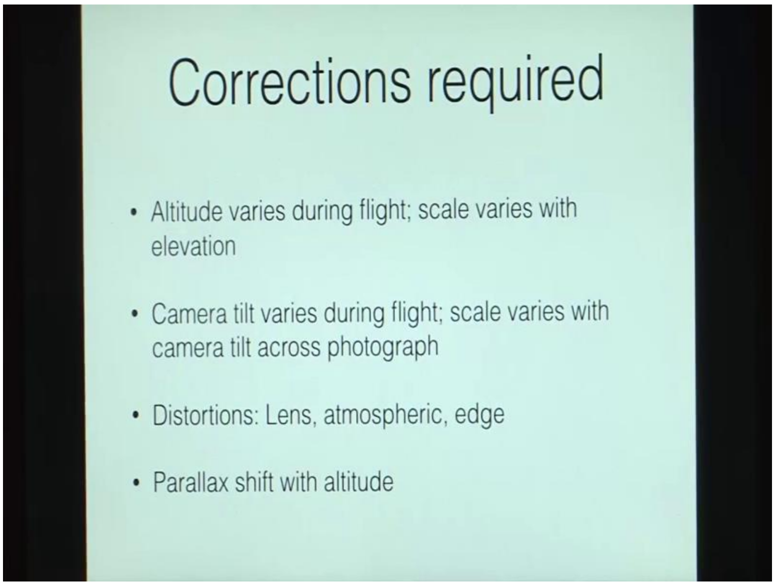

So, we looked at differences between vertical and oblique photography photogrammetry and when do we use what.

(Refer Slide Time: 14:41)



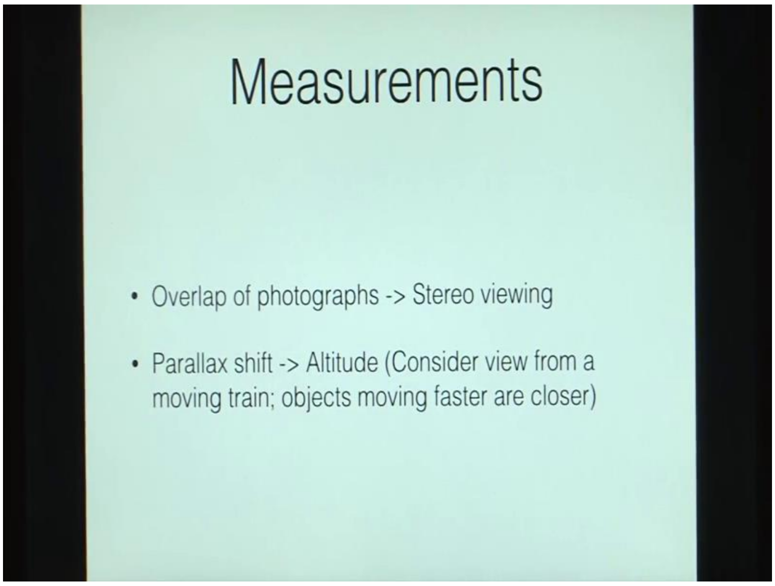
Then we saw that in the case of aerial photogrammetry, specially the photographs that are taken have some amount of overlap between two pictures and this amount of overlap is then used for triangulating different distances.

(Refer Slide Time: 14:56)



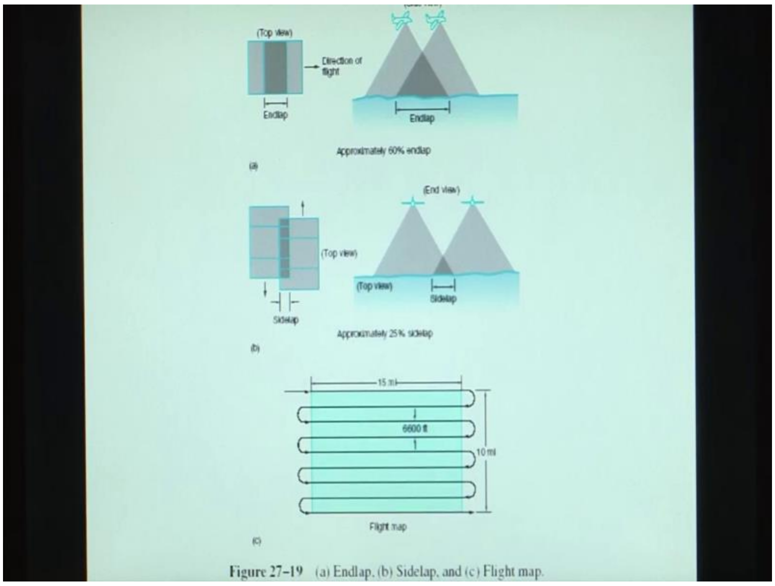

So, there are a number of corrections that are required. So, these corrections can these days we done automatically by using a number of different softwares.

(Refer Slide Time: 15:05)



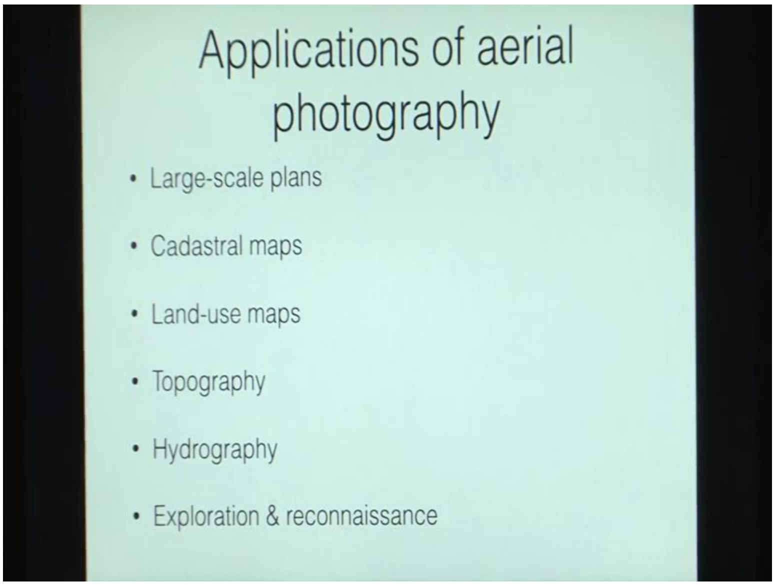

Then we can take measurements by using this principle of a stereo viewing.

(Refer Slide Time: 15:09)




So, in all these photographs we have an overlap between the ends and overlap between the sites, and that can be used to do the measurements. Then we also looked at the applications of area photo photography.

(Refer Slide Time: 15:24)



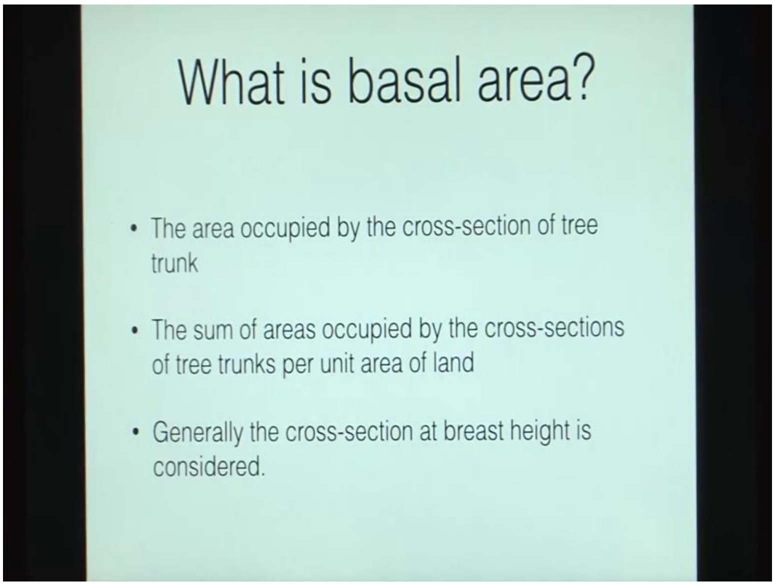

So, it can be used to construct a number of different maps, larger scale or small scale whether we can use to study hydrography of a location and we can also use it for exploration and (Refer Time: 15:35) purposes.

(Refer Slide Time: 15:41)


Then there are some other products that come out of this science of photogrammetry like digital elevation models or DEMs ortho photos thematic GIS data, and other derived products and maps.

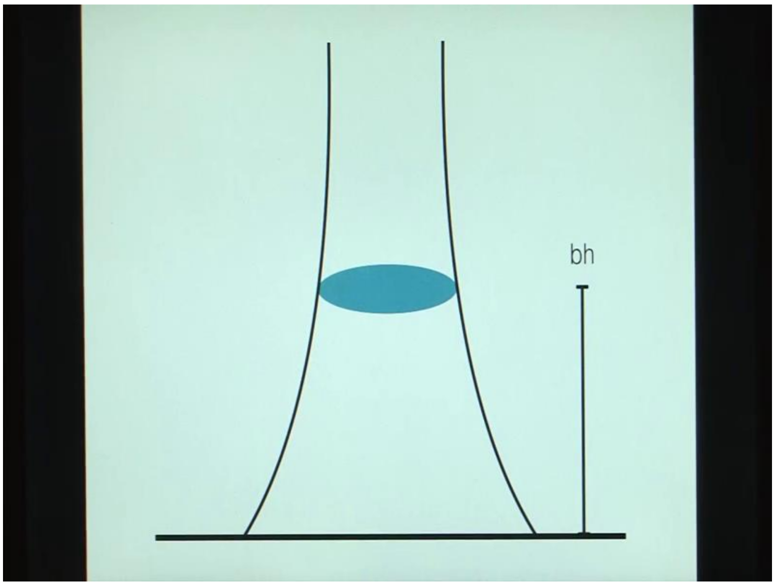
Now, in the next section we looked at the basal area of a tree and a stand.

(Refer Slide Time: 15:56)




So, we defined the basal area as the area that is occupied by the cross section of a tree truck.

(Refer Slide Time: 16:01)

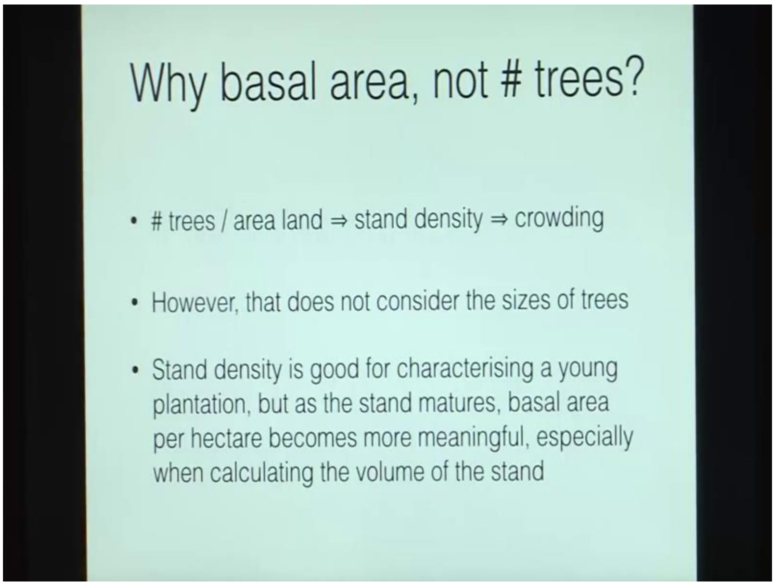



Usually measured at the breast height.

(Refer Slide Time: 16:04)

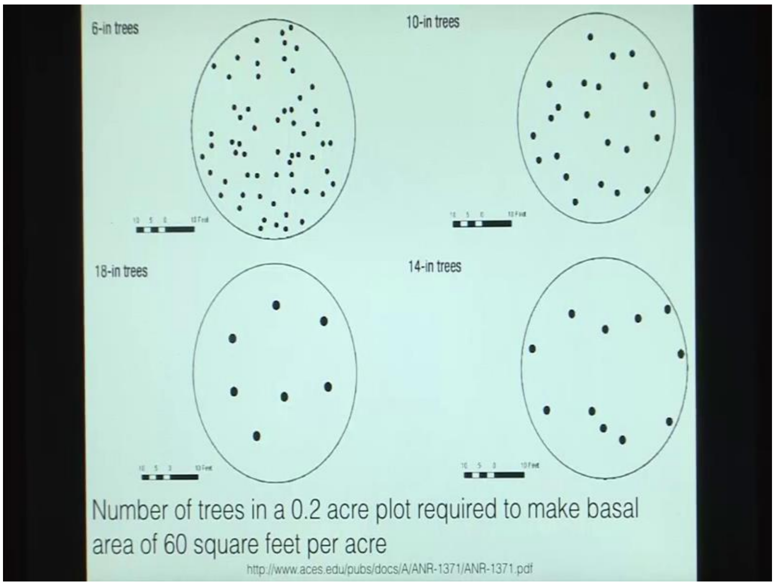

And we use basal area to get an estimate of the stand density, the stand volume, the stand growth and for forest management purposes.

(Refer Slide Time: 16:13)



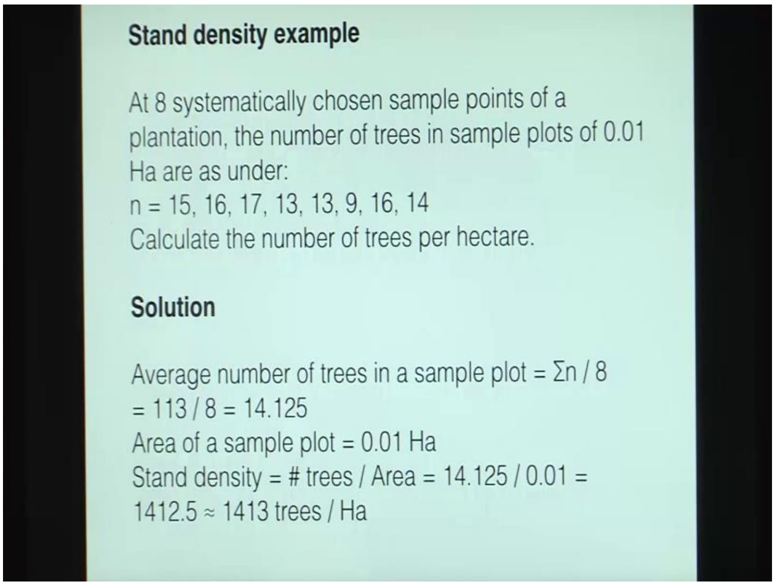

So, why do we use basal area and not the number of trees?

(Refer Slide Time: 16:17)



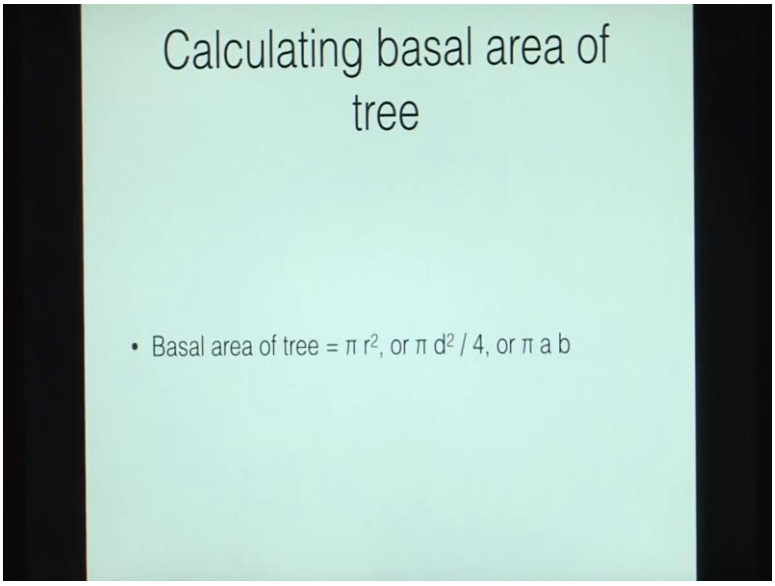

So, the number of trees or the number density is a very good indicator in case of plantations with young trees, but as our trees grow further. So, their diameter increases and the amount of space and the amount of nutrients, that they require also increases. So, in later cases are a number density is not that good a parameter as compared to the basal area density.

(Refer Slide Time: 16:41)



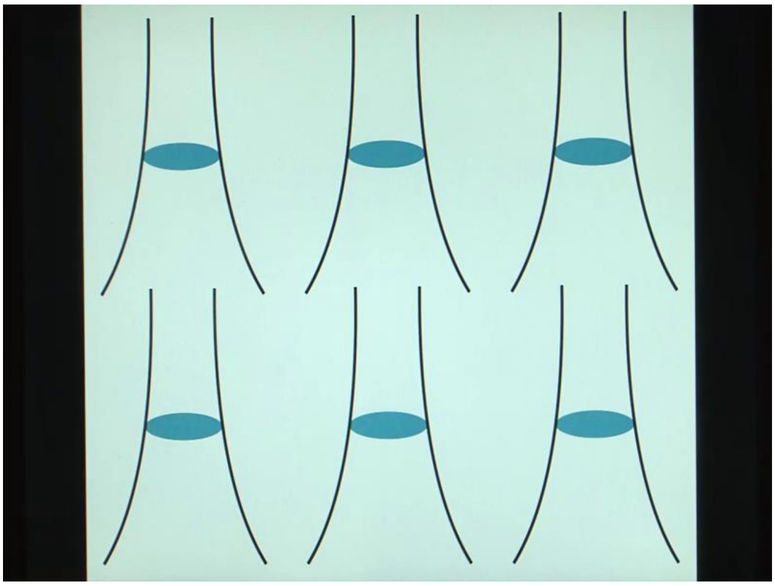

So, next we saw how do we calculate the stand density or the number density. So, we can count the number of trees per sample plot, divided by the area of the sample plot to get the stand density or the number density.

(Refer Slide Time: 16:52)

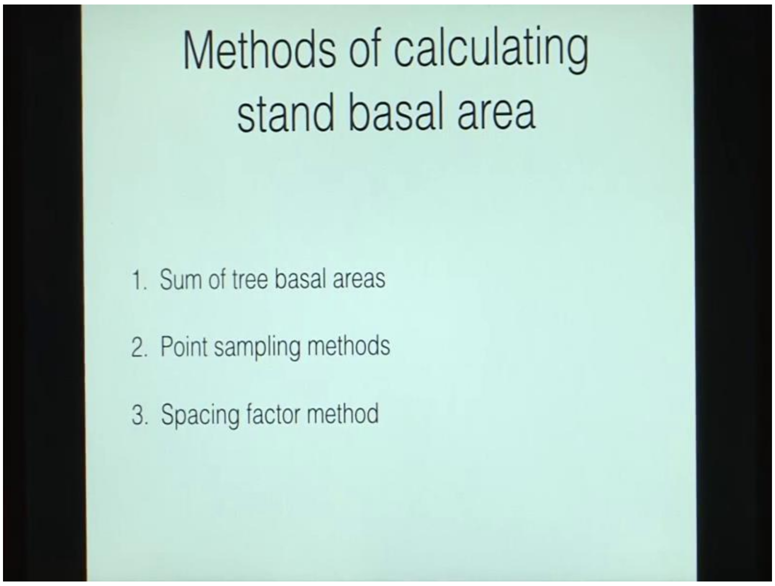



Then we looked at the calculation of the basal area of a tree. So, if you consider it to be having a circular cross section then you can use pi r square or pi d square by 4, and if you consider it to be having an elliptical cross section then you will go for pi a times where a and b are the half axis. So, next we looked at an example of finding a basal area, now in the case of a stand basal area it is the sum of the basal areas of all the trees, that are there in a sample plot divided by the area of that sample plot and it is represented in meter square per hector.

(Refer Slide Time: 17:19)

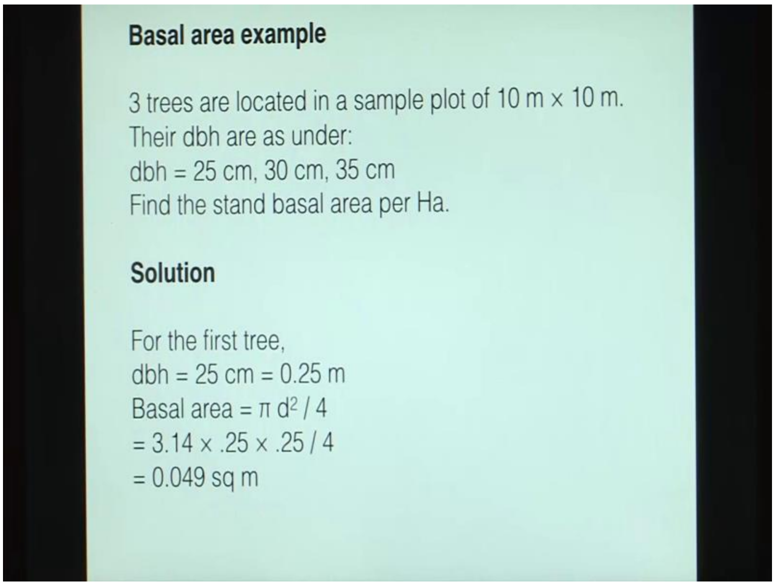


(Refer Slide Time: 17:31)



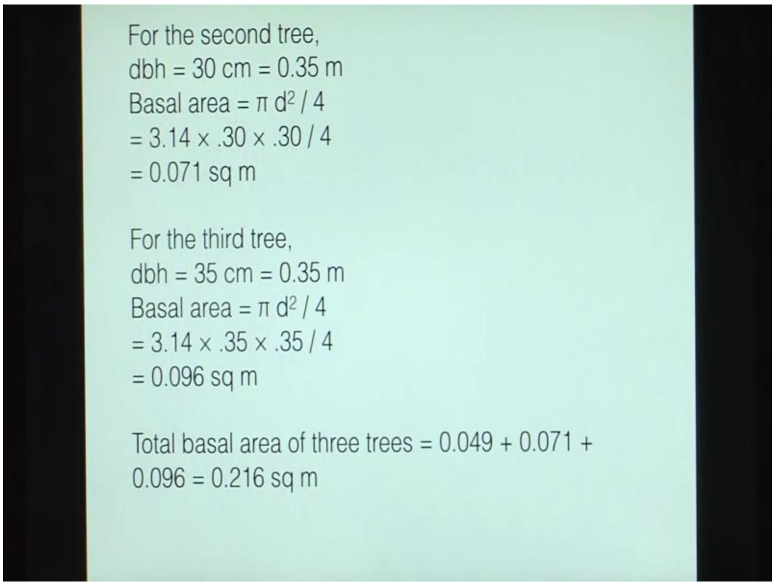

So, there are three methods of calculating stand basal area, we can do a sum of the tree basal areas we can use point sampling methods or we can go for a spacing factor method.

(Refer Slide Time: 17:42)

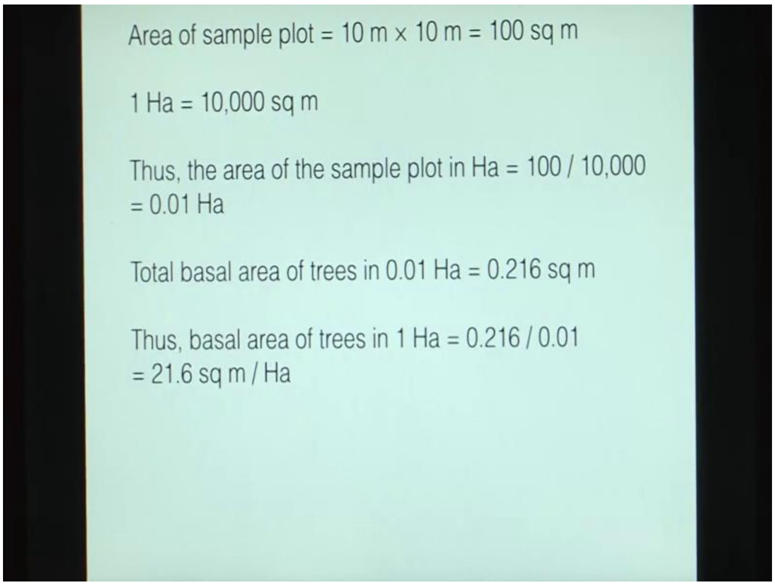



So, we first looked at this summation method. So, in which case we find out the basal areas for all the trees that are there in the area then we add them up to get the this total basal area.

(Refer Slide Time: 17:49)




(Refer Slide Time: 17:55)

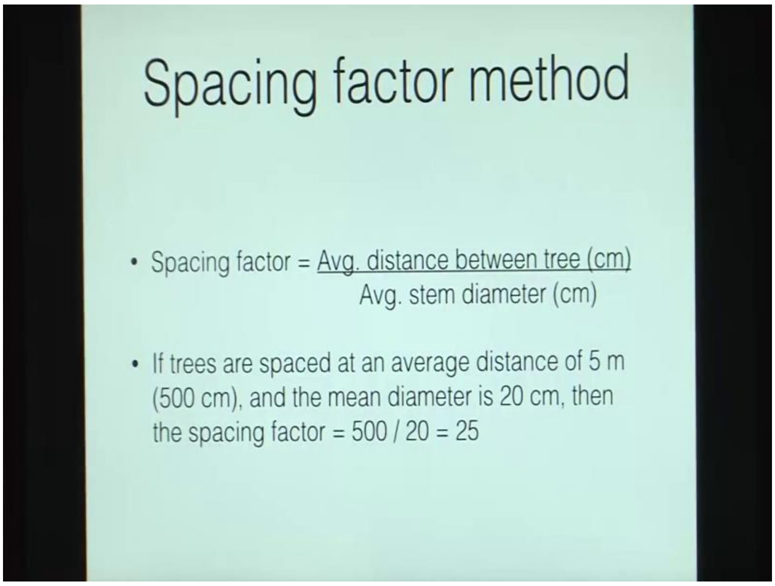



And then divided by the area of the sample plot to get the basal area of trees per hectare.

(Refer Slide Time: 18:03)

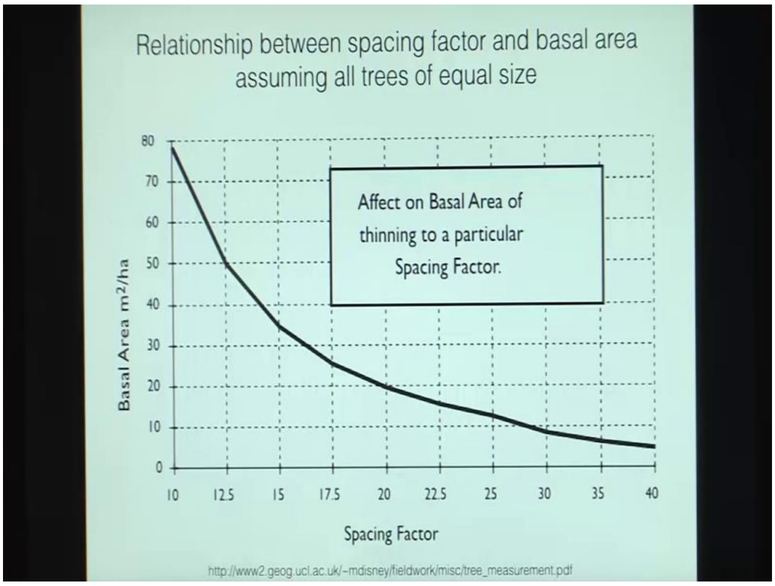

Next we looked at the other two methods of calculating the stand basal area, and also looked at crop diameter and crop age.

(Refer Slide Time: 18:08)



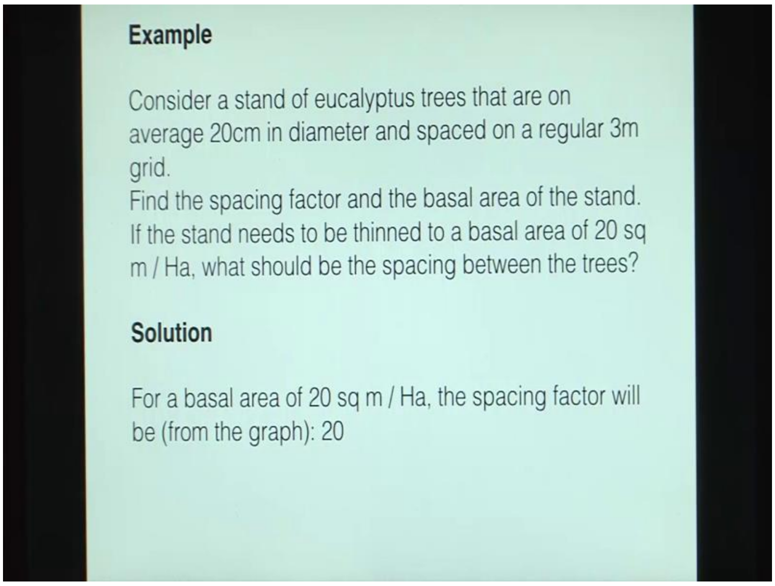

So, in the case of spacing factor method the spacing factor is given by the average distance between two trees divided by the average stem diameter between two trees, and we saw this theoretical construct in which the spacing factor is related to the basal area of the stand.

(Refer Slide Time: 18:26)



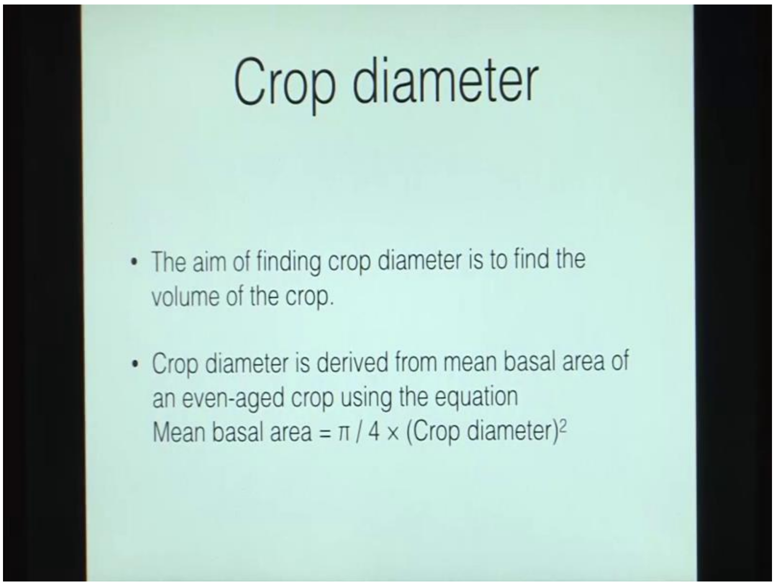

So, if we know any spacing factor we can figure out what is the basal area, and if we have if we know the basal area then we can calculate the spacing factor. Now spacing factor can be used. So, given our average tree diameter we use the spacing factor to figure out what is the average distance between two trees.

(Refer Slide Time: 18:45)



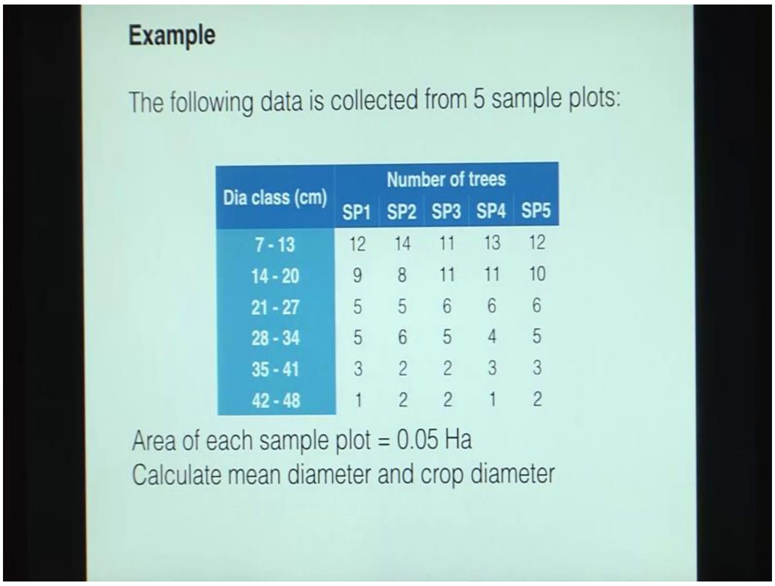

So, next we looked at this example in which we were asked to compute the spacing factor and the basal area of the stand from the graph. So, it can also be used to calculate the amount of thinning that is required and so, we looked at these examples.

(Refer Slide Time: 18:58)




Next we defined crop diameter. So, crop diameter is used to calculate the volume of the crop and we use crop diameter or d q, and we define it like this that the mean basal area of all the trees in the stand. So, here this mean basal area is the basal area of n number of trees divided by n, it is equal to pi by 4 into crop diameter square.

(Refer Slide Time: 19:24)



## Example

The following data is collected from 5 sample plots:

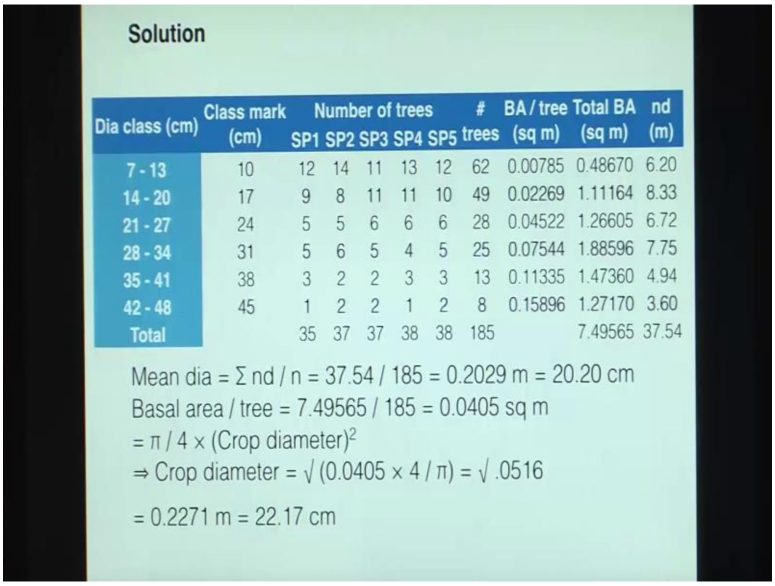
| Dia class (cm) | Number of trees | | | | |
|---|---|---|---|---|---|
| | SP1 | SP2 | SP3 | SP4 | SP5 |
| 7 - 13 | 12 | 14 | 11 | 13 | 12 |
| 14 - 20 | 9 | 8 | 11 | 11 | 10 |
| 21 - 27 | 5 | 5 | 6 | 6 | 6 |
| 28 - 34 | 5 | 6 | 5 | 4 | 5 |
| 35 - 41 | 3 | 2 | 2 | 3 | 3 |
| 42 - 48 | 1 | 2 | 2 | 1 | 2 |

Area of each sample plot = 0.05 Ha

Calculate mean diameter and crop diameter

So, next we were we saw this example of how to calculate the mean diameter, and the crop diameter.

(Refer Slide Time: 19:30)



## Solution

| Dia class (cm) | Class mark (cm) | Number of trees | | | | | # trees | BA / tree (sq m) | Total BA (sq m) | nd (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | SP1 | SP2 | SP3 | SP4 | SP5 | | | | |
| 7 - 13 | 10 | 12 | 14 | 11 | 13 | 12 | 62 | 0.00785 | 0.48670 | 6.20 |
| 14 - 20 | 17 | 9 | 8 | 11 | 11 | 10 | 49 | 0.02269 | 1.11164 | 8.33 |
| 21 - 27 | 24 | 5 | 5 | 6 | 6 | 6 | 28 | 0.04522 | 1.26605 | 6.72 |
| 28 - 34 | 31 | 5 | 6 | 5 | 4 | 5 | 25 | 0.07544 | 1.88596 | 7.75 |
| 35 - 41 | 38 | 3 | 2 | 2 | 3 | 3 | 13 | 0.11335 | 1.47360 | 4.94 |
| 42 - 48 | 45 | 1 | 2 | 2 | 1 | 2 | 8 | 0.15896 | 1.27170 | 3.60 |
| Total | | 35 | 37 | 37 | 38 | 38 | 185 | | 7.49565 | 37.54 |

Mean dia = $\Sigma$ nd / n = 37.54 / 185 = 0.2029 m = 20.20 cm

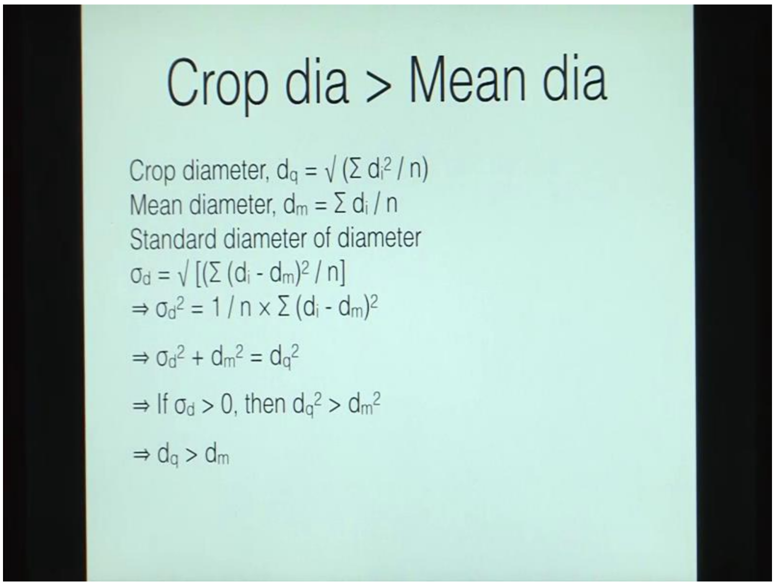
Basal area / tree = 7.49565 / 185 = 0.0405 sq m

= $\pi$ / 4 × (Crop diameter)$^2$

$\Rightarrow$ Crop diameter = $\sqrt{}$ (0.0405 × 4 / $\pi$) = $\sqrt{}$ .0516

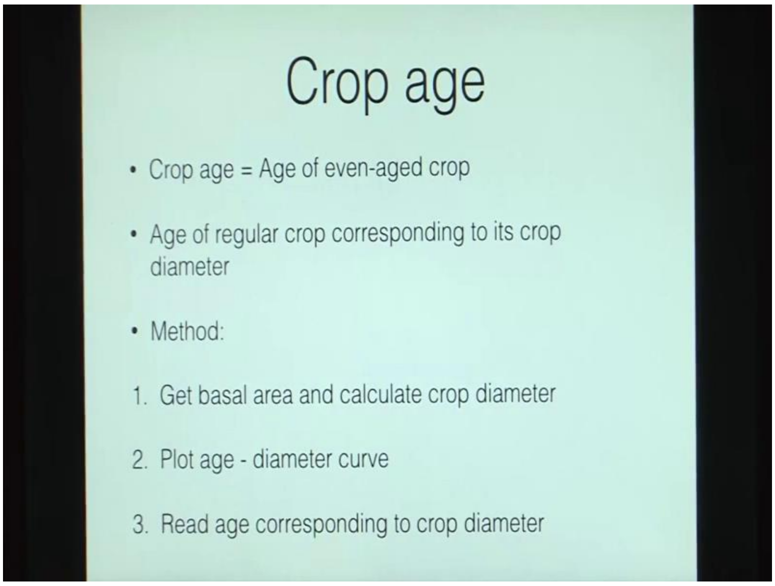
= 0.2271 m = 22.17 cm

(Refer Slide Time: 19:32)




And we saw that crop diameter is always greater than mean diameter. So, we also computed how we can prove this.

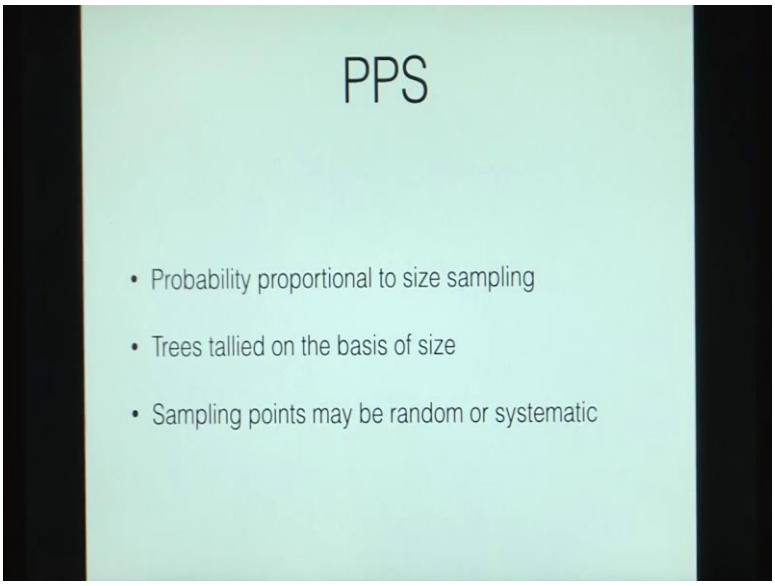
(Refer Slide Time: 19:39)




Next we looked at crop age which is the age of an even aged crop. So, in this case to find out a crop age we take the basal area and calculate the crop diameters. So, crop a diameter is given by the mean basal area per tree is equal to pi by 4 d square.

Then we plot an age versus diameter curve and we read the age corresponding to the crop diameter and that is called the crop age. So, that is not the mean age of the crop that is a different figure that we get out of the crop diameter. So, it is not from the mean diameter, it is the crop diameter. So, that is something that you need to remember.

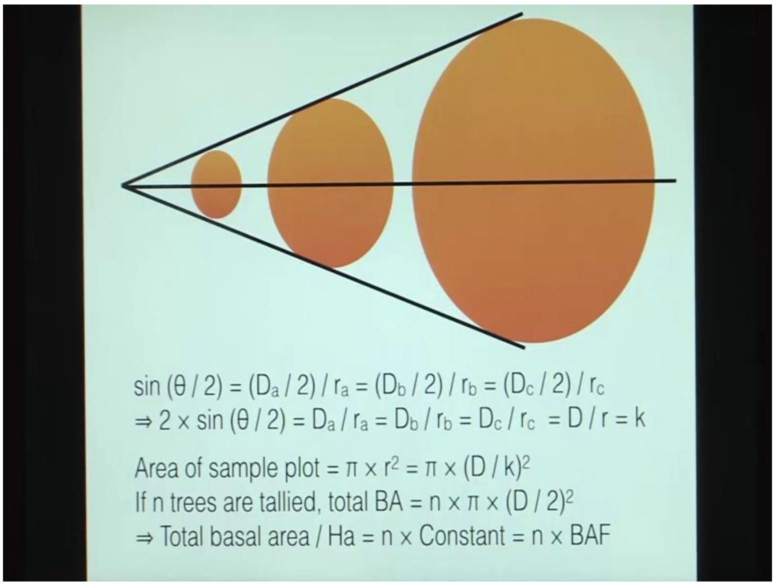
(Refer Slide Time: 20:17)



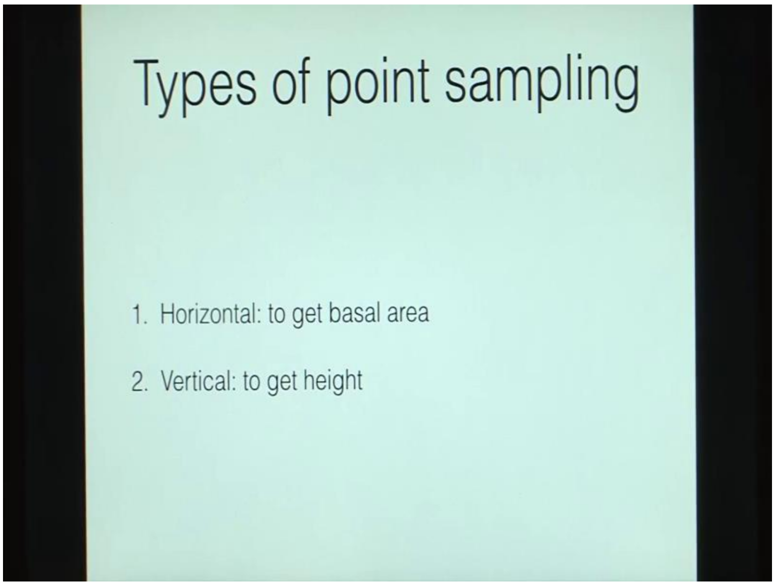

So, point sampling is a sampling that goes by the name of pps. So, it is probability propositional to size sampling. So, in this accuse if we maintain a constituent critical angle. So, we can use that critical angle to get the sum of the basal areas of trees, and we can also use it to get the basal area of the stand by using the equation, that the basal area of the stand is equal to n times the basal area of factor.

Now, this basal area factor is computed from the critical angle.

(Refer Slide Time: 20:29)

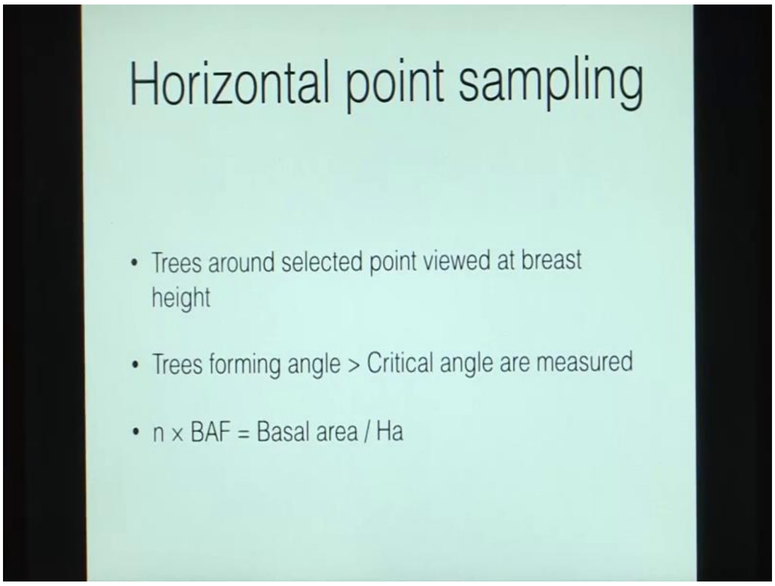



(Refer Slide Time: 20:51)



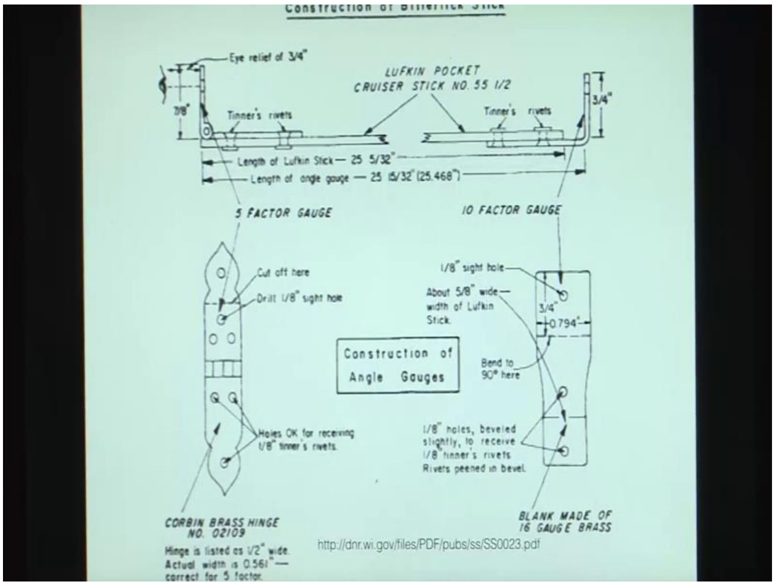

So, there are to two types of point sampling, it can be in a horizontal fashion to get the basal area or it can be done in a vertical fashion n to get the height.

(Refer Slide Time: 20:58)




So, in the case of horizontal point sampling, the trees are measured at breast height you can use any instrument.

(Refer Slide Time: 21:07)



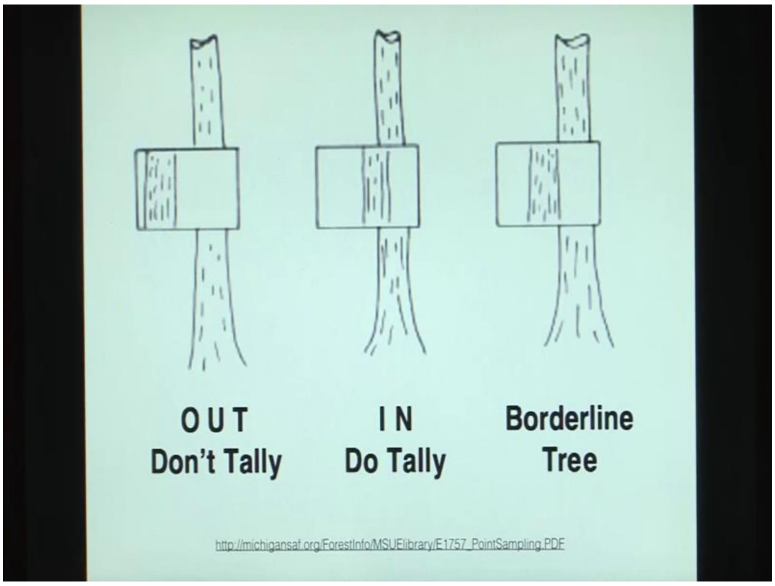

You can use specially constructed instruments or tubes or you can use even the end of a tape or you can use even a penny or you can use this instrument or that gives you three different basal areas or you can use the end of your thumb, and whenever you are using these instruments than any tree that subtends an angle that is greater than the critical angle is counted as a full tally.

(Refer Slide Time: 21:26)


Any tree that subtends an angle that is less than the critical angle is not counted, and any tree that subtends an angle that is equal to the critical angle is counted as a half tally.

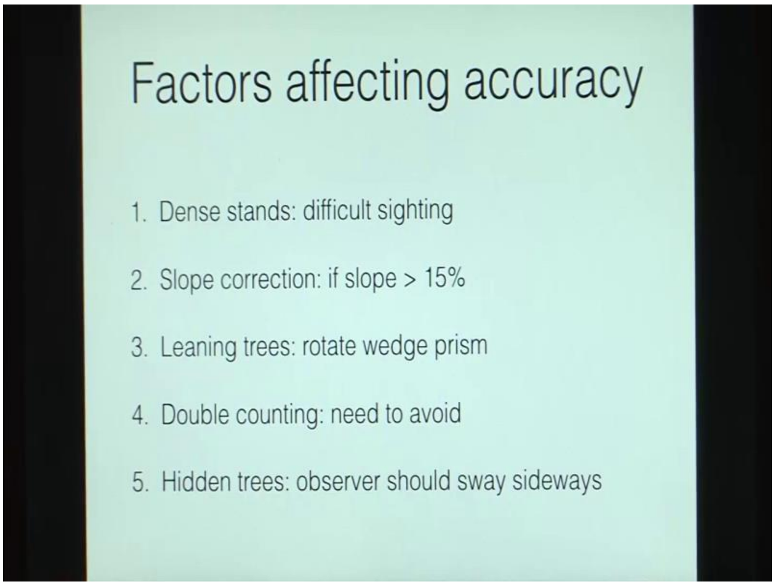
Then we also looked at a wedge prism. So, a wedge prism results in a displacement of the tree. So, when we use it to observe trees in a forest.

(Refer Slide Time: 21:53)



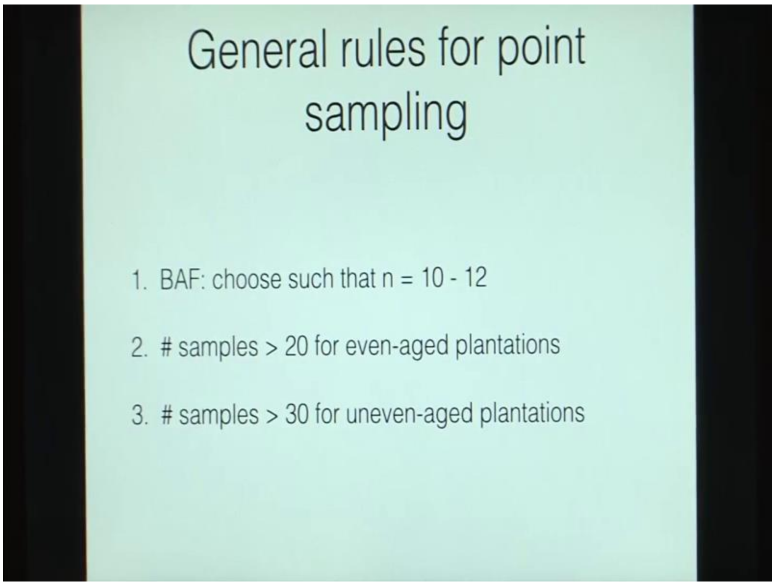

So, we can see some trees that are out. So, when they when they are completely out we do not tally them. If they are completely in then we call it a tally then we have a border line free in which the right edge of this displace free is meeting the left edge of the actual tree then we call it a borderline tree and we call it a half tally.

(Refer Slide Time: 22:14)




So, there are other number of factors that affect accuracy in the case of pps sampling. So, for instance it is difficult in the case of dense stands, we need to correct for slope we need to correct for leaning freeze. We need to ensure that that there is no double counting when we are going all around 360 degrees and then if there are some hidden trees then we need to go 60 degrees, and then if there are some hidden trees then we need to go sideways.

(Refer Slide Time: 22:38)




Now, these are the general rules for point sampling, we choose BAF such that the number of counts is between 10 to 12, and then the number of samples is also given.

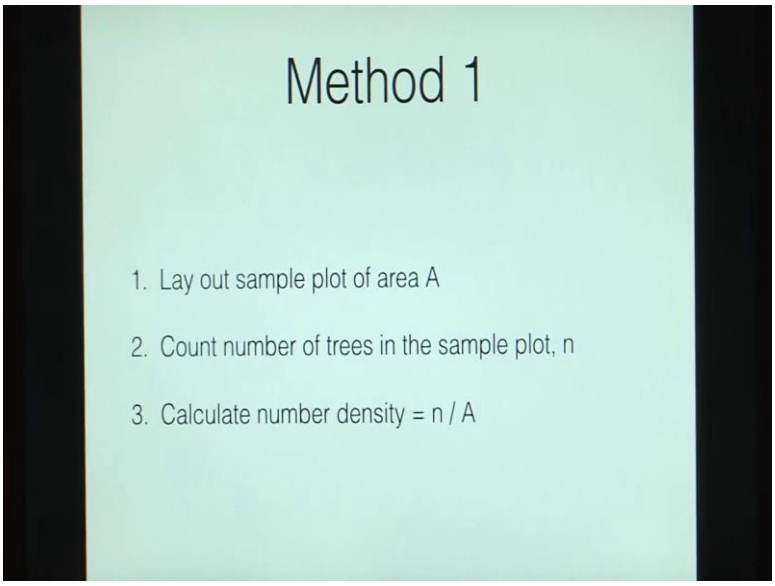
So, now the computations from point sampling, so we can compute the number of trees per hectare by this equation, the number of trees per hectare is the basal area factor that is given from the instrument itself, multiplied by sum of the inverse of basal areas of the tally trees. Then we also have we also calculate the number of trees per hectare in each diameter class, by multiplying the number of tally trees with the basal area factor and dividing it by the basal area of the midpoint of the diameter class.

Then we can also calculate the standard basal area per hectare as we have seen before it is n into BAF. So, next we use next we saw some examples in which we were asked to compute, the number of trees per hectare and the number of trees in each diameter class. So, that was given next we looked at the advantages and limitations of point sampling.

So, there is no need to fix any to lay any fixed area sample plot. So, it is save a lot of time; plus in the case of pps sampling the high value trees are sampled in greater numbers. So, because high value trees are what we are we want to know more about. So, these are trees with larger diameters. So, these are those trees that can be extracted very easily from the forest. So, that is another advantage, there is no need to directly measure diameter for basal area per hectare and volume calculations and it is quick especially for reconnance reconnaissance surveys. So, even if there is some amount of error or if there are some limitations, even though even then we can use it you can reconnance reconnaissance surveys use to get a quick figure.

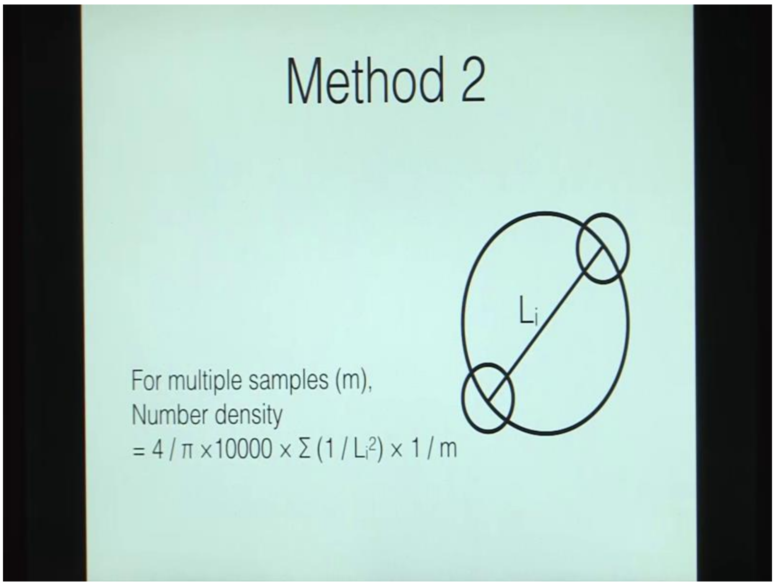
Now, we also looked at its limitations, we cannot calculate sampling intensity it is difficult to calculate plus it requires some skill plus it is difficult in the case of heavy undergrowth in the case of tropical forest, and then because we only have a value between 10 to 12. So, even a small error in tallying can get exaggerated and then we need to take care of slope hidden trees and so on. Then we looked at the estimation of number density. So, number density or the standard density is given by number of trees per area.

(Refer Slide Time: 25:06)



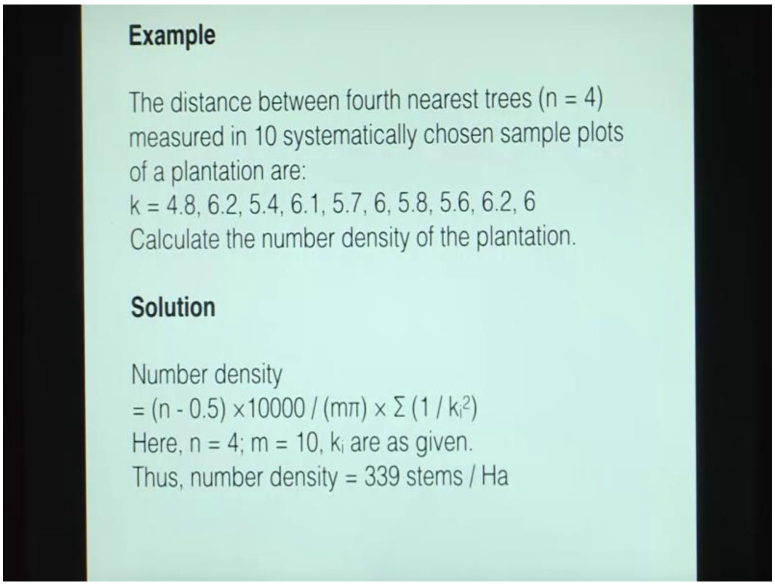

So, there are a number of methods to do it we can use a sample plot method in which we lay out a sample plot of area A, count the number of trees and then divide that figure by the area of the sample plot. So, we then looked at some examples.

(Refer Slide Time: 25:18)



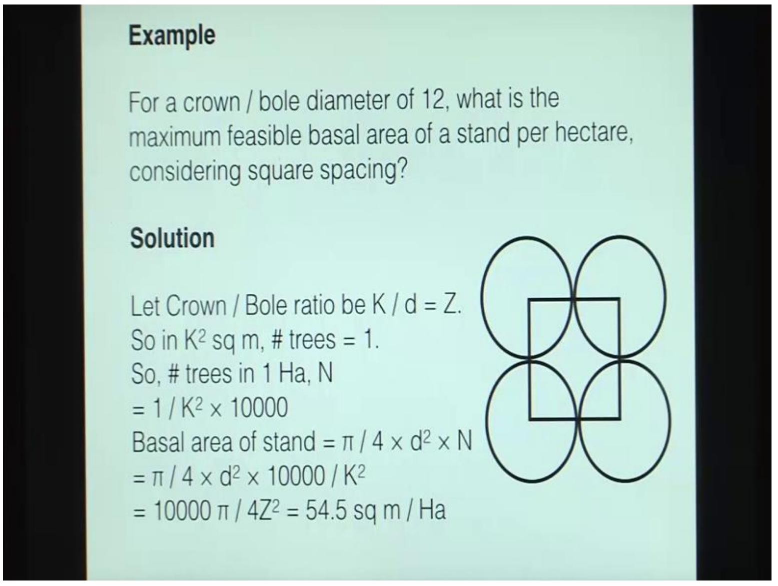

Next we saw this method in which we can find out this distance between nearest trees, and then we can use the equation as the number of trees per hectare is given by 4 by pi into then thousand by L i square and if we have a number of measurements then we can take the average of one by L i square. So, then we looked at some problems in which we use these equations, then another method is to compute distance not between the these nearest neighbors, but between the nth nearest neighbors. So, in that case we say that the number density is n minus half into 10000 divided by m pi into the sum of one over k i square, where k i is the distance between the nth nearest neighbors.

(Refer Slide Time: 26:13)



So, then we also looked at some examples, then next we looked at some other sample calculations. So, we looked at these methods again.

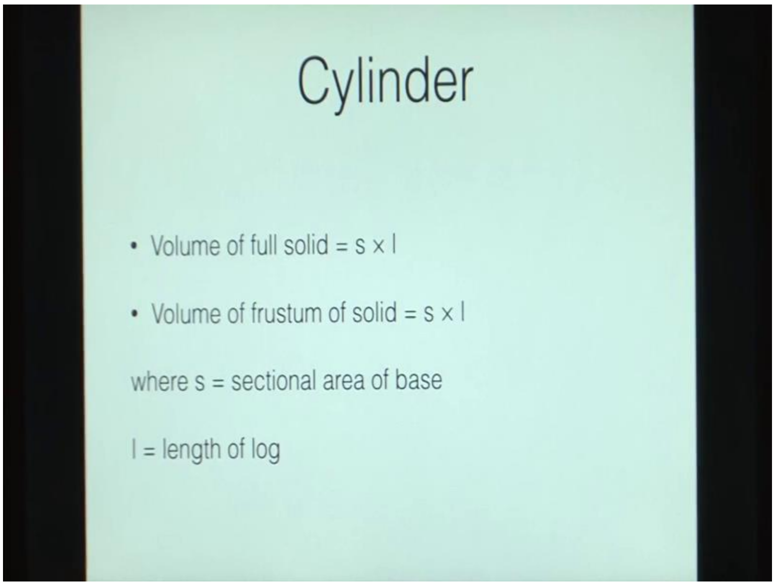
(Refer Slide Time: 26:24)




And then we looked at this crown by bole diameter if, that is given and if that is fixed then we can figure out the maximum feasible basal area of a stand per hectare given certain kinds of a spacings. So, for instance if you have a square spacing then the number of trees per hectare is given by 1 by k square into 10000, and the basal area of the stand is given by 10000 pi by 4 z square.

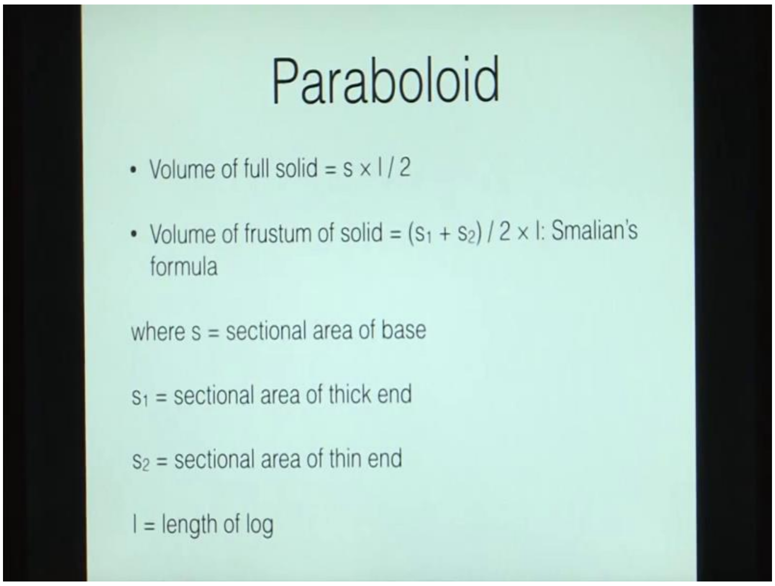
So, this crown by bole diameter is written as z. So, just by using this figure you can calculate the basal area of the stand. Next we looked at some other examples of how to use the basal area factor in the next section we looked at volume calculations. So, volume calculations can be done through sections. So, like in this example in which we have cut our tree in standard sizes and then we take the measurements.

(Refer Slide Time: 27:20)



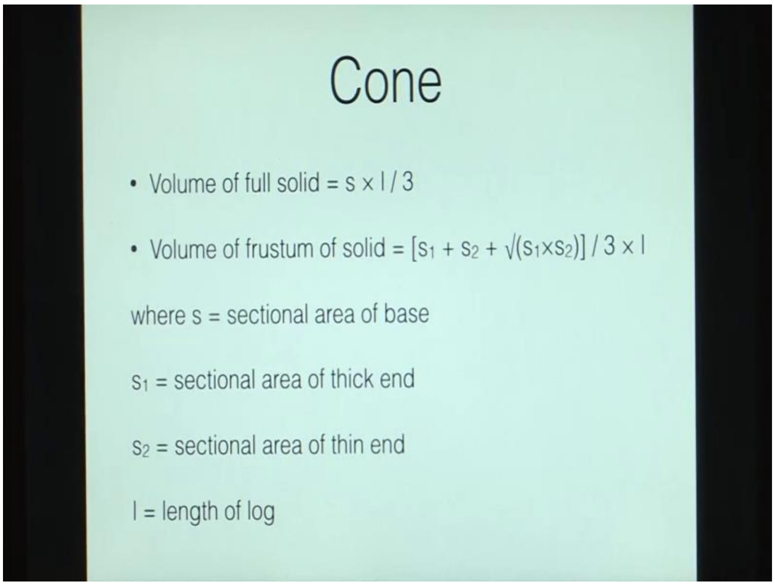

Then next we looked at the volumes of different forms. So, in the case of a cylinder we use pi r square into h, which can also be written as S into l.

(Refer Slide Time: 27:34)

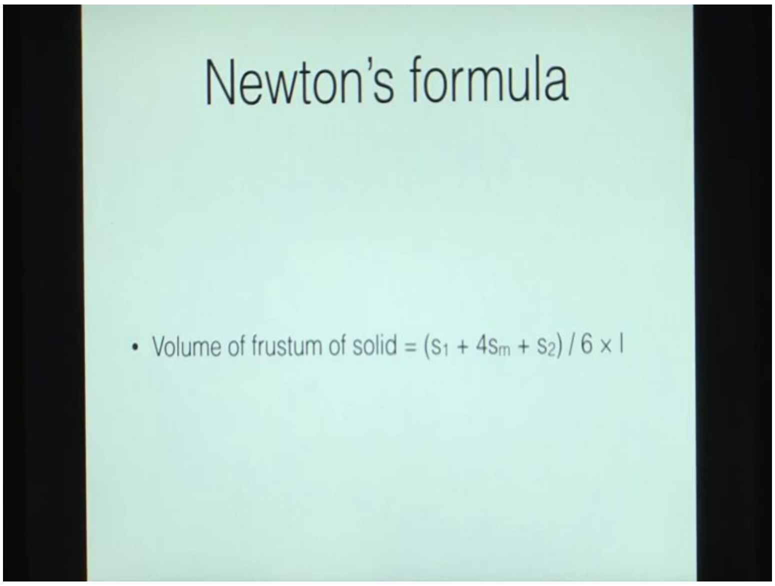



Then we looked at Smalians formula, Hubers formula and Newton’s formula for different solids and their frustums.

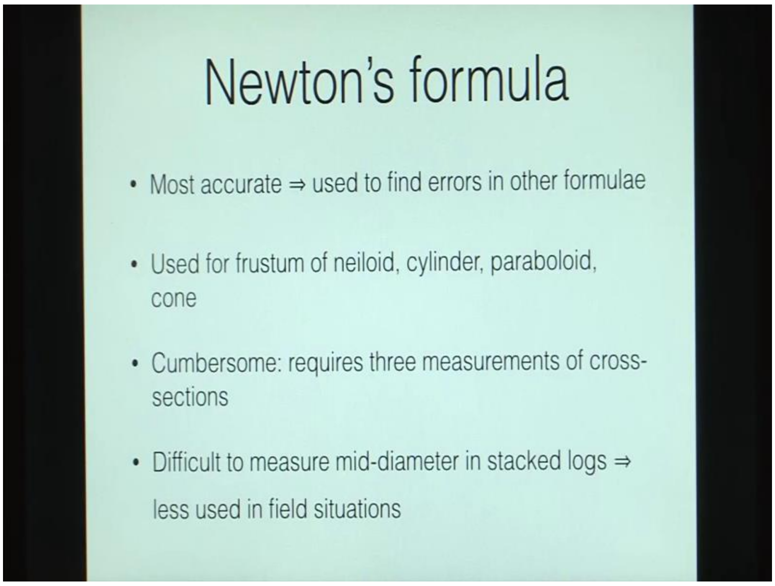
(Refer Slide Time: 27:40)




(Refer Slide Time: 27:44)

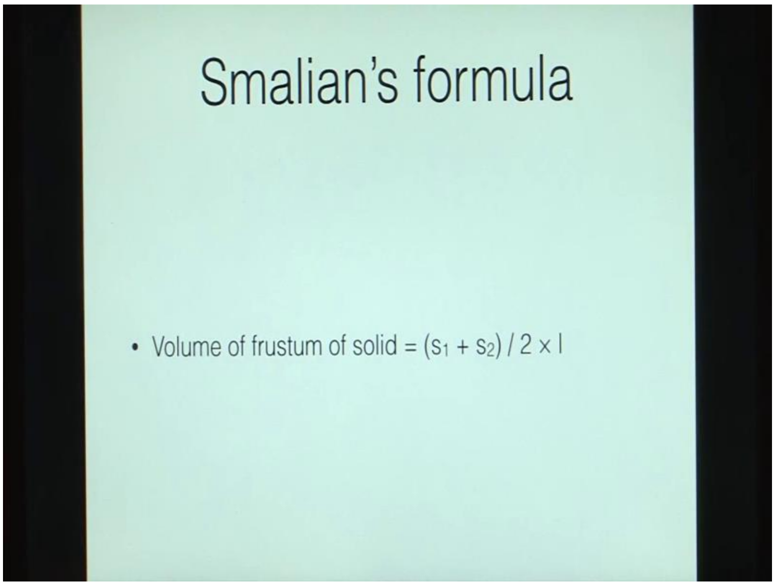


(Refer Slide Time: 28:03)



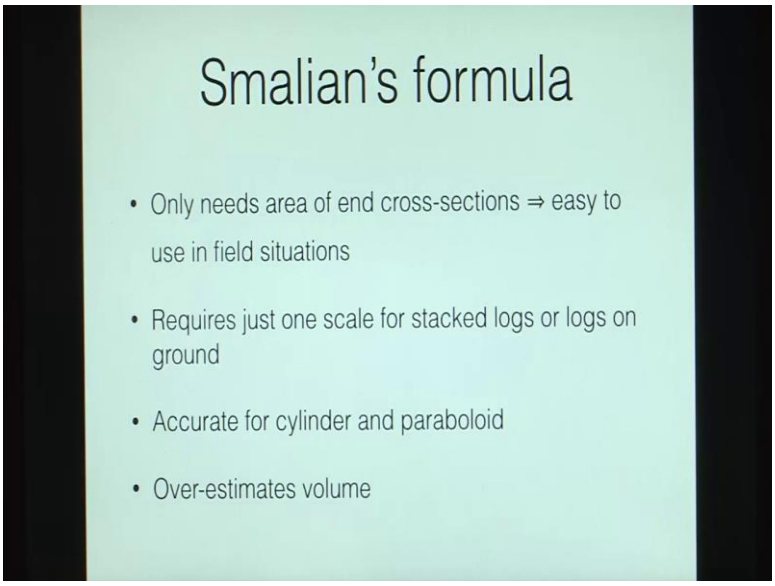

So, Newton's formula is considered to be the most accurate formula. So, in this case we multiply the length of the log by with 1 by 6 of S 1 and S 2. So, S 1 and S 2 are the end surface areas or the end basal areas, and 4 times of the middle basal area, that is Newton's formula.

(Refer Slide Time: 28:07)

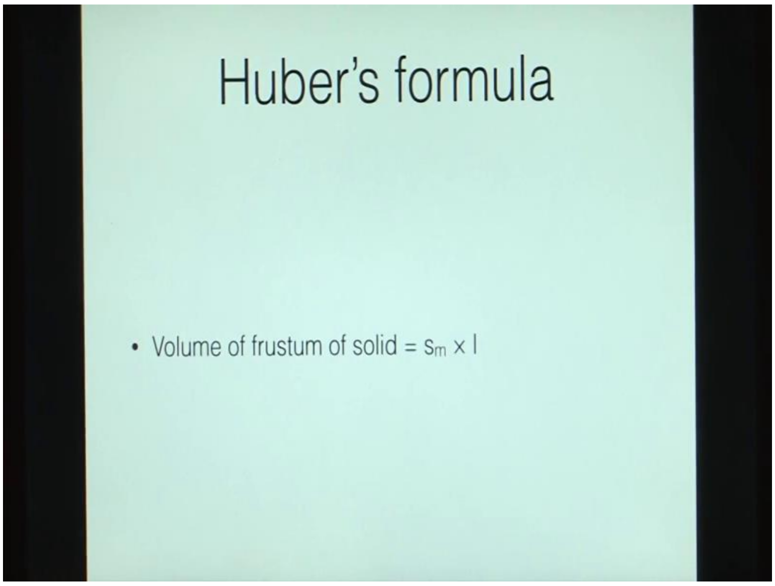



In the case of a Smalian formula we take two measurements of the of the two ends of the log, then take the average multiply that with the length and in the case of Huber's formula we just take one measurement at the middle, and we multiply that with the length.

(Refer Slide Time: 28:14)



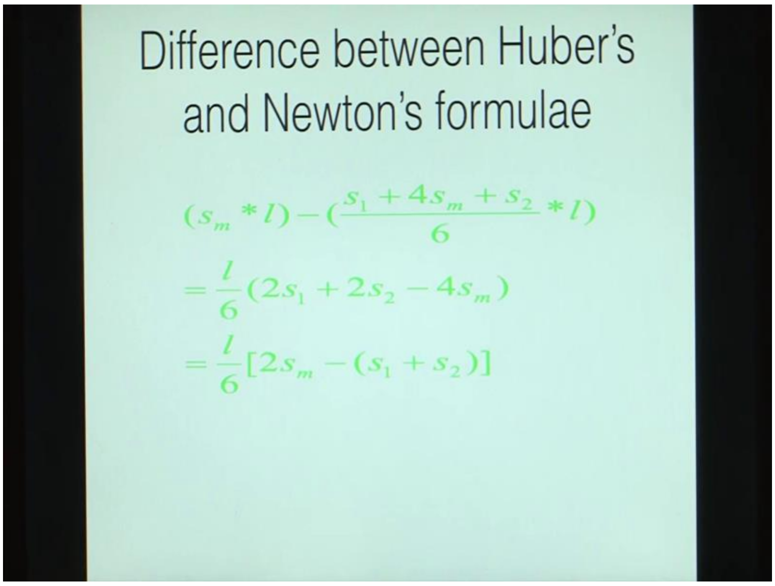

(Refer Slide Time: 28:16)



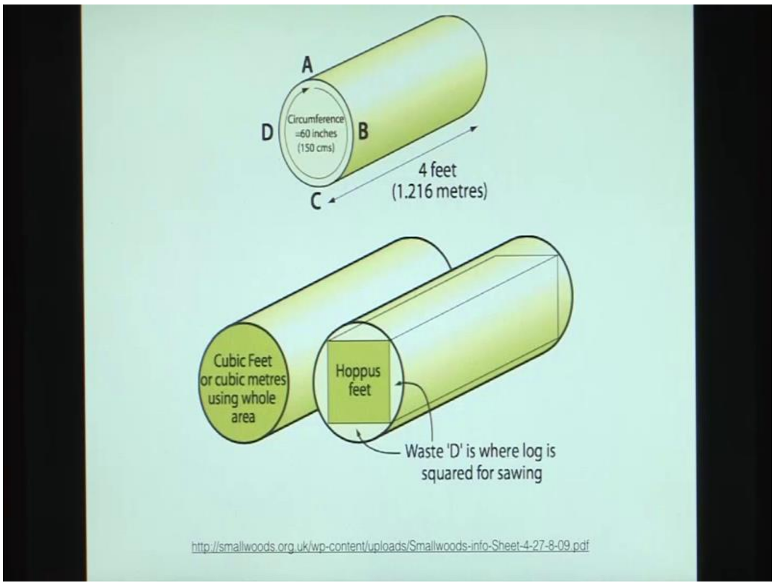

And then we saw that in the case of Smalian and. So, Newton's formula is used to calculate the errors in different other formulae.

So, in the case of Smalian formula and in the case of tubers formula the errors are on opposite sides of 0.

(Refer Slide Time: 28:32)

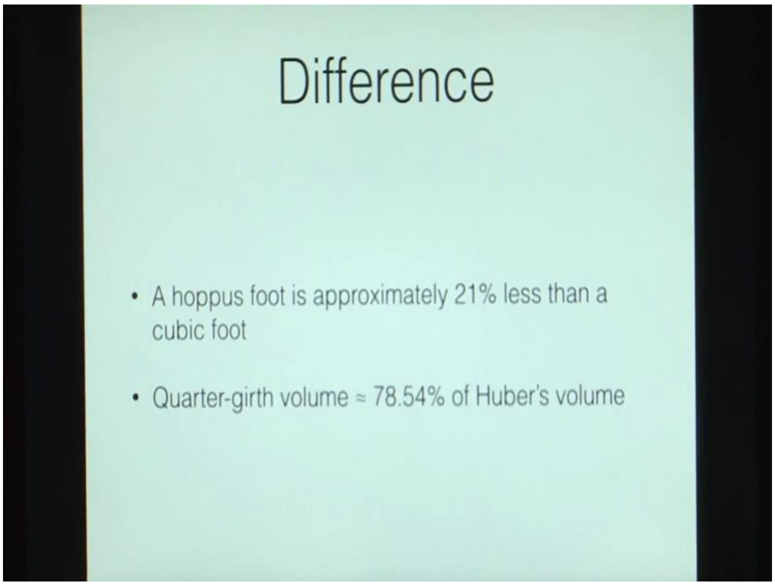



(Refer Slide Time: 28:42)



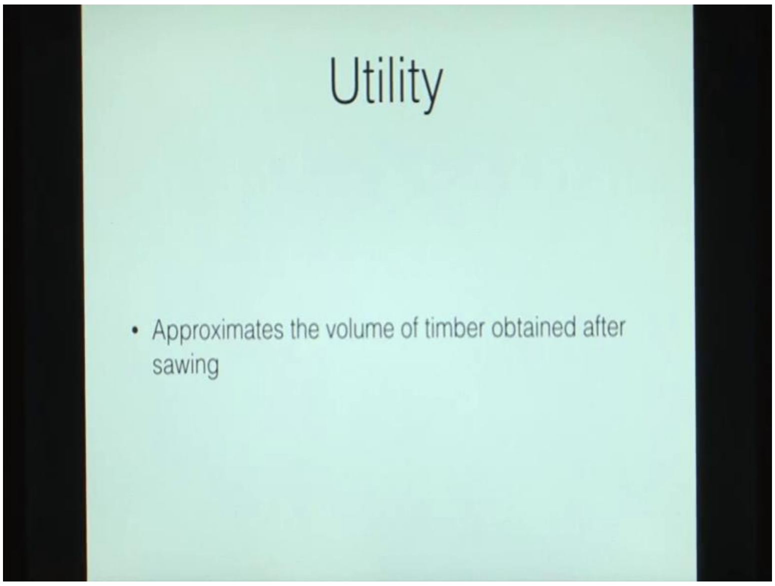

Now, we also looked at the quarter girth formula, in which we assume that our this is also known as the hoppers formula. So, in this case we assume that all these 4 D's will be lost out in sawing and the volume of our log that remains will be equal to g by 4 as the edge. So, it will be g by 4 into g by 4 into the length of the log.

(Refer Slide Time: 29:06)




So, next we saw that it is around say 78.54percent of the actual volume of the cylinder.

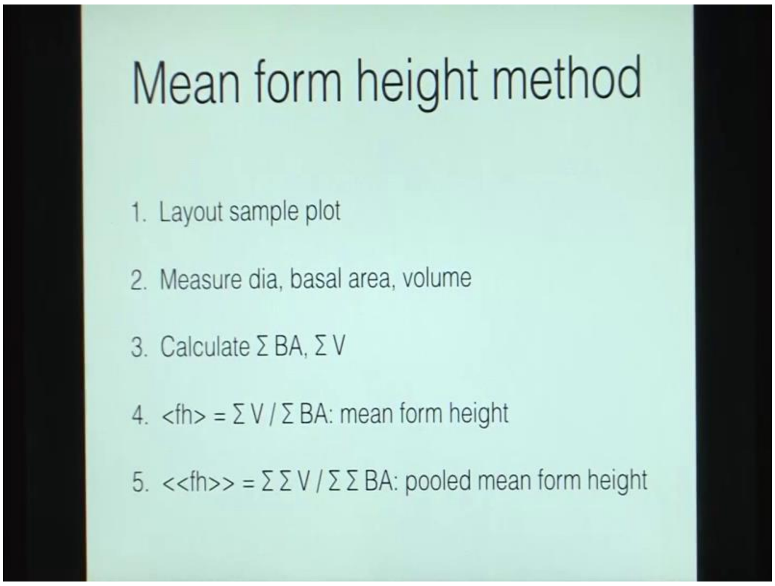
(Refer Slide Time: 29:14)




Now, it approximates the volume of timber that is obtained after sawing. So, that is one utility of it, then we also saw some computations of how to use the quarter girth formula.

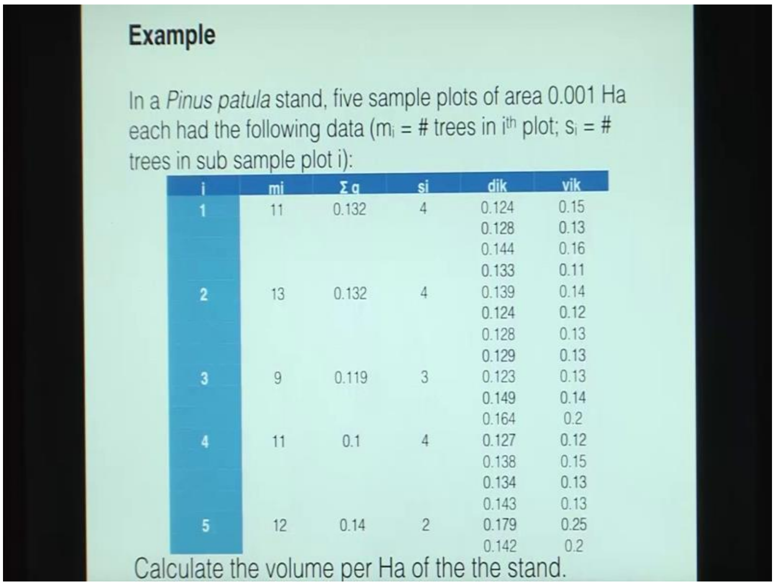
Next we looked the at volume computations in the field. So, one method is summing up the volumes of different trees that we can use, the next is the mean form height method.

(Refer Slide Time: 29:33)




So, mean form height is given by sum of the volumes divided by sum of the basal areas of the trees, and we can also use pooled mean form height by talking a measurements from a number of sample plots, and then we did this question in which we used both the fomite and the pool fomite to get the volume density.

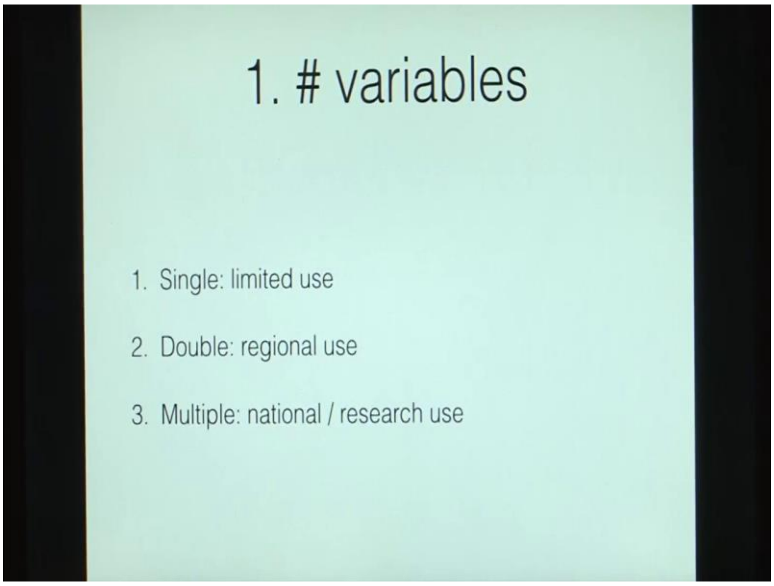
(Refer Slide Time: 29:52)




Then we also looked at the regression method of computation of the volumes. So, in this case we take the basal area and the volume, and then we use it to calculate a regression equation and that regression equation is then used to calculate the volume density of the stand.

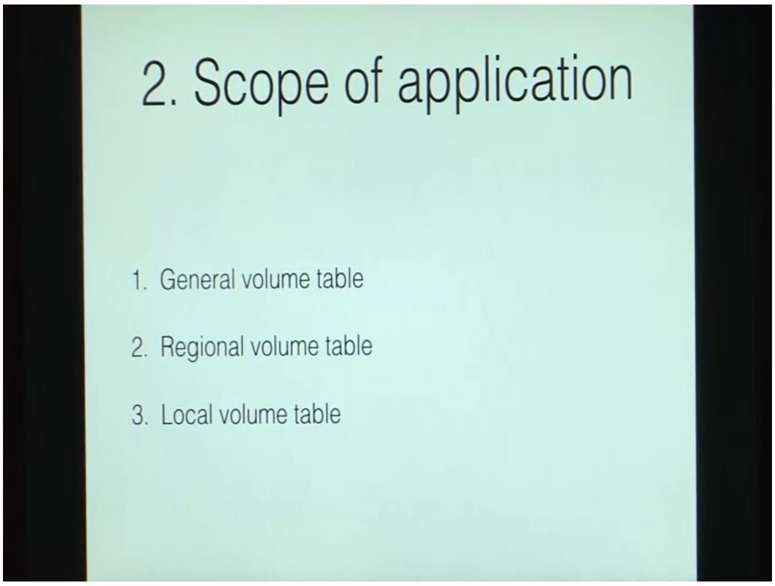
Next we looked at volume table. So, volume table is a table that shows volume of a given species for one or multiple dimensions. So, those dimensions can be diameter at beast height d b h and height, d b h height and taper. So, taper can be given in the e form of form factor and so on. So, there are a number of tables that are included in the volume table.

(Refer Slide Time: 30:40)



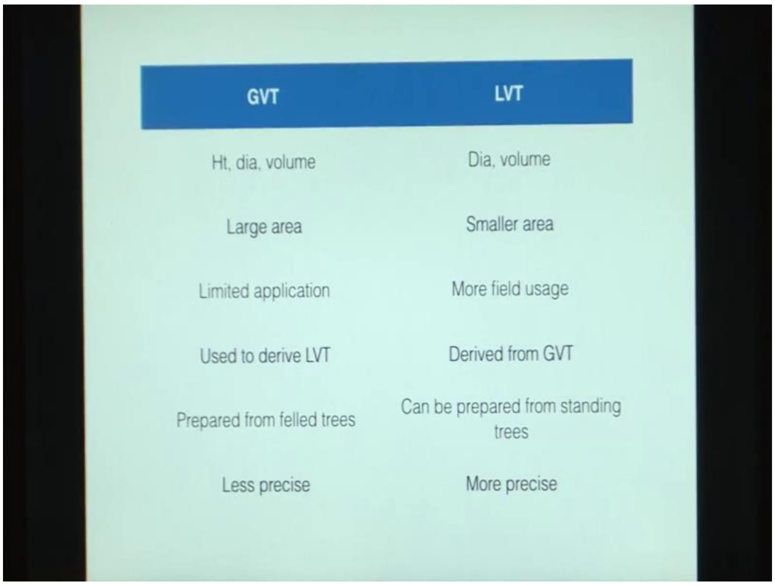

Now, depending on the number of variables we have three kinds of volume tables. So, we can have a single variable that is the d b h, we can have two variable that is dbh and its height for instance or we can have multiple variables such as dbh height form the form factor and so on.

(Refer Slide Time: 31:00)

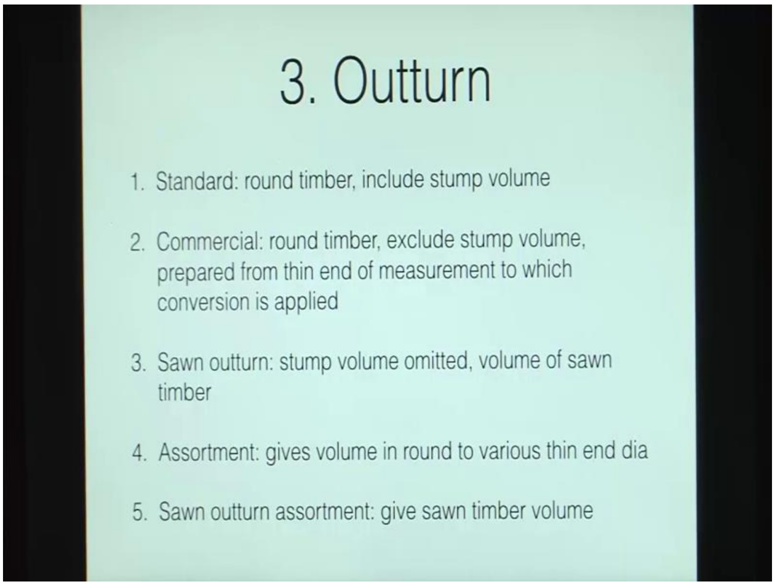



Then depending the scope of application we have general volume table, regional volume table and local volume table.

(Refer Slide Time: 31:06)

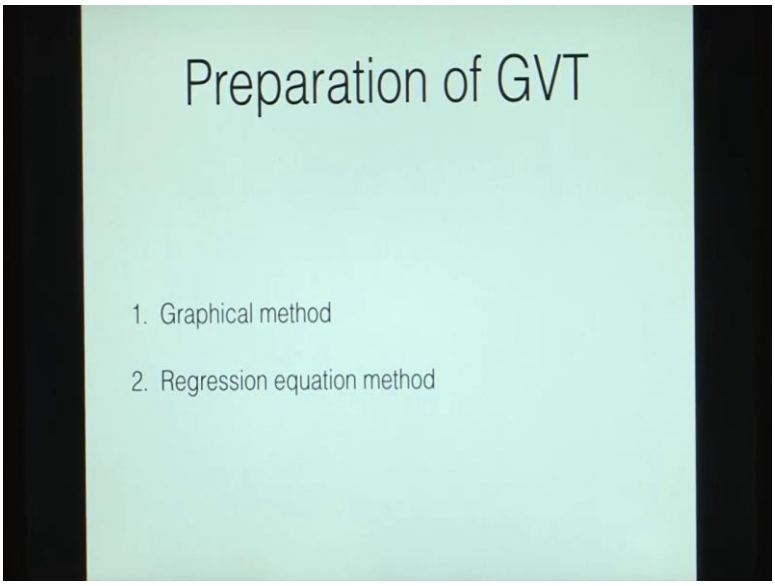


(Refer Slide Time: 31:09)

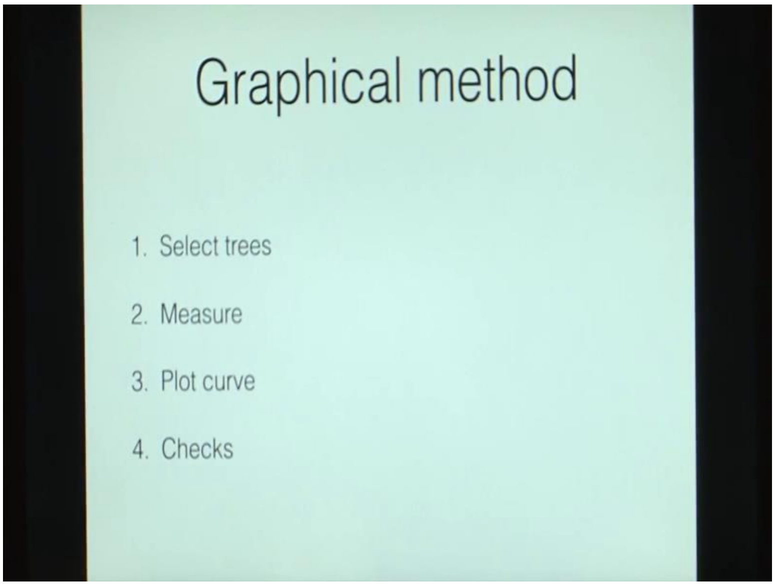



We looked at their differences then depending on the outturn that is what we are trying to measure we can have standard round timber, volume table, commercial round table volume table and so on. Then we looked at the preparation of general volume table and local volume table by graphical method and regression equation method.

(Refer Slide Time: 31:19)

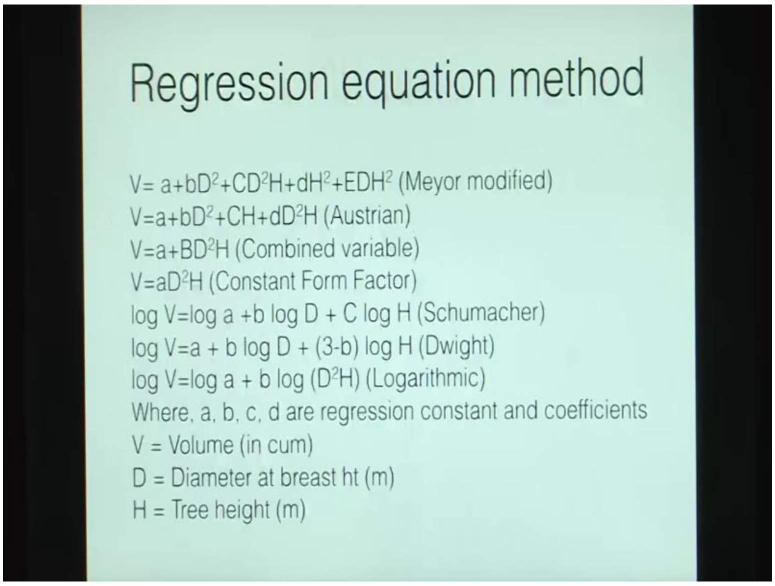


(Refer Slide Time: 31:28)




So, in the graphical method we select trees then we fell those trees, we measure those trees plot the curves do some checks and balances, and then we use those to get the general volume table and in the regression equation method.

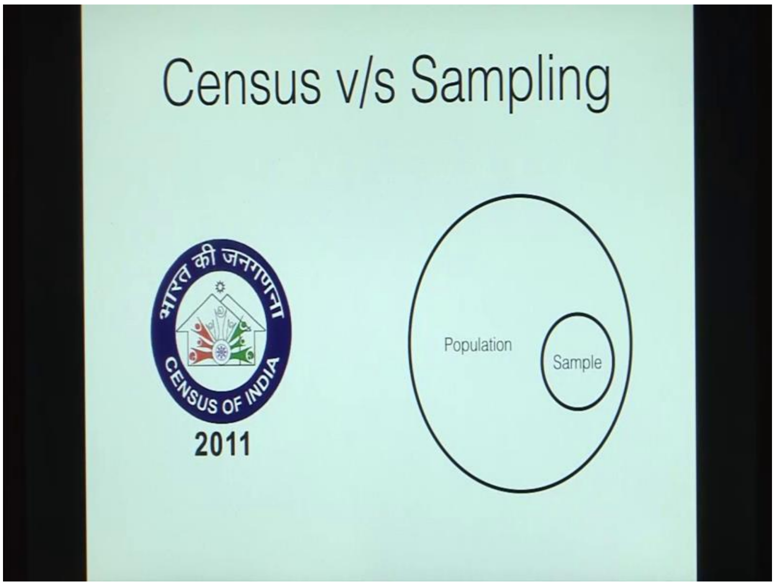
(Refer Slide Time: 31:40)




We define some generalized regression equations, and then we use the values of the trees that have been taken from the field to find out the these regression constants, and from that regression constant we can then find out a your general volume equation and the this general volume table.

Now, in the case of preparation of local volume table we plot our GVT values of volume diameter and height, and then we take our radians on the field and then we draw a smooth curve to get the local volume table. Then we looked at its utility and limitations we also looked at forest sampling and we also saw difference between census and sampling.

(Refer Slide Time: 32:27)




So, in the case of (Refer Time: 32:34) of census all the individuals and your population or all the units in the population are going to be measured, where as in the case of sampling we just take a small sample from the population take those measurements and then generalize them over the population.

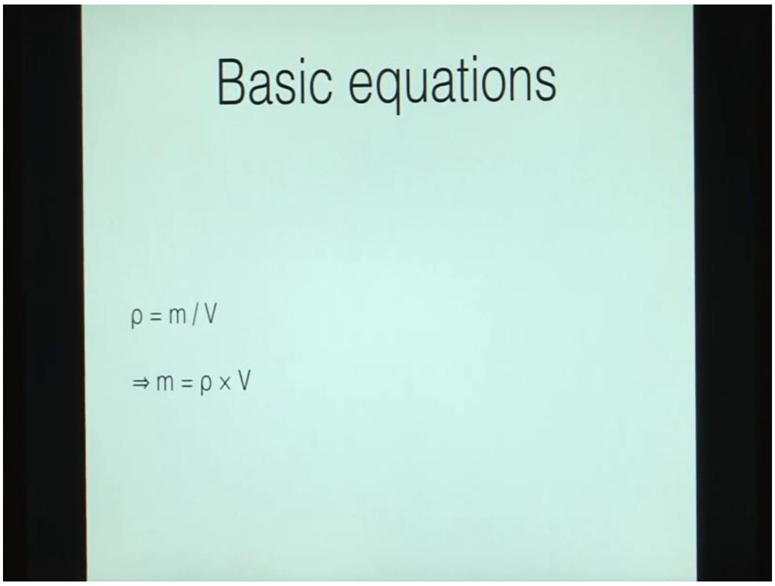
So, we looked at what is population sampling units sampling frame sample, sampling intensity and the kinds of plots.

(Refer Slide Time: 32:56)


So, you can have plots of different shapes and sizes, then we also looked at kinds of sampling. So, in the case of simple random sampling all the individuals at population have an equal probability of being a part of the sample, in the case of a systematic sampling we take every nth unit in the sample, in the case of stratified sampling we divide our population in to a number of strata and then we take a samples from each strata. In the case of multi stage sampling we define large units as large samples and then we take sub samples from there, and in the case of pps sampling that is similar to the point sampling, the probability of a unit getting into the sample is dependent on its size.

Next we looked at the density and mass measurements.

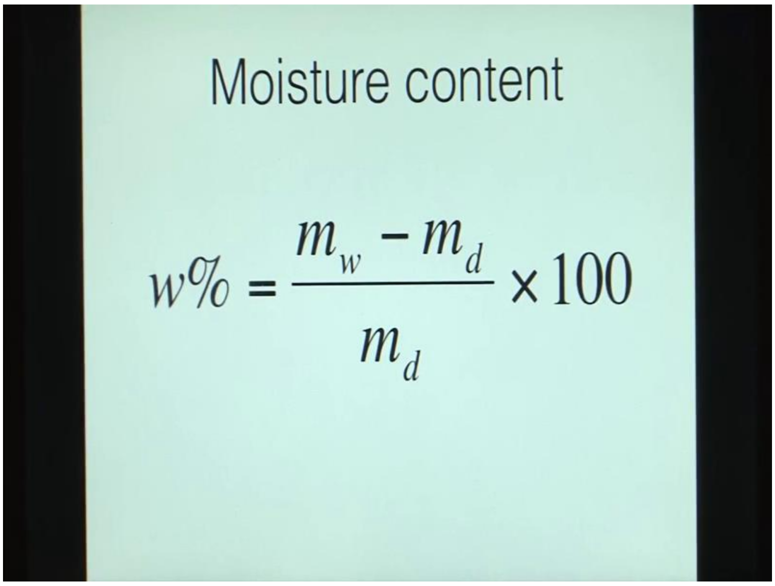
(Refer Slide Time: 33:44)



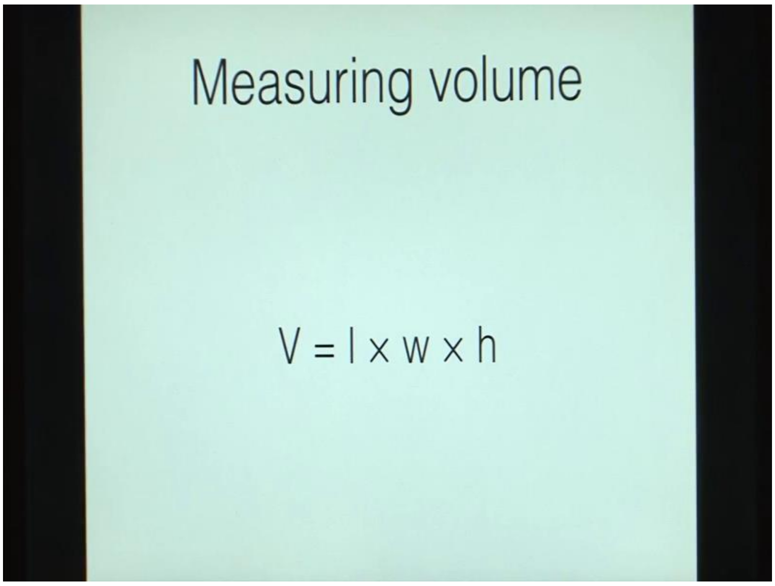

So, the basic equations are density is equal to mass by volume. So, why do we need this this density measurement? Because measuring the mass of large logs is difficult, but measuring their volumes is very easy. So, if we know the density of logs then we can calculate the mass of the logs, and mass of the logs can also be used to calculate the amount of sequestered carbon that is there in the logs or in the trees.

We looked at archimedes principle. So, we get our sample using an increment borer, now mass is very much dependent upon the amount of water content. So, we can take these measurements and then we can find out the moisture content.

(Refer Slide Time: 34:25)

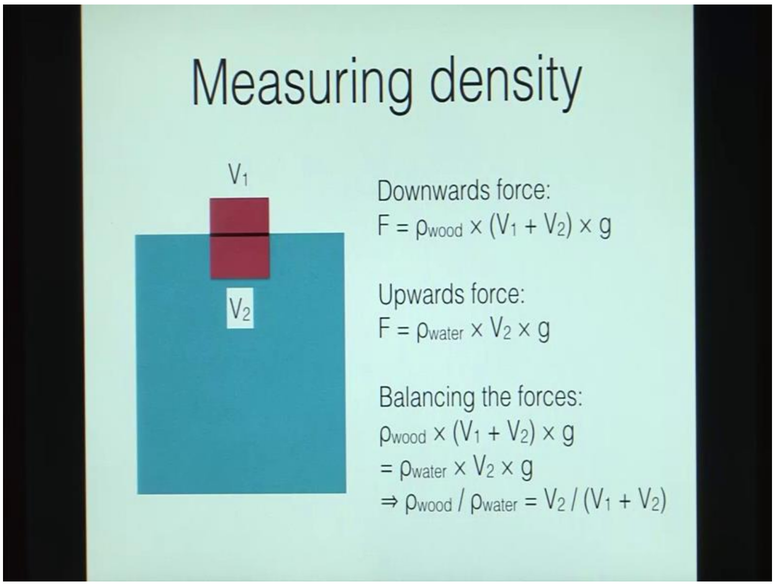



(Refer Slide Time: 34:27)



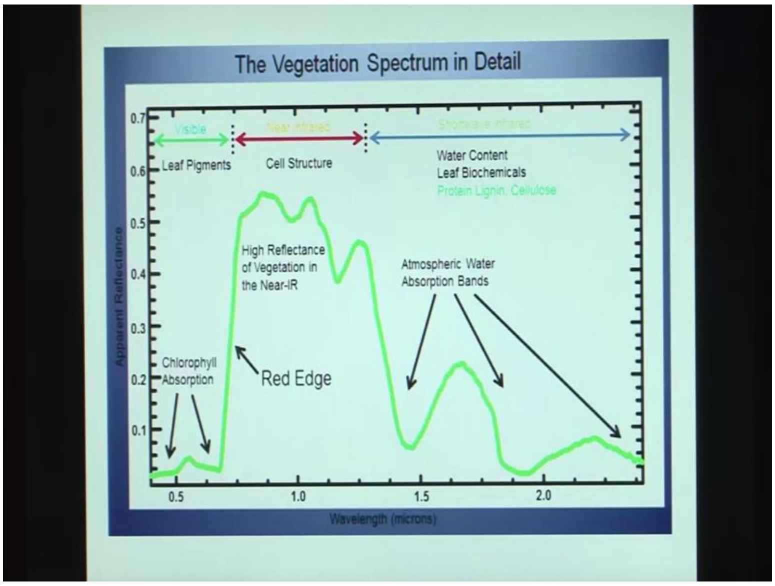

In a sample of wood to measure the volume we can either use these equations of volume like length into breadth into height. If we have a this cuboidal sample or pi r square into h if we have a cylindrical sample and so on or else we can go for a water displacement method in which our sample is pushed inside a liquid, with a needle and its mass is measured or we can use Xylometer that is this device to measure the volume of wood or we can directly measure density by using the buoyancy laws and by balancing the forces.

(Refer Slide Time: 34:57)



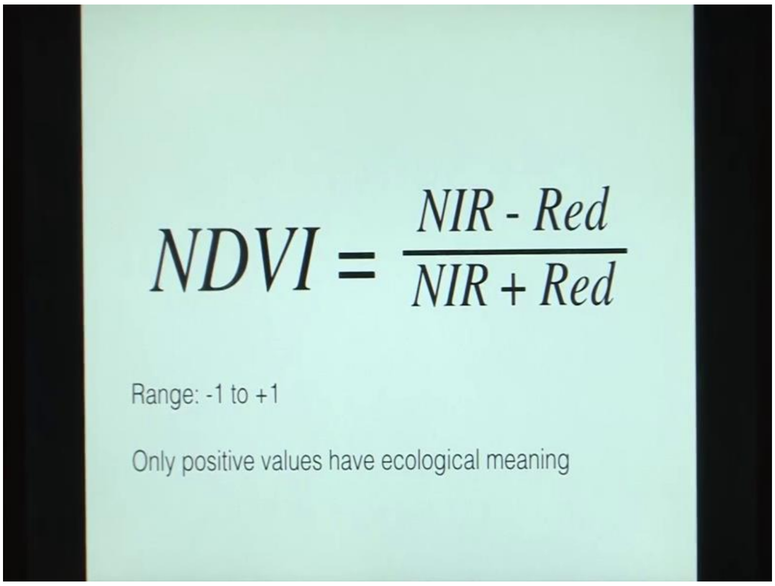

Next we also had a look at NDVI which stands for the normalized difference vegetation index. So, NDVI is a technique that measures the reflectance of different surfaces to get information about those surfaces. So, we looked at true color composites the vegetation spectrum.

(Refer Slide Time: 35:23)




So, in the case of vegetation spectrum, we can utilize this red edge to find out vegetation and to differentiate it from different surfaces.

(Refer Slide Time: 35:34)

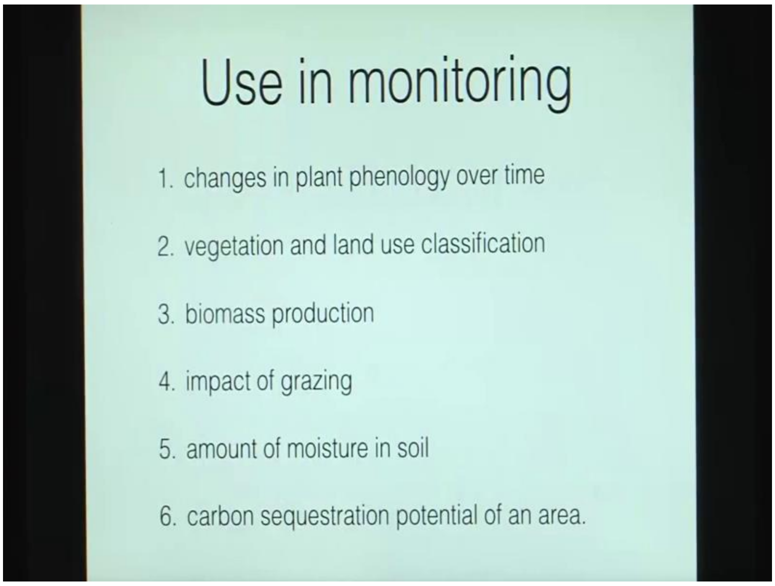



Then we define NDVI as NIR minus red divided by NIR plus red.

(Refer Slide Time: 35:39)

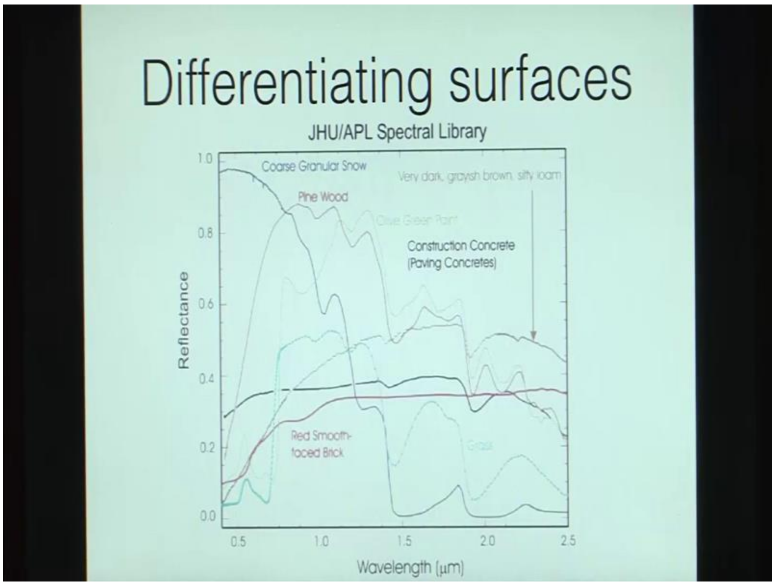
So, in this two color composer, if we wanted to know whether this green color was because of vegetation or because of green colored tops of buildings that have been painted green we can use an FCC; in the case of an FCC we will display infrared in the red band then red in the green band and green in the blue band, to get these images or we can use NDVI. So, in this case anything that is black does not have any vegetation and as it goes towards whitish values. So, it has vegetation.

(Refer Slide Time: 36:18)




Now, this index can be used to measure changes in plant phenology, it can be used for vegetation and land use classification biomass production, impact of grazing may be even impact of fire, amount of moisture in the soil, carbon sequestration potential of an area and so on.

(Refer Slide Time: 36:34)



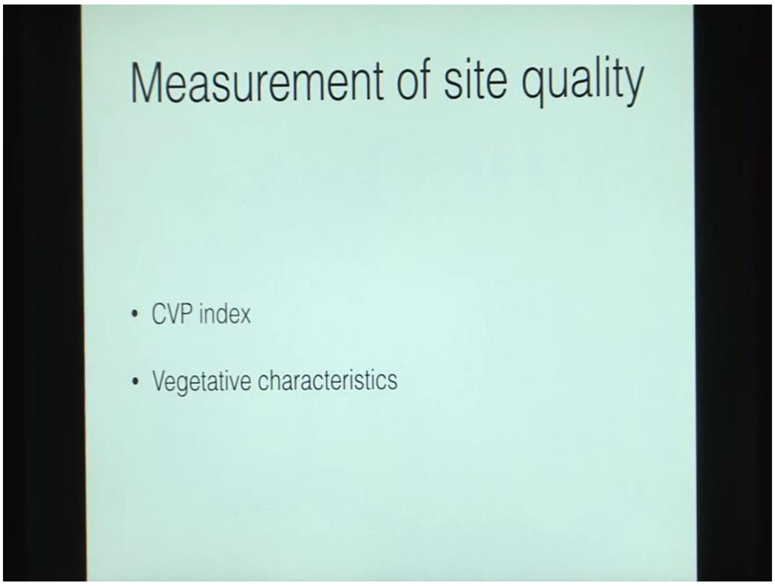

So, for instance we can use it to differentiate different surfaces, differentiate between different kinds of vegetation discerning the health of a plant and so on.

(Refer Slide Time: 36:47)


(Refer Slide Time: 37:04)

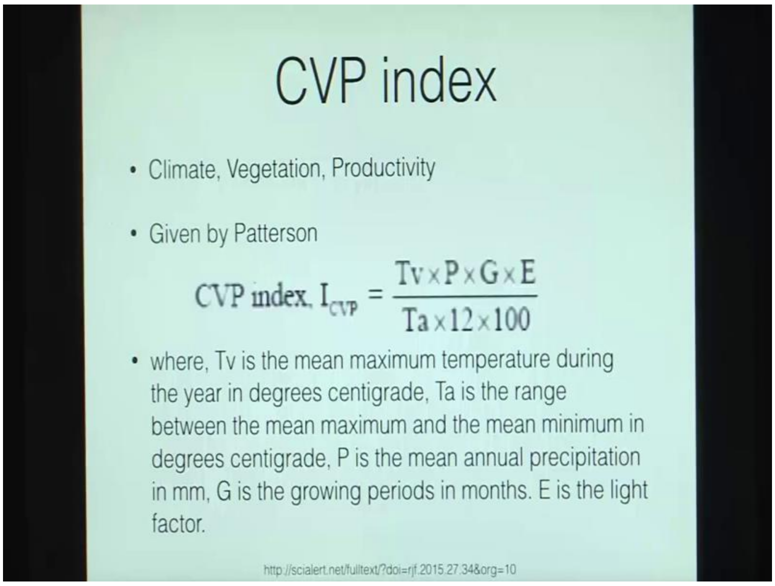

So, in the case site quality we use this equation area plus environment gives us the type and quality of vegetation. So, there are a number of factors that affect production of an area. So, for instance rock soil climate topography vegetation and so on, and site quality measures the relative production capacity. So, productivity is given as quality plus management input. So, if you keep all these management inputs as constant, that is fertilizer site treatment irrigation grazing soil compaction growing stock manipulation in other management inputs. So, if they are constant, then this equation of site productivity is equal to site quality plus management input will give us that site quality is rightly proportional to the site productivity.

(Refer Slide Time: 37:40)



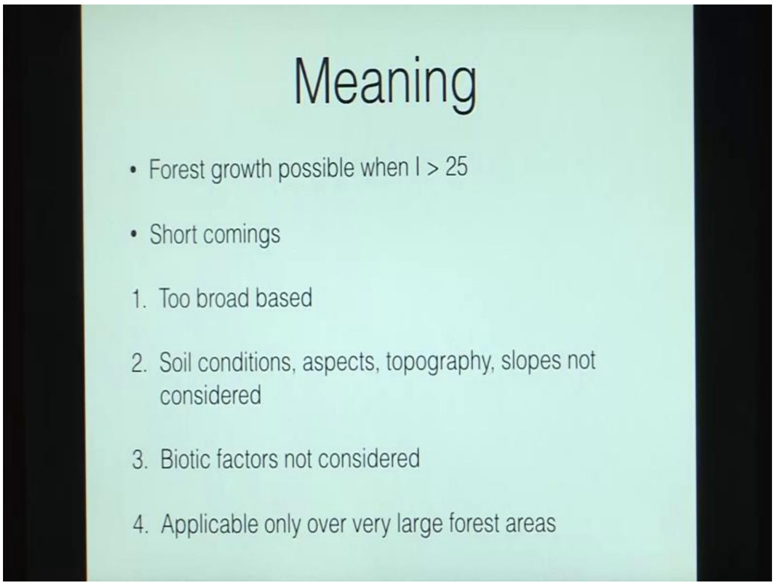

Now, we can measure site quality using two methods, one is this CVP index and the second is vegetative characteristics.

(Refer Slide Time: 37:43)

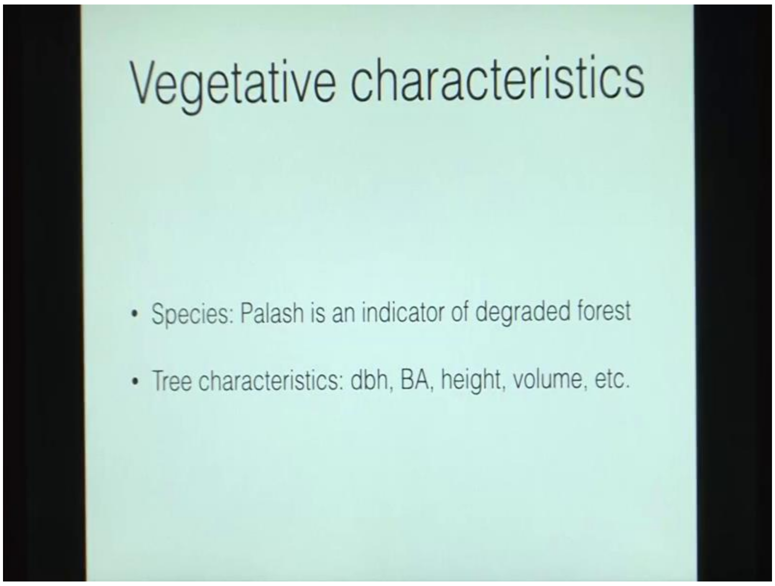



So, in the case of CVP index we defined this index I is equal toT v by T a multiplied by P multiplied by G by 12 and multiplied by E by 100. So, that will give us end of value and if that value is greater than 25 then we can have forest growth, then we also looked at its limitations.

(Refer Slide Time: 38:00)

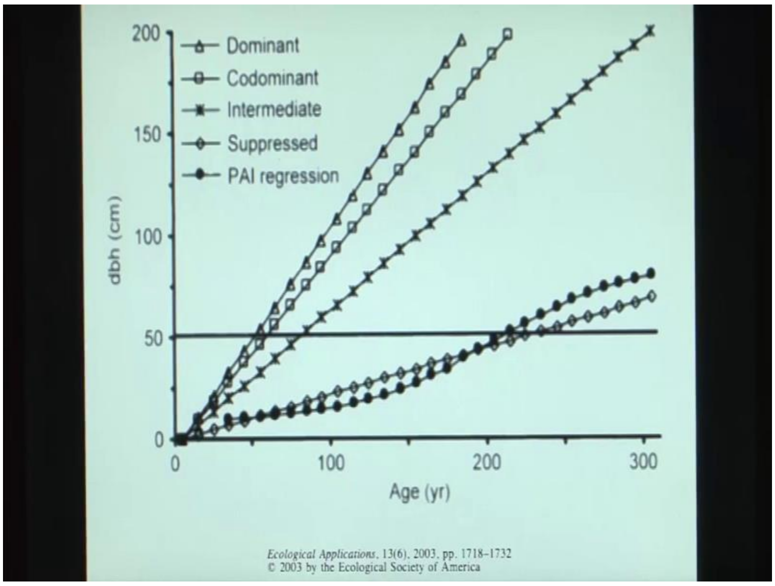



(Refer Slide Time: 38:02)



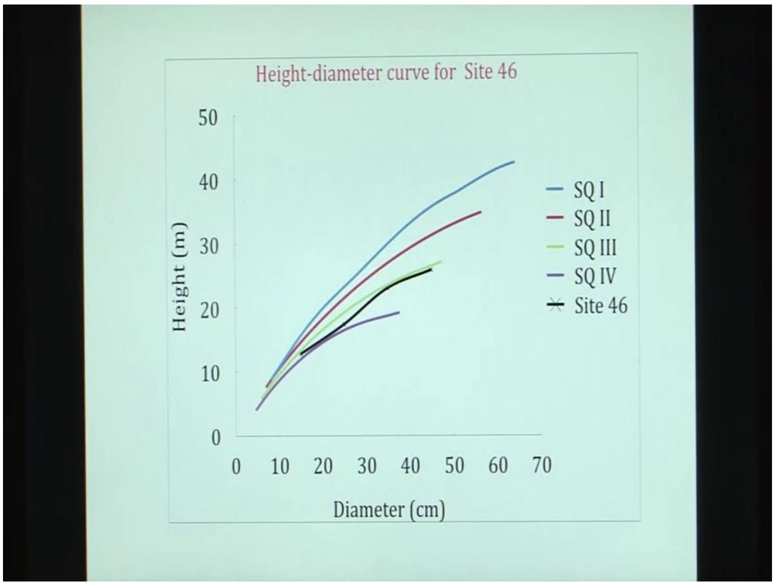

Now, in the case of vegetative characteristics, you can look at the species that are there on a site and we can also look at a characteristics of the tree in terms of d b h breast basal area height volume and so on. So, for instance some species such as Palash are an indicator of degraded forest. So, if those species are there than the site quality is not high and if we have two forest sites that are having the same species, then if on one site the our trees have larger volumes than that is site is having a greater quality.

(Refer Slide Time: 38:36)



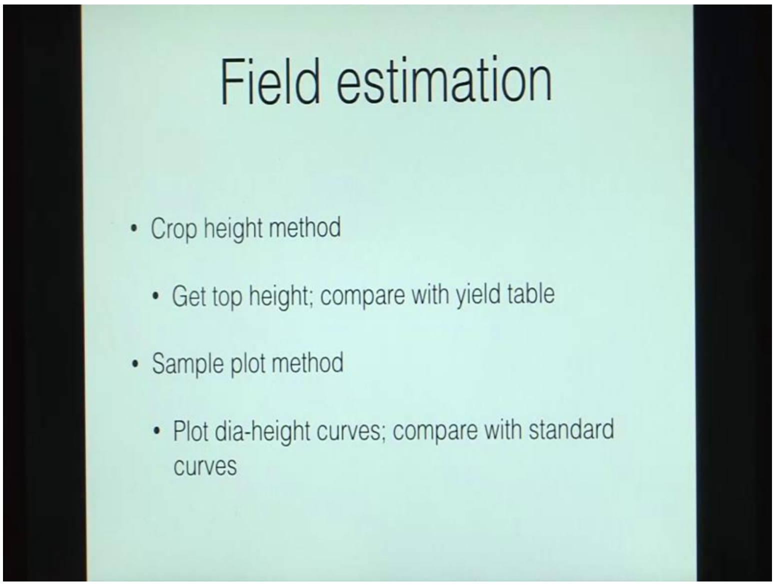

So, we saw how these factors can affect the growth of trees and how in a standard way we use a diameter and height curves to find out the site quality.

(Refer Slide Time: 38:43)




So, in the case of site quality we can use crop height methods. So, in the case of crop height method we get the top height and compare it with a yield table.

(Refer Slide Time: 39:01)




And in the case of sample plot method we plot diameter versus height curves and compare them with standard curves. So, like for instance in this case you have your site quality curves for four standard site qualities 1 2 3 and 4 plotted here, and for your site of interest if you plot diameter versus height curve. So, any curve that it comes closest to gives you the site quality. So, that is all for revision all the best for your exams.

Thank you for your attention and [FL], do good.