Forests and Their Management
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Module - 12
Revision
Lecture - 34
Revision (Part 1)

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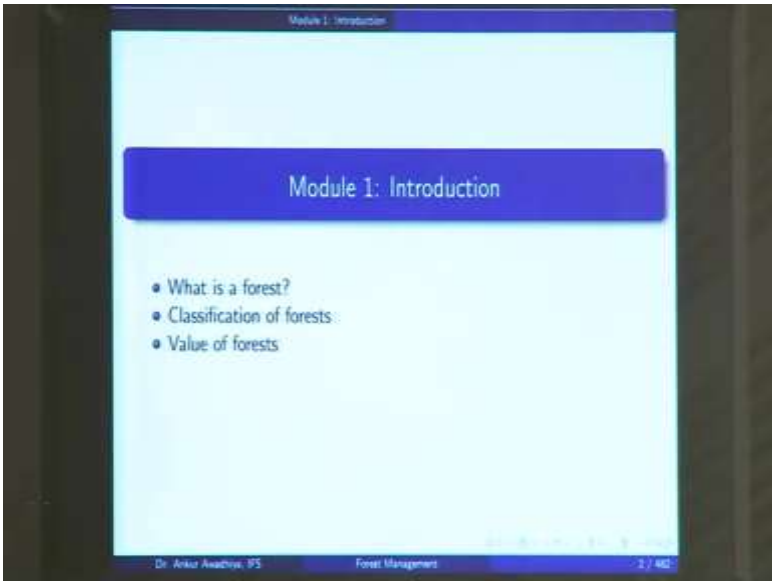

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[FL]. So, now, we have reached to the end of this course, and in this lecture, we will start doing the Revisions. So, we started this course by looking at what a forest is.

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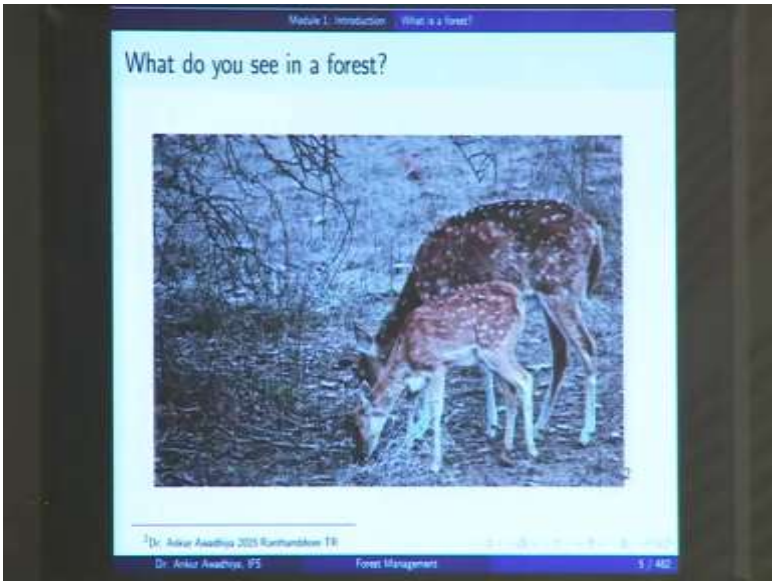

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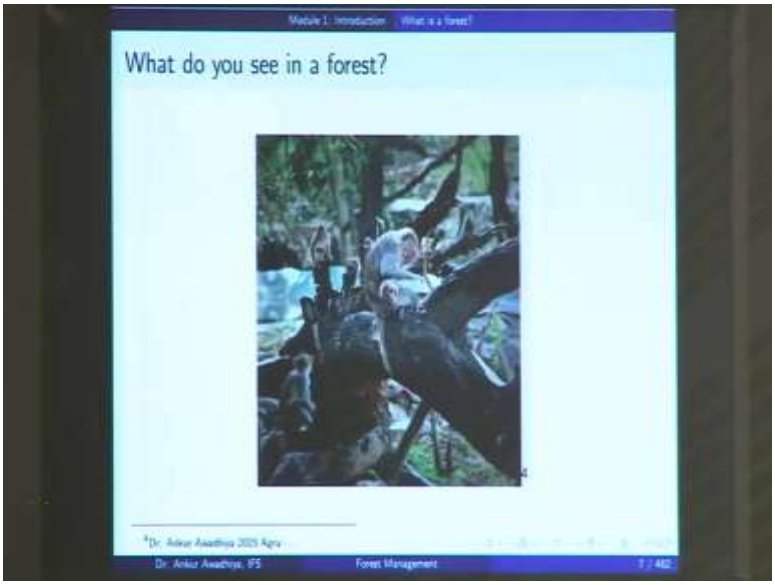

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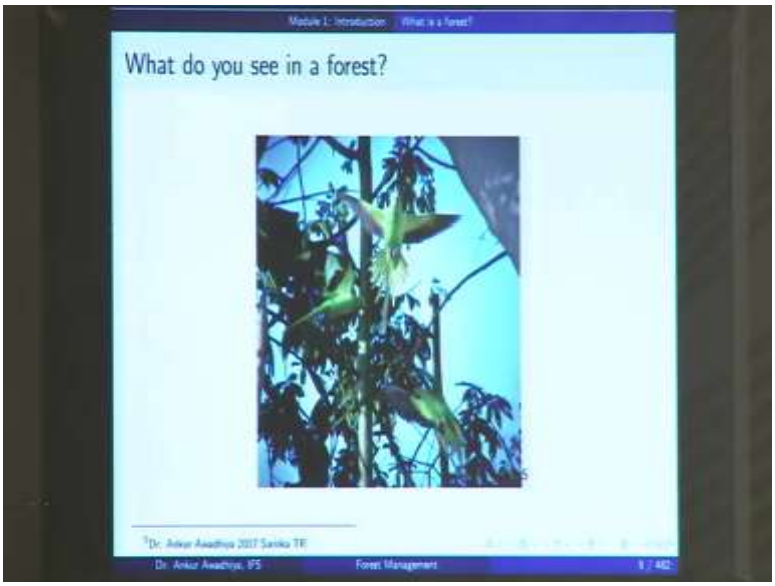

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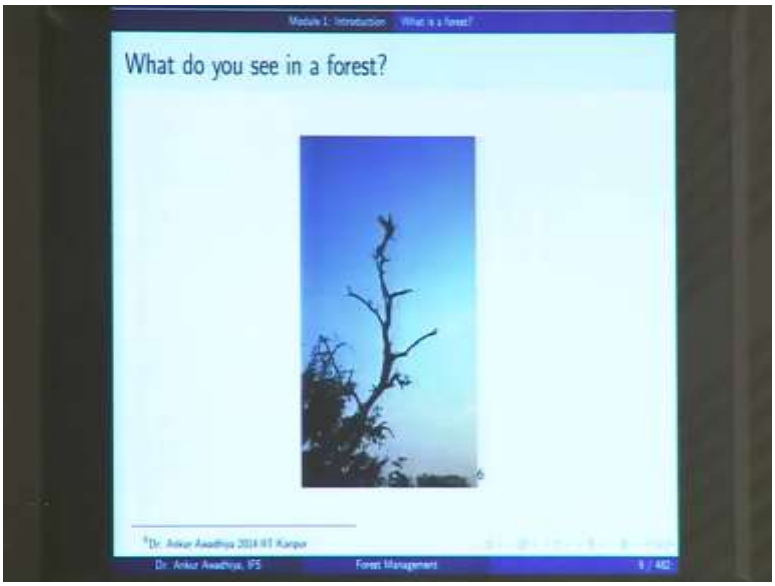

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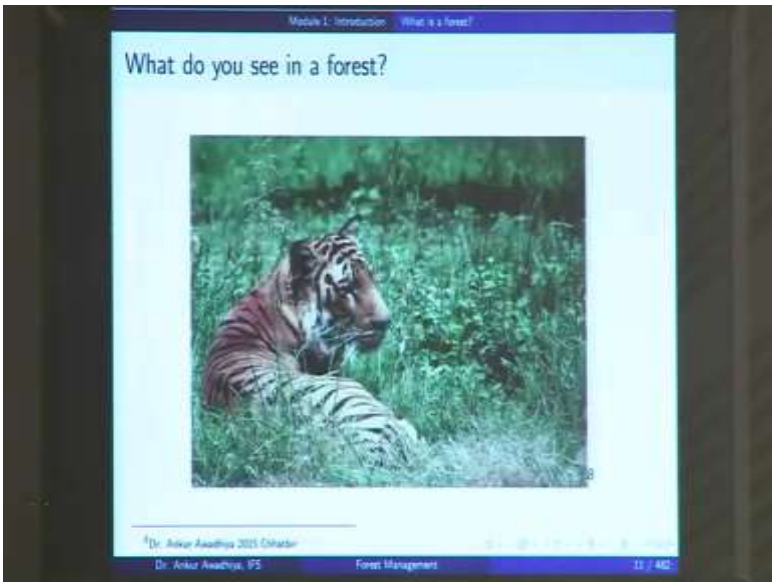

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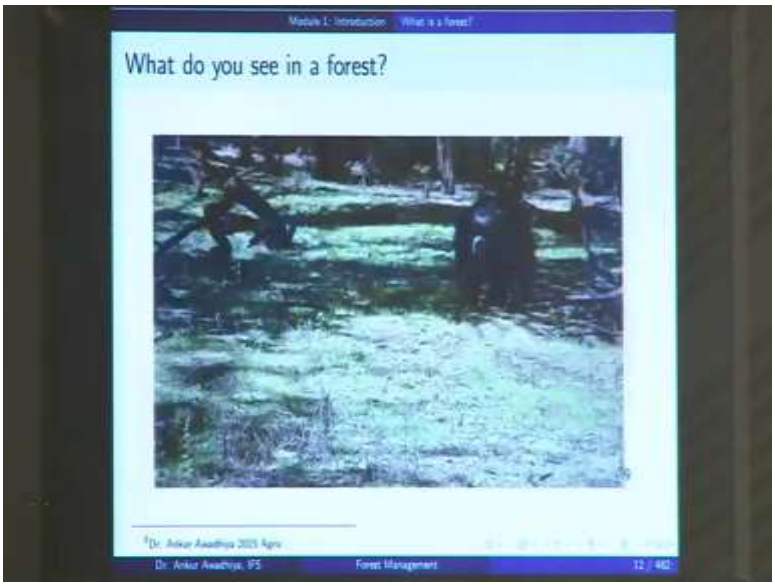

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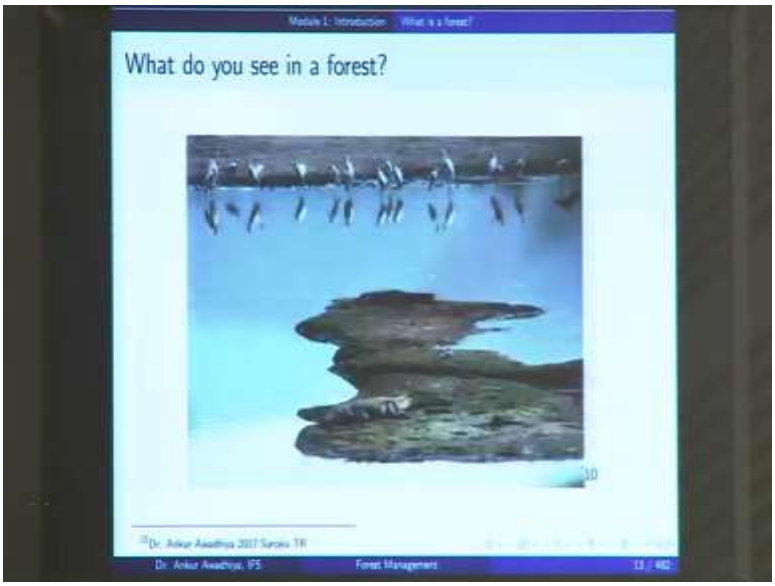

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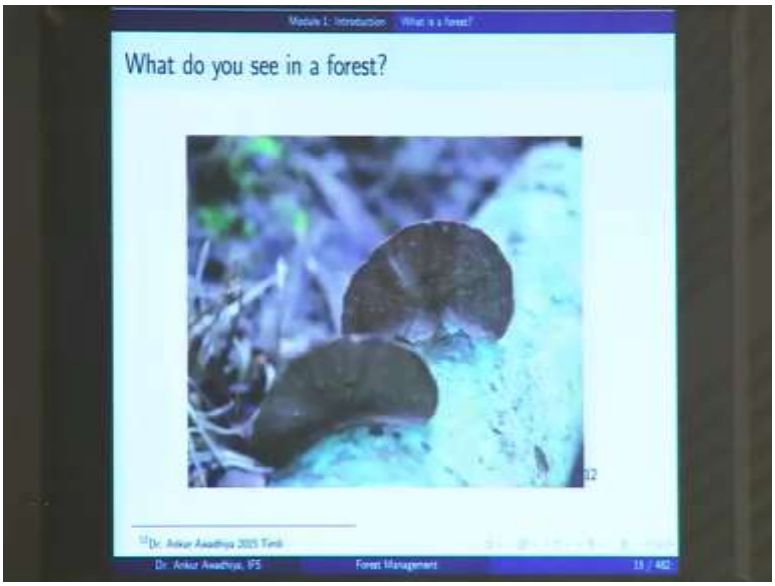

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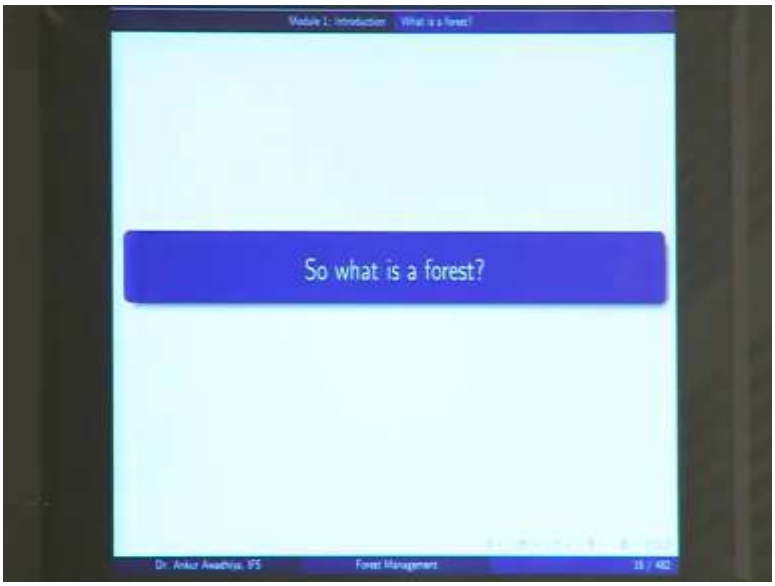

So, this is a typical forest; you find different animals in the forest; animals, birds, signs some larger animals, some fungi and then, we looked at different definitions of the forest.

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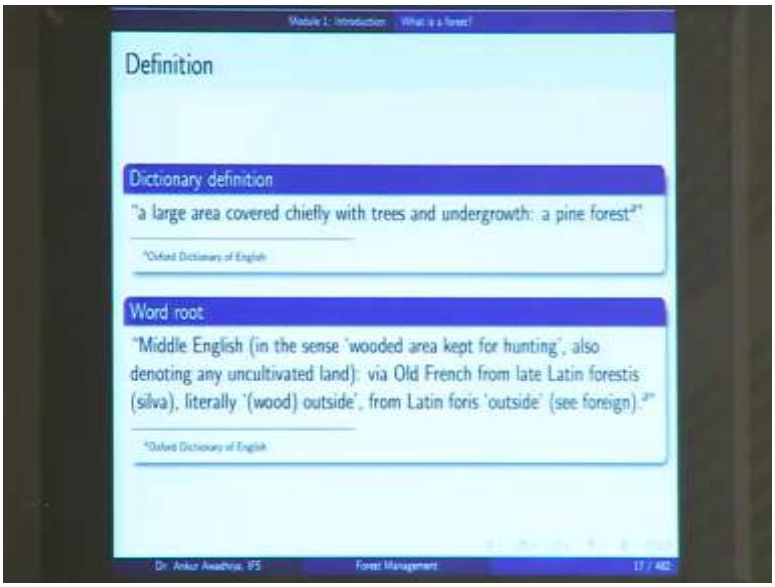

So, we looked at the dictionary definition; "a large area covered chiefly with trees and undergrowth" from coming from the Latin word, "forest" which means "outside."

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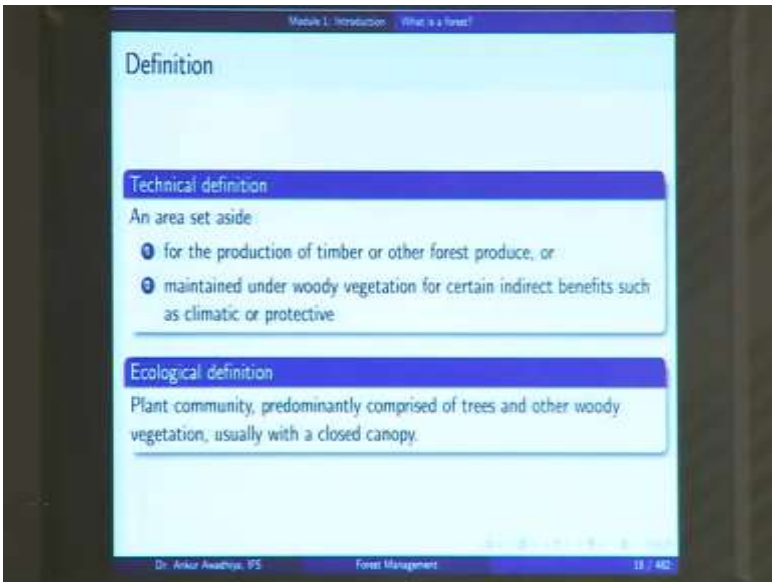

Then, we looked at the technical definition; “an area that is set aside for the production of timber or other forest produce or maintained under woody vegetation for certain indirect benefits such as climate or protective.”

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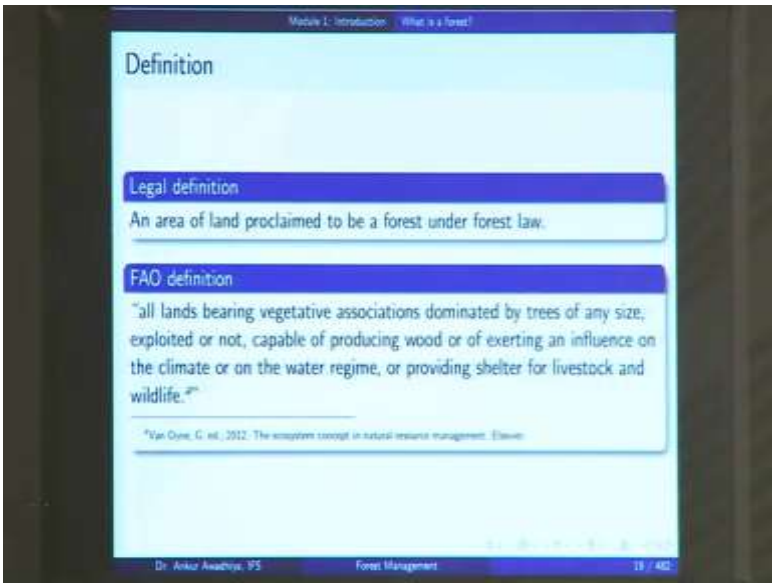

Then, we looked at ecological definition; “plant community, predominantly comprised of trees and other woody vegetation usually with a closed canopy.” Followed by a legal definition, “an area of land proclaimed to be a forest under the forest law.” The FAO definition of, the food in agriculture of organization; “all lands bearing vegetative

associations dominated by trees of any size, exploited or not, capable of producing wood or of exerting an influence on the climate or on the water regime, or providing shelter for livestock and wildlife."

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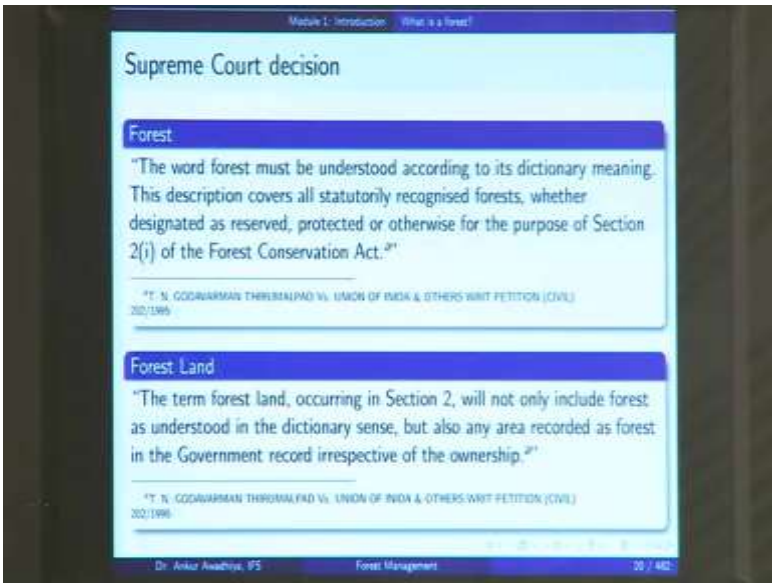

Next, we looked at the supreme court's decision in the Godavarman case, in which case the supreme court has said that, "the word forest must be understood according to its dictionary meaning. And, this description covers all statutorily recognized forest, whether they are designated as reserved forest, protected forests or otherwise for the purpose of Section 2(1) of the Forest Conservation Act."

Then, we looked at forest land, and we said that the term forest land not only includes forests as understood in the dictionary sense, but also any area that is recorded as forest in the government record; irrespective of its ownership. So, no matter who owns the land, it is a forest land.

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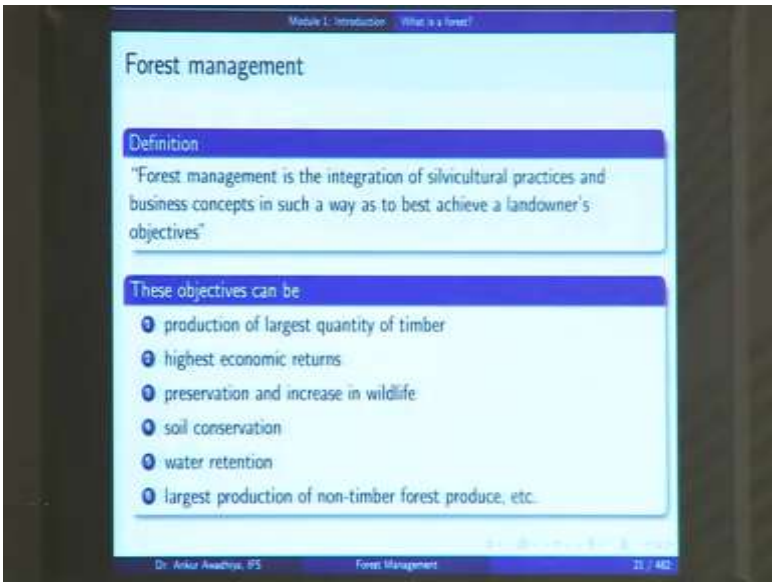

When we looked at forest management which is an integration of the silvicultural practices and business concepts in such a way, as to best achieve a landowner's objectives, and then you have different kinds of objectives that are being met using forest management.

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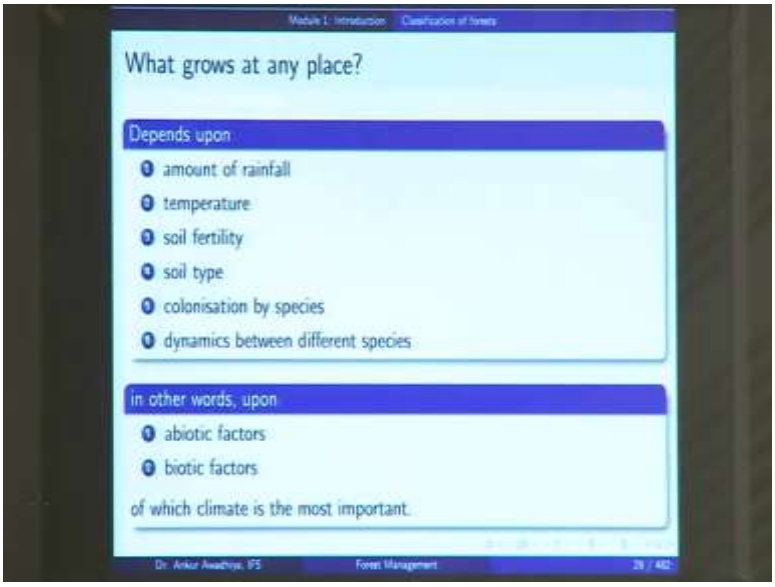

In the second lecture, we looked at classification of forest. So, there are different kinds of forest, and it is determined by the amount of rainfall, the temperature, soil fertility, soil type, colonization by species, and dynamics between different species.

So, these are all different factors; they can be abiotic factors or biotic factors that determine what grows at any place and climate, is the most important one.

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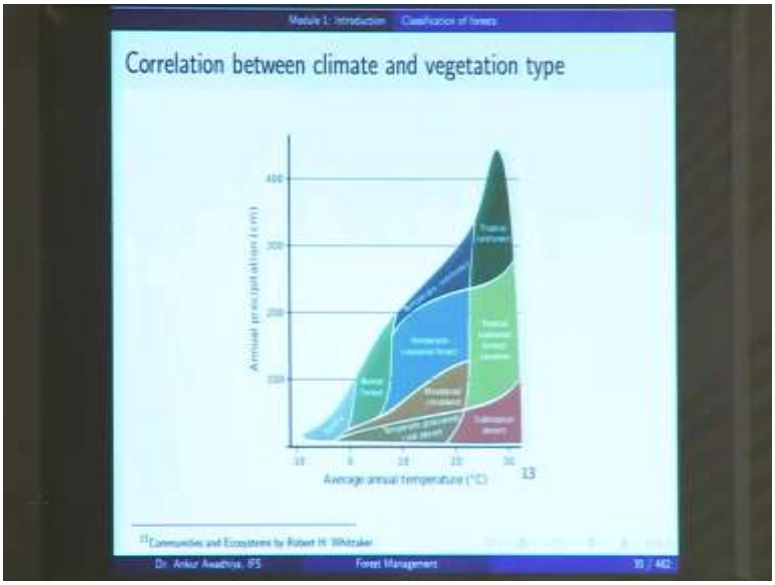

And so, if you look at this curve, you have angle precipitation on the y-axis and average annual temperature on the x-axis. And, we say see that depending on the temperature and the rainfall of different areas, we have different kinds of forests.

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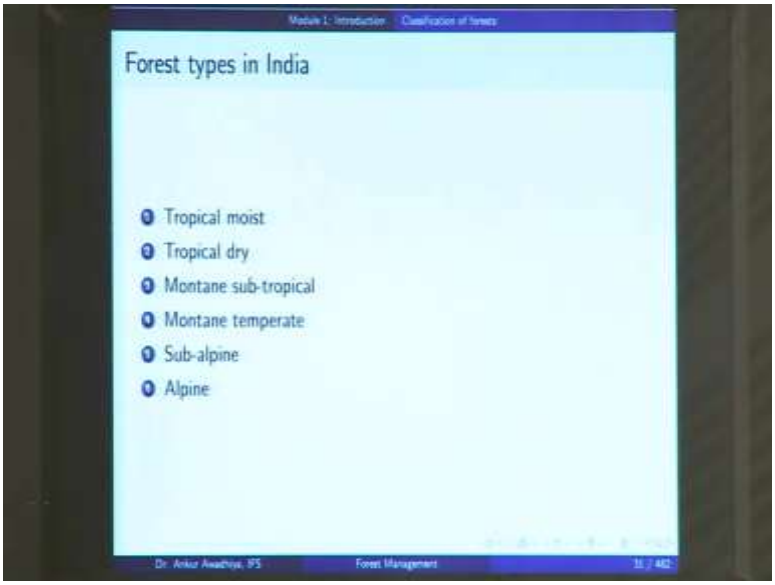

In India, we said that we have 6 major types of forests; tropical moist, tropical dry, montane subtropical, montane temperate, subalpine and alpine.

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Then, we looked at all of these in more detail. So, tropical moist forest; so, you have tropical; it is warm moist, it is wet. So, you have wet evergreen, semi-evergreen, moist deciduous, littoral and swamp vegetation.

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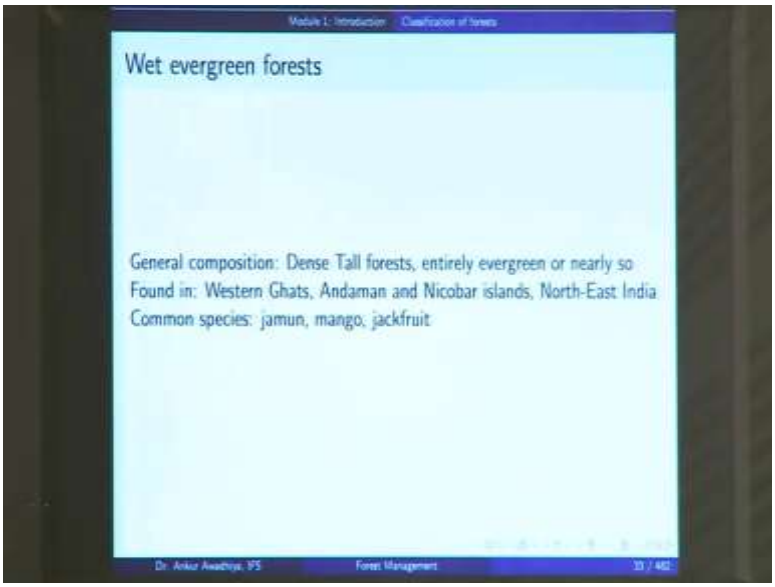

So, then, we looked at all of these in more detail. So, wet evergreen; dense and tall trees entirely evergreen or nearly. So, found in Western Ghats, Andamans and Nicobar's, North East India common species are Jamun, Mango and Jackfruit semi evergreen.

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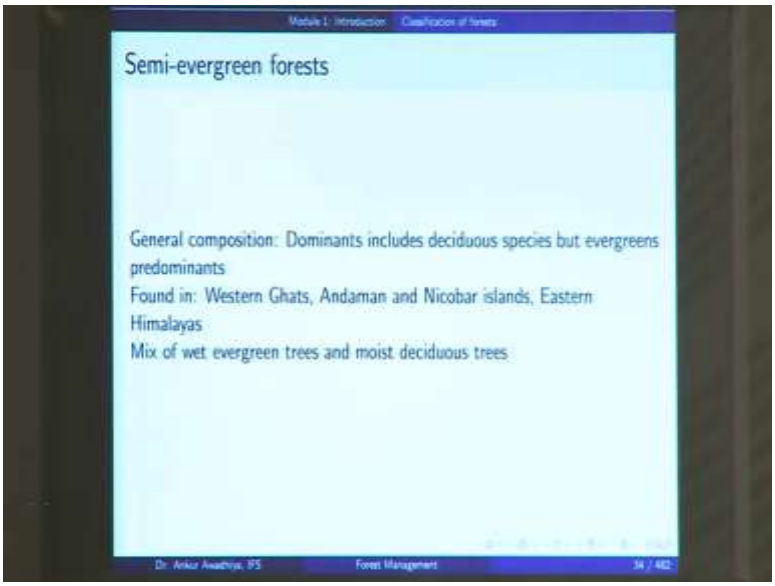

So, you have dominants which include deciduous species, but evergreens are also predominant. It is found in Western Ghats, Andaman and Nicobar Islands, Eastern Himalayas and we have a mix of wet evergreen trees and moist deciduous trees.

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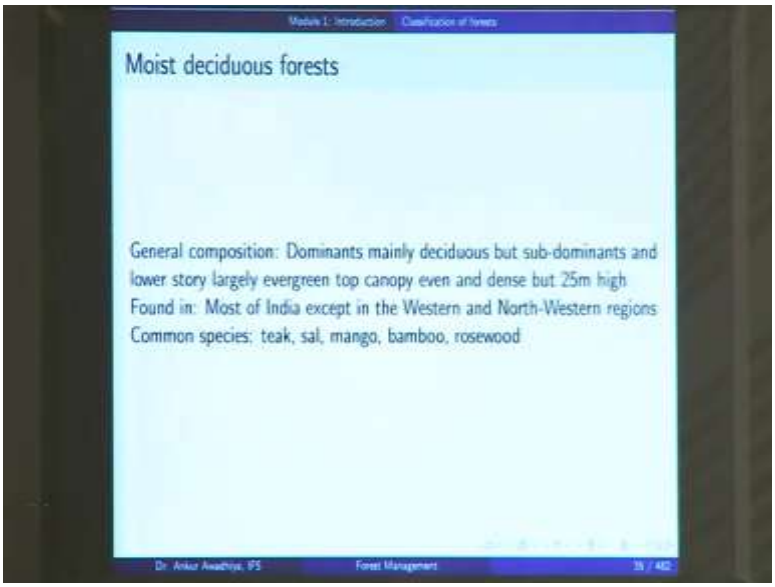

Now, moist deciduous forests; you know, you have dominants are mainly deciduous, but sub dominant and lower story is largely evergreen. Top canopy is even and dense, and 25 meters of height in general. It is found in most of India except in Western and North Western regions, and the common species are teak, Sal, mango, bamboo and rosewood.

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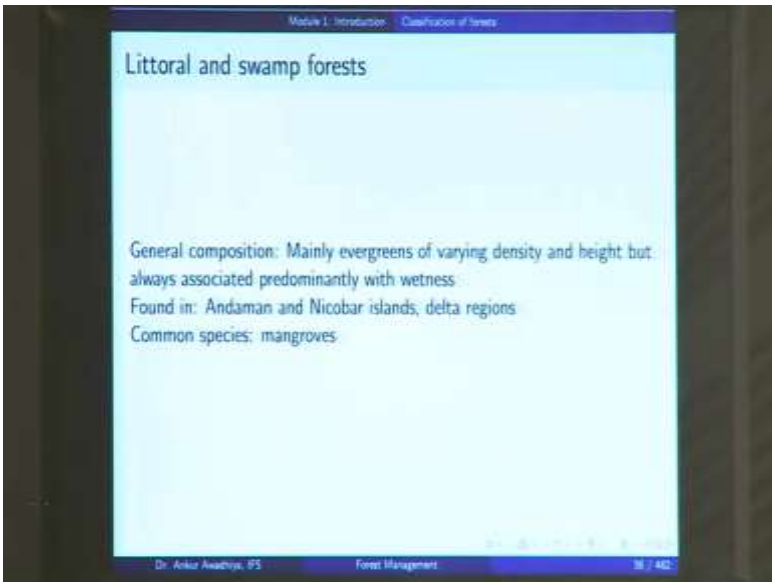

Next, we have littoral and swamp forest; the general composition is mainly evergreens of varying density and height, but always associated predominantly with wetness. And, these are found in Andaman and Nicobar islands, delta regions. And, a common species is mangrove which we saw, in the lecture, that it has a number of adaptations that make it suitable for a life in such areas. So, the littoral and swamp forests are found in wet areas.

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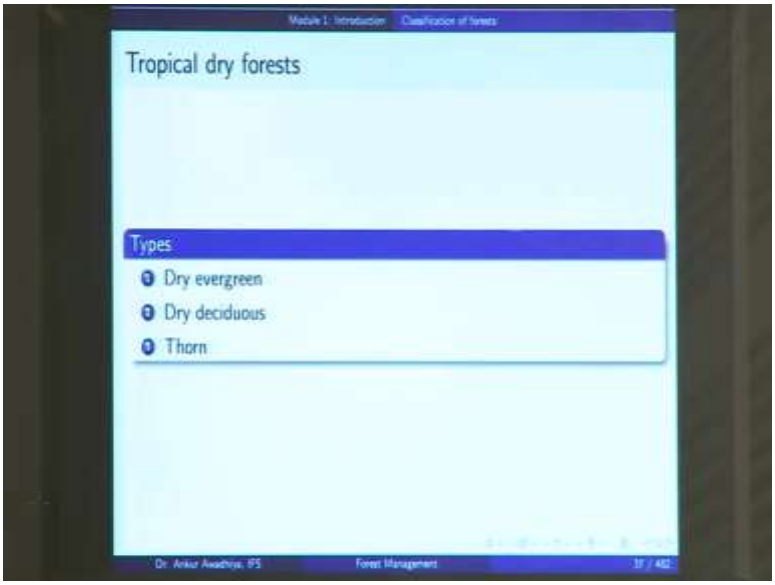

Next, we have tropical dry forests. Now, these are tropical. So, high temperature and these are dry, because you have less amount of rainfall. And, there are 3 different types you have dry evergreen; you have dry deciduous, and you have the thorn forest.

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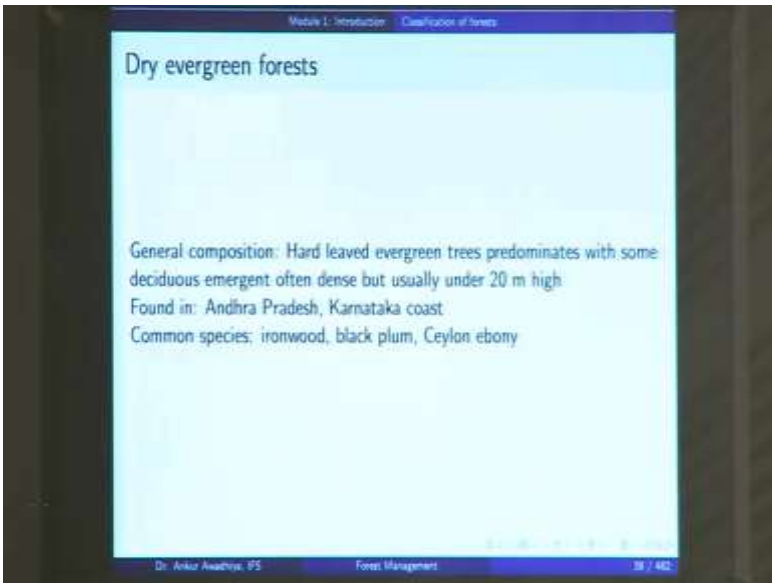

Now, dry evergreen; the composition is hard leaf evergreen trees which predominate with some deciduous emergent; often dense, but usually under 20 meters of height. Found in Andhra Pradesh, Karnataka coast; common species are iron wood black pump plum and Ceylon ebony.

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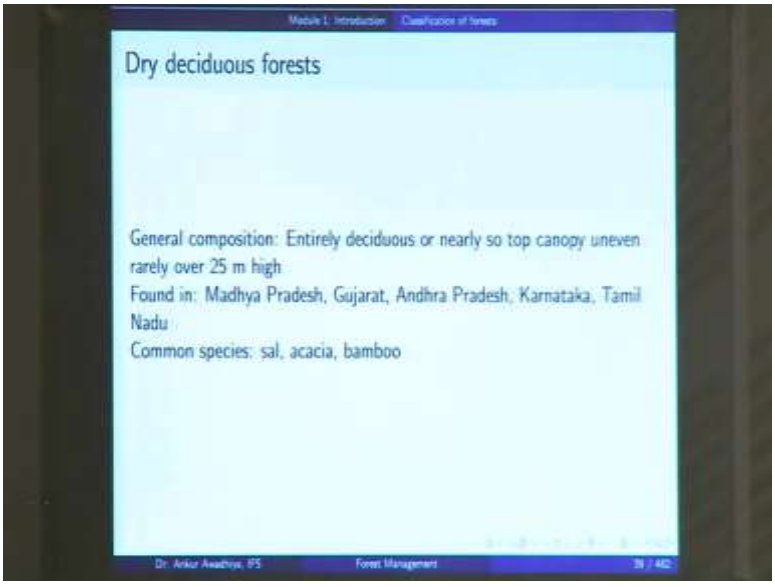

Dry deciduous trees; no, remember that deciduous trees are those trees that shed their leaves in certain season of the year or certain part of the year, typically, to conserve moisture.

Now, in the case of dry deciduous forests, the general composition is entirely deciduous or nearly. So, top canopy is uneven rarely over 25 meters in height, found in Madya Pradesh, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu; and, the common species are sal, acacia and bamboo.

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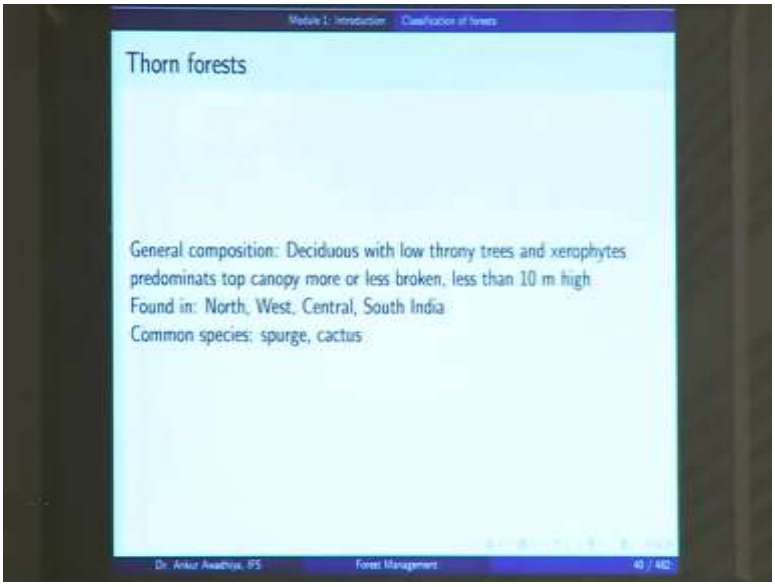

Then, we looked at thorn forest. So, thorn forest at xerophytic vegetation, very less amount of water is there. So, the general composition is deciduous with low thorny trees; and xerophytes pre predominates low canopy; top canopy is more or less broken and these are less than 10 meters in height. Found in North, West, Central and South India. Common species include things like spurge and cactus.

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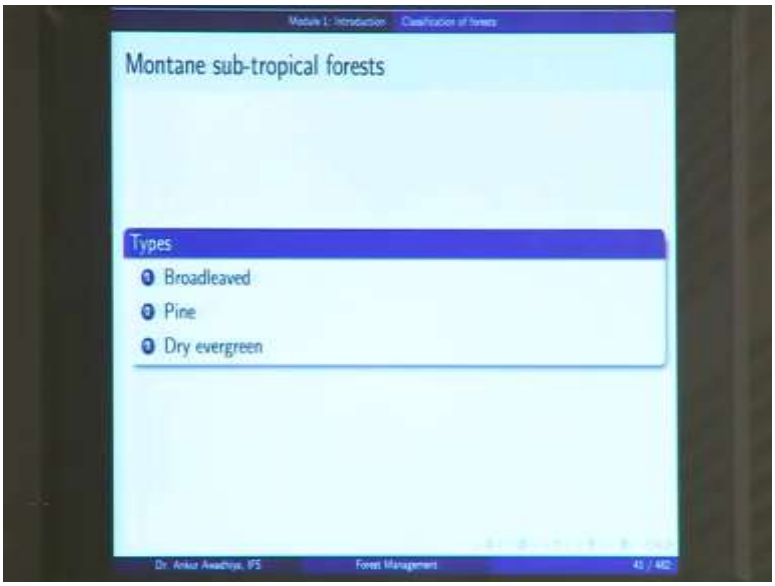

Next, we looked at montane sub-tropical forest. So, these are in mountainous areas and these are subtropical. So, it is not that much warm now. So, you have broad leave vegetation, pine vegetation and dry evergreen forests.

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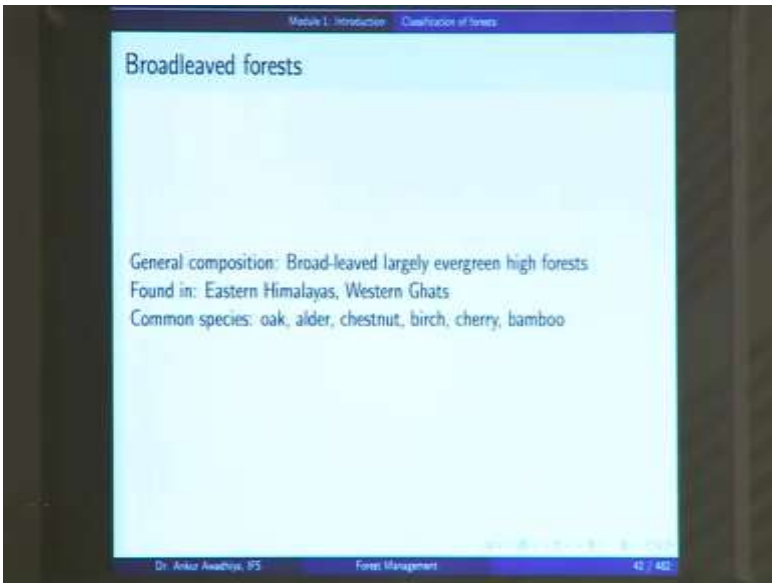

Now, broadleaved forest as the name suggests this these have brought sized leaves. So, these are broadleaved forests, largely evergreen high forest found in Eastern Himalayas and Western Ghats and common species include oak, alder, chestnut, birch, cherry and bamboo.

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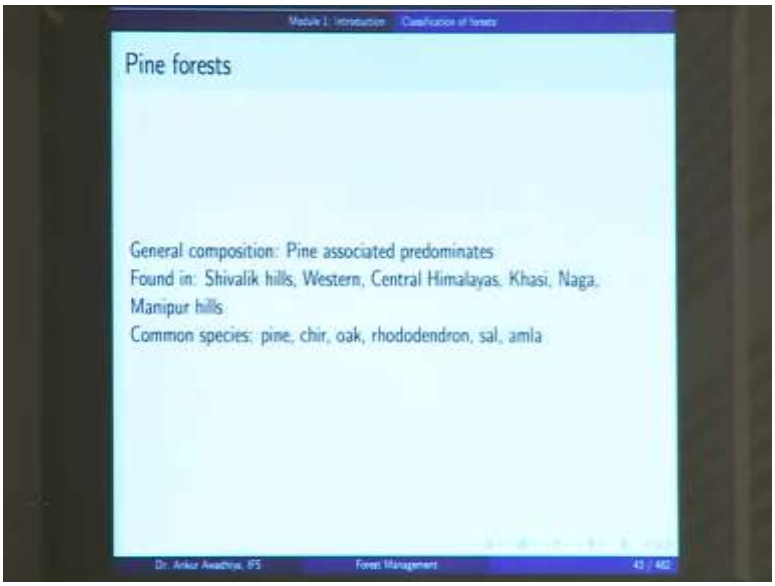

Next, we have pine forests. So, the general composition is pine and associates that predominate. Now, pine is coniferous vegetation in which you have needle-like leaves. Now, in these forests; these are found in Shivalik hills, Western and Central Himalayas, Khasi, Naga and Manipur hills. The common species are pine, chir, oak, rhododendron, sal and amla.

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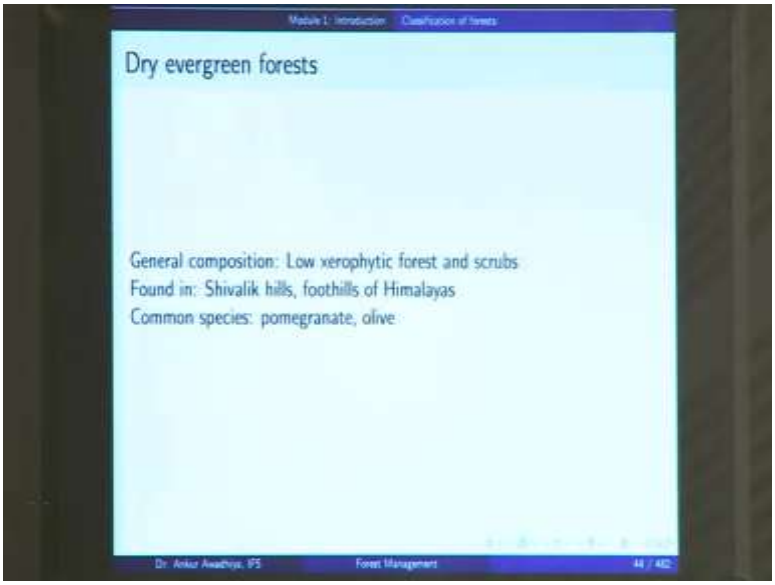

Next, we have dry evergreen forests; the general composition is low xerophytic forests and scrub. So, xerophytic is dry vegetation that is growing in drier areas. These are found

in Shivalik hills and the foothills of Himalaya's; common species include things like pomegranate and olives.

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Next, we have montane temperate forests which are of 3 categories; wet, moist and dry depending on the amount of rainfall that you have in these areas.

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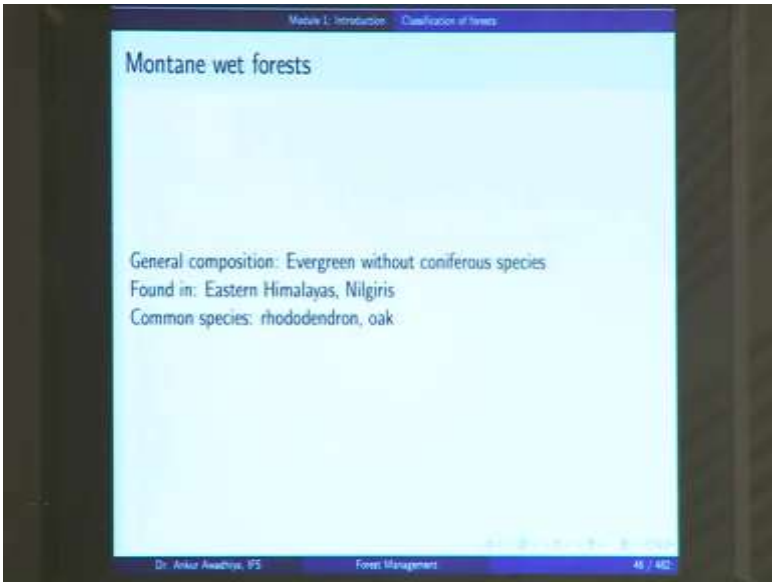

Montane wet forests. The general composition is evergreen, but without coniferous species. So, you find these in Eastern Himalayas and in the Nilgiris; the common species are rhododendron and oak.

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Next, we have montane moist forests. So, you here you have evergreen forest mainly scleriphyllous, oak, and coniferous species; found in Western Himalayas and Eastern Himalayas, and the common species include oak, walnut, rhododendron, bamboo and fern.

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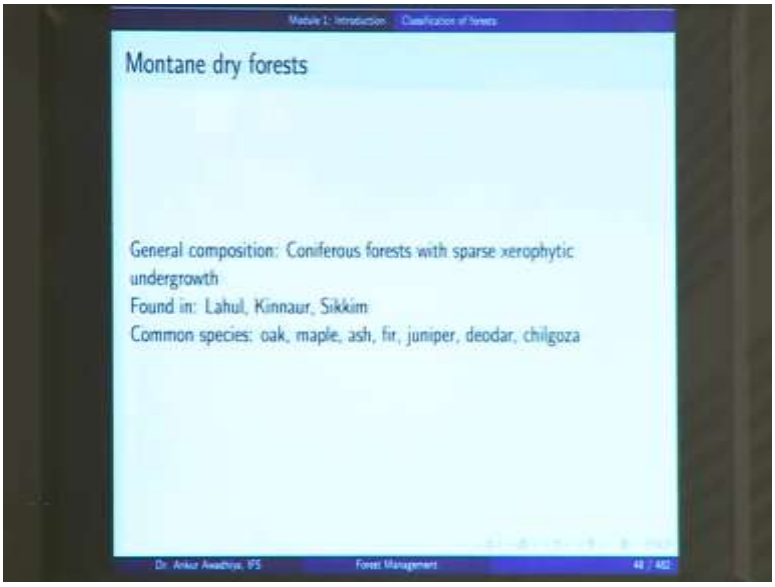

Next, you have montane dry forest. So, here the general composition is coniferous forest with sparse xerophytic undergrowth; found in places like Lahul, Kinnaur, Sikkim. So,

these areas are very cold areas and very dry areas. The common species include oak, maple, ash, fir, juniper, deodar, chilgoza.

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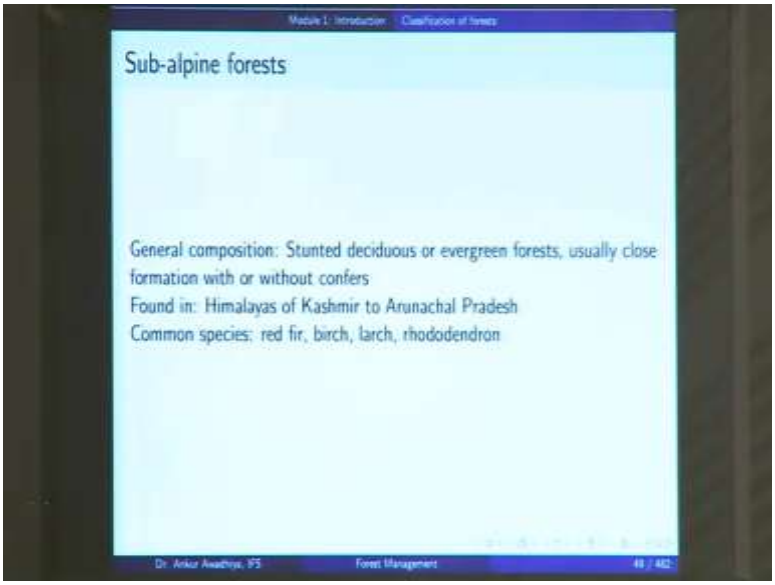

Next, you have sub-alpine forests. So, the general composition is stunted deciduous or evergreen forest. Usually close formation with or without the confers. Found in Himalayas of Kashmir to Arunachal Pradesh; common species include red fir, birch, large and rhododendron.

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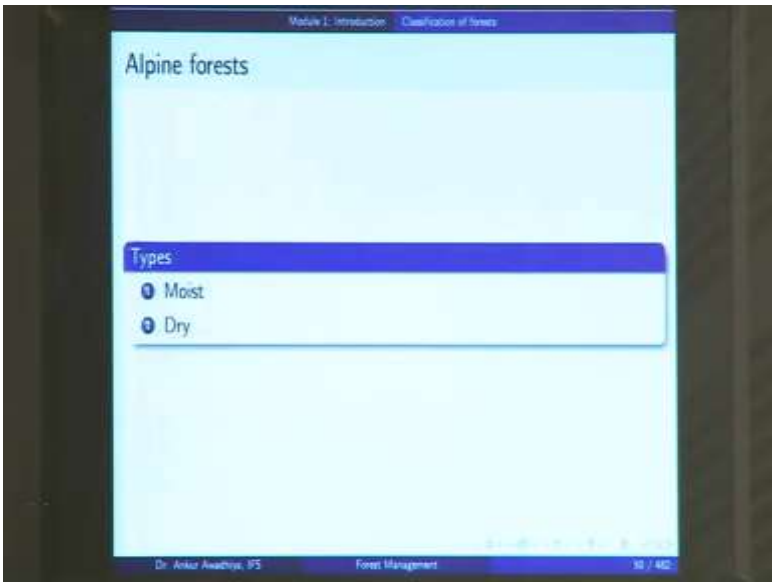

And then, we have the alpine forests. Now, alpine forests are typically on the tops of mountains; very cold areas, and you have two different categories: moist alpine and dry alpine.

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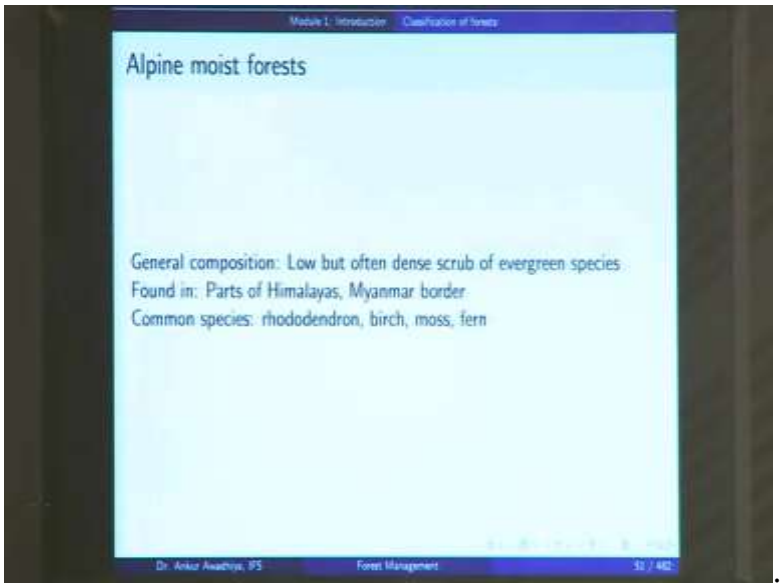

Now, alpine moist forests have low, but often dense scrub of evergreen species; found in parts of Himalayas and in the Myanmar border. Common species include things like rhododendron, birch, moss and fern.

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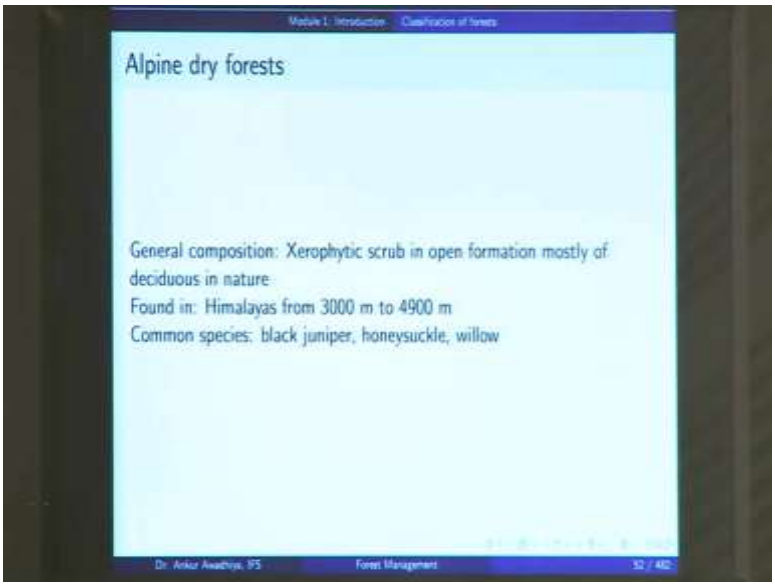

The alpine dry forests. The general composition is xerophytic scrub in open formation, mostly of deciduous nature. These are found in Himalayas from 3000 to 4900 meters, and the common species are black juniper, honeysuckle and willow. So, basically, what this lecture was telling us was that, in different areas, you have different kinds of vegetation which is adapted to different kinds of conditions in those areas; and, these conditions include both the biotic factors as well as the abiotic factors.

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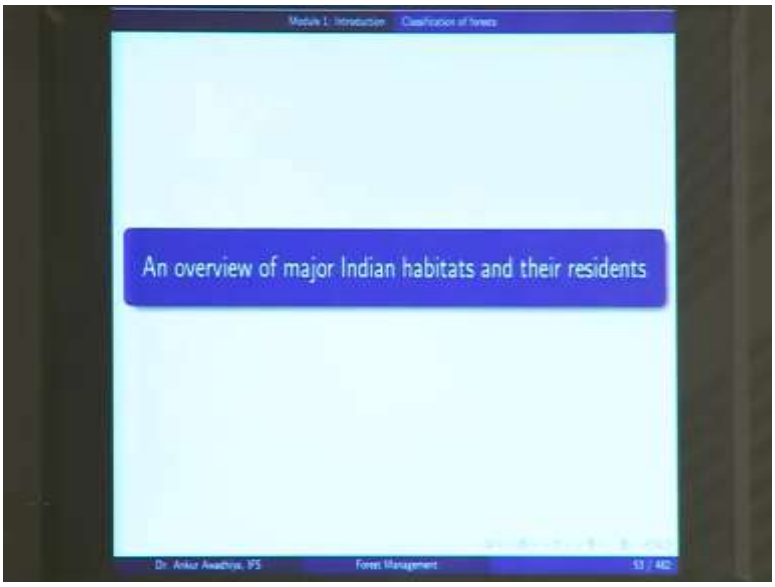

Then, we looked at major Indian habitats and their residents.

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So, we looked at alpine meadows. So, you have huge lush grassland.

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In Jammu and Kashmir and Uttarakhand, you have alpine forests.

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Moist deciduous forest, dry deciduous forest. Now, as you can see in the case of the moist deciduous forest, the forest floor is looking very green in colour. Whereas, in the dry deciduous forest, you have of forest floor that has and that is full of dry leaves.

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Next, you have the scrub forest in Rajasthan. So, it like this is in Ranthambhore national park.

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You have sand dunes in Jodhpur. So, here again, you have less amount of water that is available; the trees are short in height. You have ample amount of breaks in the canopy and you also have thorny vegetation.

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But then, even these are very important for certain species such as this spiny tailed, lizard.

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Then, we looked at the Runn of Kutch. Here also, it is a very open sort of vegetation, and if you have areas where you have water, then you will find different species.

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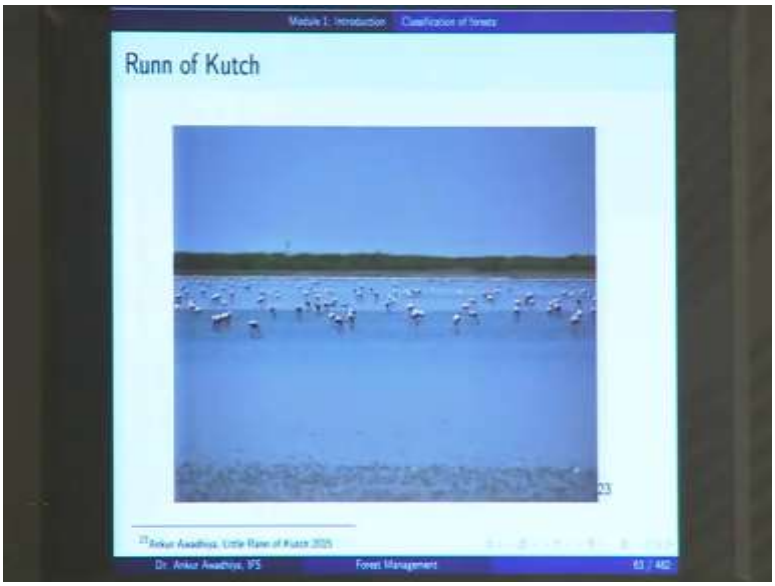

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When you have Brahmaputra floodplains; on the back, you can see that you have a very dense vegetation. In these areas which where you have the floodplains. Because of the yearly floods; so, the plants are unable to grow in these areas, I the large trees are unable to growing these areas and so, you get very good grasses that support number of species such as the rhinoceros.

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Then, we looked at Shola forests as are found Coorg.

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We looked at equatorial forests. Now, in the case of equatorial forests, you have ample amount of rainfall; ample amount of sunshine. So, it is a very dense vegetation; it is very difficult to go through this forest, and the your trees are very large in size. So, for instance, you can see this piece of log that is being dragged using an elephant and you can see how large it is.

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Then, we looked at the mangrove forest, which in which case the plants are very well adapted to a life with lots of water.

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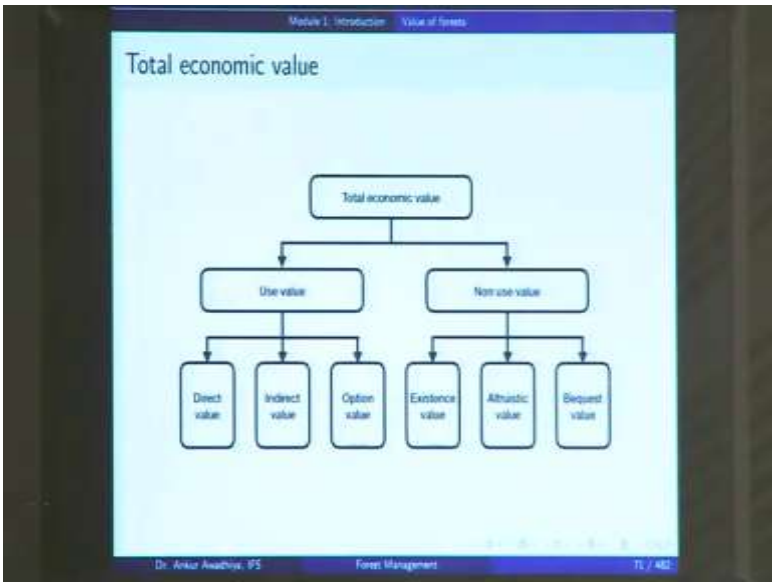

Next, we looked at the value of forest. And, we began with this chart which said that the total economic value depends on use value and the non-use value. Now, use value is something in which case you are using the resource. Non use value is where you are getting a value even though the resources not being used. Now, in this case, the use value is comprised of to the direct value, indirect value, and option value. And, the non use value is comprised of existence value, altruistic value and bequest value.

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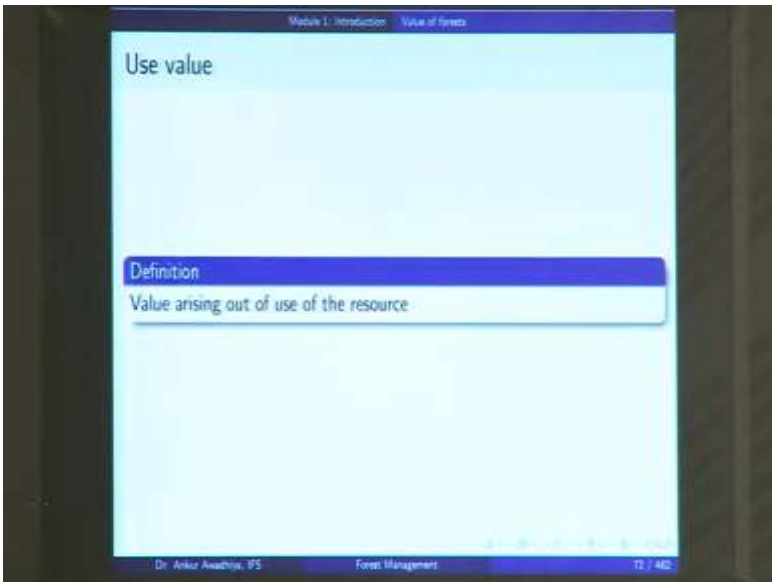

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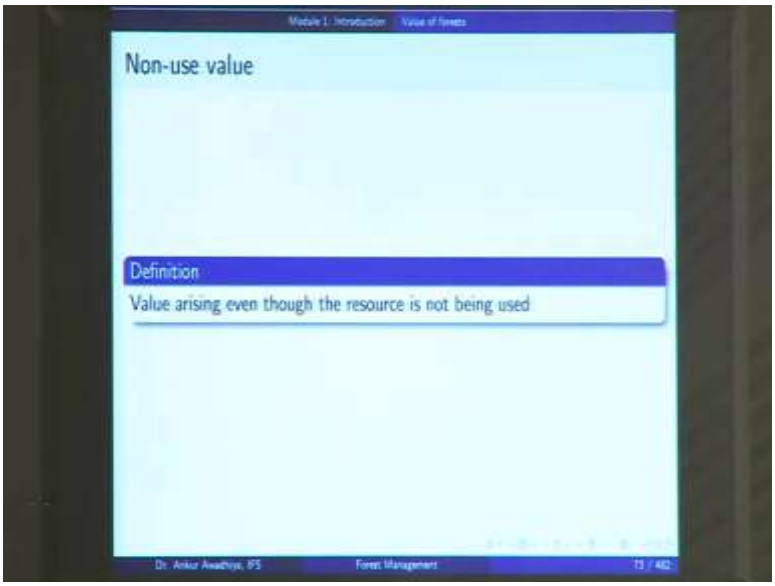

Now, use value is value arising of a use of resource. Non use value is value arising even though the resource is not being used.

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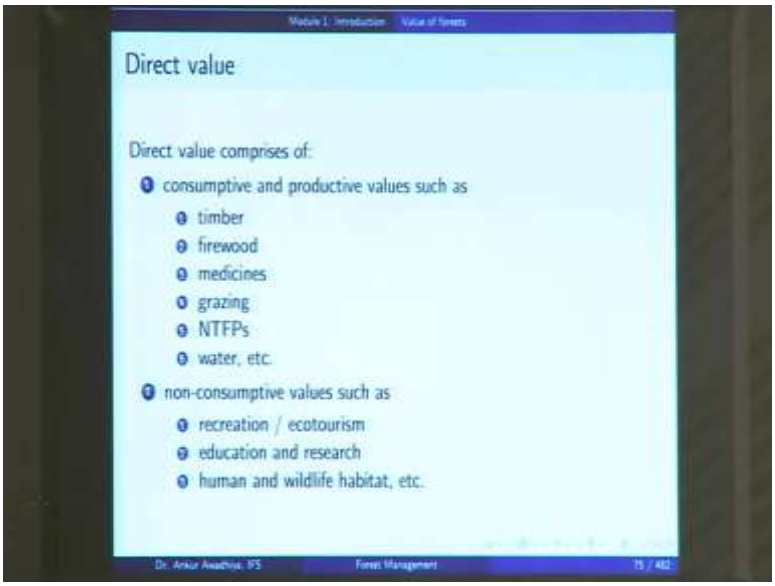

Now, the use value comprises of direct value. So, direct value is something that we are using directly, such as consumptive values and the non-consumptive values. Now, consumptive values are those in which, if one person is using those resources, the they are not available in that much amount for use by another person. So, a good example is timber.

So, there is a tree, and if I extract the timber out of that tree, you will not be able to extract timber from the same tree, because the timber is now gone. It can either be used by you or it can be used by me. So, we have the consumptive and productive values, such as timber, firewood, medicines grazing, non-timber forest produce and water. And then, we have non consumptive values, such as recreation or ecotourism, education, and research, human and wildlife habitat etcetera.

So, a good example of a non consumptive value is a tiger. So, if I see a tiger and I derive a value of say 1000 rupees by seeing this tiger. So, if you see this tiger, the value has not gone down because I have seen this tiger. So, essentially, whenever any person is using a non-consumptive; whenever any person is doing a non-consumptive utilization of a resource, then the resource says amount and the quality remains the same for use by another person as well.

So, the direct value is consumptive and non-consumptive values.

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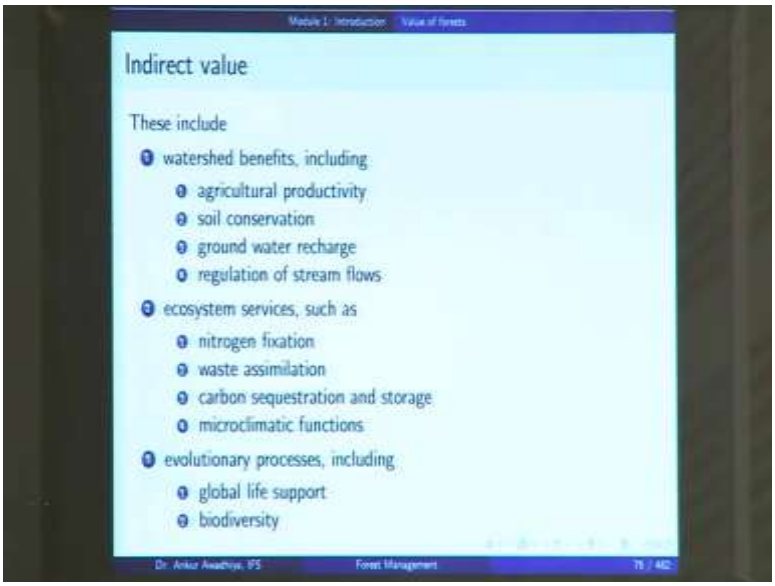

Then, the indirect values include watershed benefits such as agricultural productivity, soil conservation, groundwater recharge, regulation of stream flows; ecosystem services such as nitrogen fixation, waste assimilation, carbon sequestration and storage microclimatic functions; and evolutionary processes such as global life support and biodiversity.

Now, the point in the case of direct of indirect value is that, we are using these values they are important for us, but we are not using them directly. So, for instance, if there is nitrogen fixation that is happening somewhere; so, this nitrogen fixation that is being done biologically. We are not using it directly; it is there to support a different number of different life form and so, it is in indirect value

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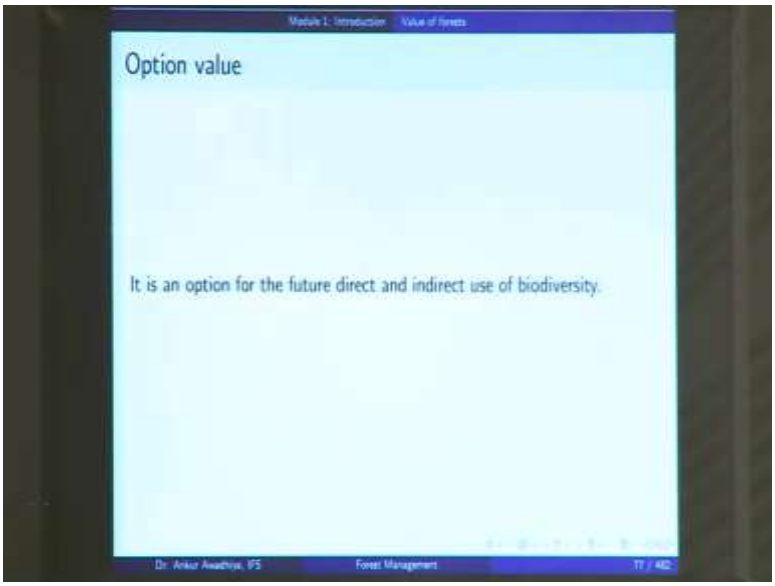

Next, we looked at option value. It is an option for the future; direct and indirect use of biodiversity of the forest. So, in this case what we are saying is that we are not using it, but we want to retain an option that this resource should be available for a future use. If we wanted you to use it in future; so, just because you want to use it in future, you are maintaining it today. So, that is an option value. We do not know when we are going to use it; we do not know if we are going to use it, but we still want to maintain this resource to have this option of using it in, at a later stage, if it is required.

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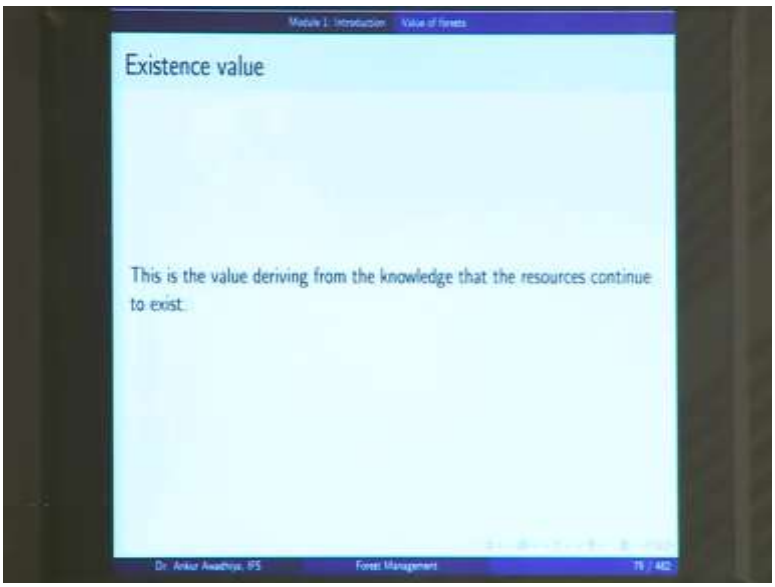

Next, we looked at existence value; in the value deriving from knowledge that the resource continues to exist such as the polar bear. So, even though you are not using a polar bear in any way, but still if the polar bear exists; in this species has not gone extinct. So, we are feeling happy about it. So, this is the existence value.

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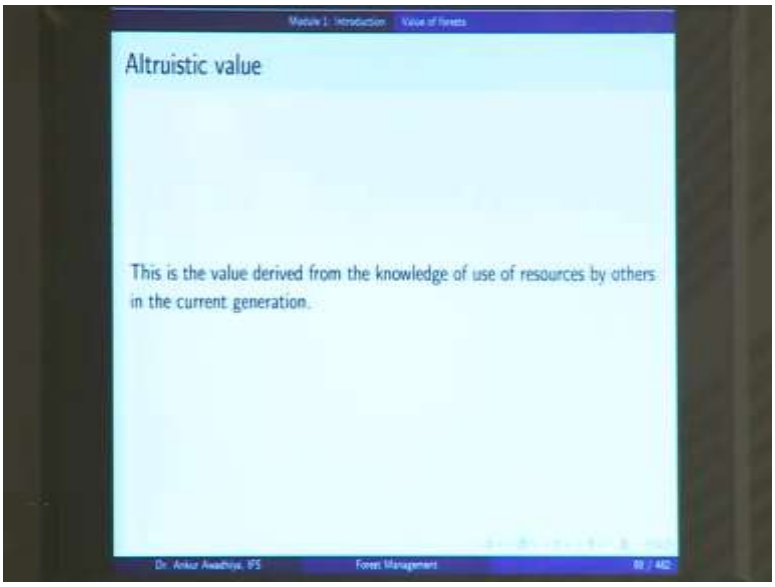

Then, you have altruistic value; value derived from the knowledge of use of resources by others in the current generation. A good example would be the tigers of Sunderbans. So, if I am living in Madhya Pradesh and I am not using those tigers, but I know that my fellow citizens, my fellow compatriots of the same planet are using that resource it is providing them livelihood and so, I am happy, because they are able to use this resource. So, this is altruistic value; it is different from a selfish value.

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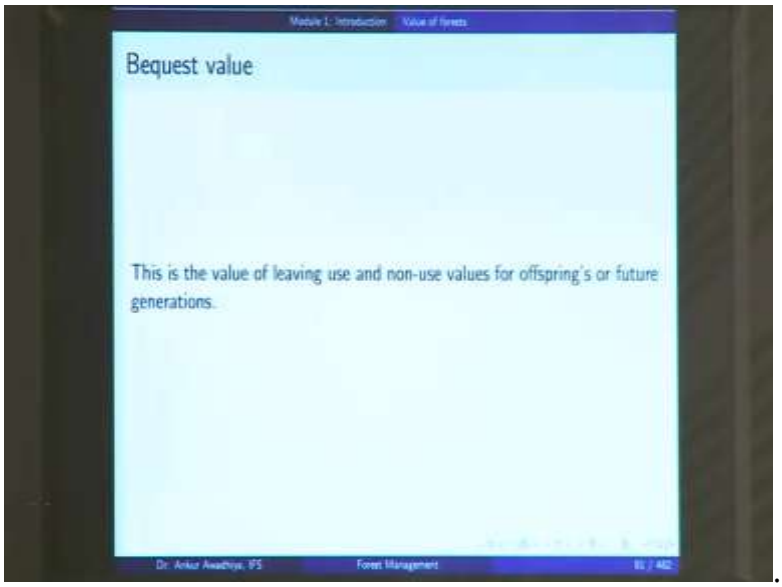

And then, third is the bequest value. The value of living use and non-use resources; use and non-use values for off springs or future generations. So, in this case, we are giving this these resources as a bequest to the future generations. So, we are just managing them; we are conserving them, so that our children or our grandchildren or the future generations will be able to use these values. So, we are giving them as a bequest; as a gift. Now, with all of these different values, we also have several methods of valuation.

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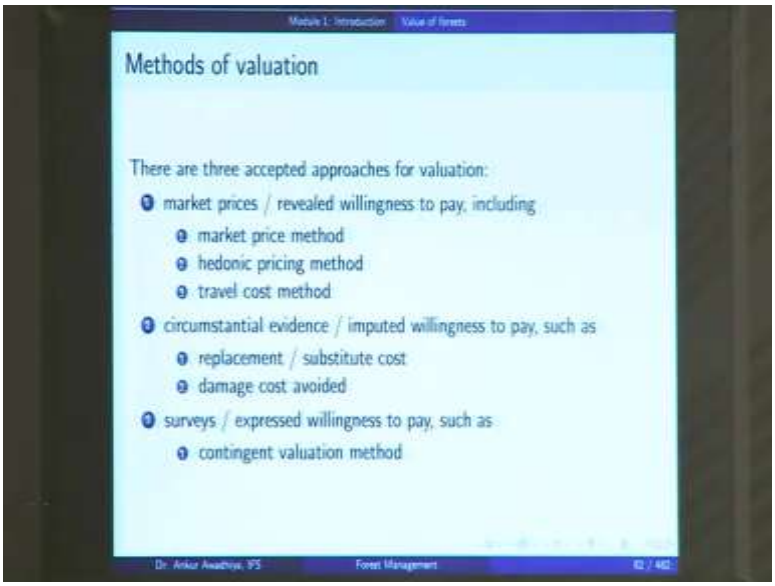

So, there are 3 accepted approaches for valuation. The first one is the market prices method or the revealed willingness to pay. So, in this case, you are looking at what is the price that any commodity or any resource is demanding in the market. So, the first one is market price method. So, in the case of your forests, they are providing you n number of resources. So, for instance, if you are extracting timber out of the forest, and you we are extracting say 100 tons of timber from the forest; what is the price of 1 ton of timber? Multiply that with 100, and you get the market value of timber that you are getting every year.

Now, suppose you are also using this forest for, say, a non-timber forest produce such as fruits and you are extracting say 50 tons of fruit. So, you find out the market price of 1 ton of fruit; multiply that with 50 and you get the total amount of market value that you are deriving out of the 50 tons of fruits. And so, you make a list of different resources that you are extracting from the forest. And, for each of them, you figure out how much is the amount that; or how much is the quantity that you are extracting for from the forest. And, you also figure out what is the market price of each of these commodities that you are extracting. So, you multiply the market price with the amount or the quantity to get the economic value of each and every commodity that you are extracting from the forest; add them up and you get a market price of the forest.

Next, you have the hedonic pricing method. So, hedonism is a in the sense of feeling happiness. So, if you have a forest; so, the lands that are near to that forest will be having less amount of pollution or probably people will be able to see the wild animals.

So, in that case, there is a possibility that certain prices of goods will go up. So, a good example was that you have two buildings; one is near to a road, which is having a large amount of noise; a large amount of smoke and dust. On the other hand, you have another building of a very similar size; at a very similar location or distance from the industrial centers. And, the good thing about the second building is that it is right next to a forest and so, the amount of dust and smoke and noise is less

So, typically, people will be willing to pay a premium or more amount of money for the second building. So, the difference between the rates, multiplied by the total number of flats that you have in that in the second building, will give you an idea of the price that

people are willing to pay to get the happiness of living in the second building. So, this is the hedonic pricing method.

Now, the third one is the travel cost method. So, in this case, people travelled to see a forest from different locations. And, whenever spending money on transportation; they are spending money on eating outside; they are spending money for lodging and boarding; they are spending money to get into the forest; paying the paying the gipsy fees; paying the guide and so; if you add up the different amounts that people are willing or that people are actually paying to come and see your forest. So, in that case, you can get a value of the forest.

The second method is a circumstantial evidence or the imputed willingness to pay, such as a replacement or substitute cost. So, in this case, we were saying that you have a forest that is right next to the oceans and this forest is protecting the lands from tsunamis. Now, if you let go of these forests. If you cut these forests, but still you want to have protection from the tsunamis. So, in that case, you will have to build up a concrete wall, so that would be a replacement or a substitute to the forest. Now, in the case of a replacement or a substitute, what is the amount that you will have to shell out to build this wall and to maintain it? So, that will give you an idea of the value of the forests.

The other method is the damage cost avoided method. In which case, you say that the on the value of your forest is equal to the amount of the of damage that it is able to avoid just by its presence. So, for instance, if you do not have this forest and if a tsunami comes there will be a huge loss of life and property; which is the damage that is being avoided by having the forest there. So, that is the value of the forest.

And the third accepted method is surveys or expressed willingness to pay such as the contingent valuation method. So, in this case, you ask people what is the amount of money they are ready to pay to have a resource. So, if you ask people that suppose the government wants to cut a forest remove a forest, but if you want to keep this forest, then the government is going to add an extra tax.

So, what is the amount of tax that you are willing to pay. So, this is an expressed willingness because neither the government is going to cut the forest nor is the government asking for any tax. But then, you give this hypothetical situation in the form

of a survey to get an idea or an estimate of how much are people willing to or expressing to pay for the forest, and that will give you an idea of the valuation of the forest.

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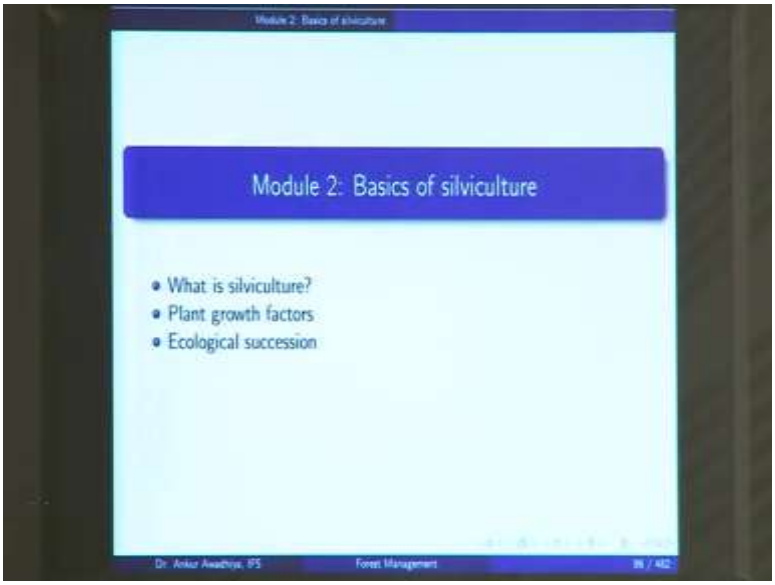

Now, in the second module, we looked at the basics of silviculture and we started with what is silviculture.

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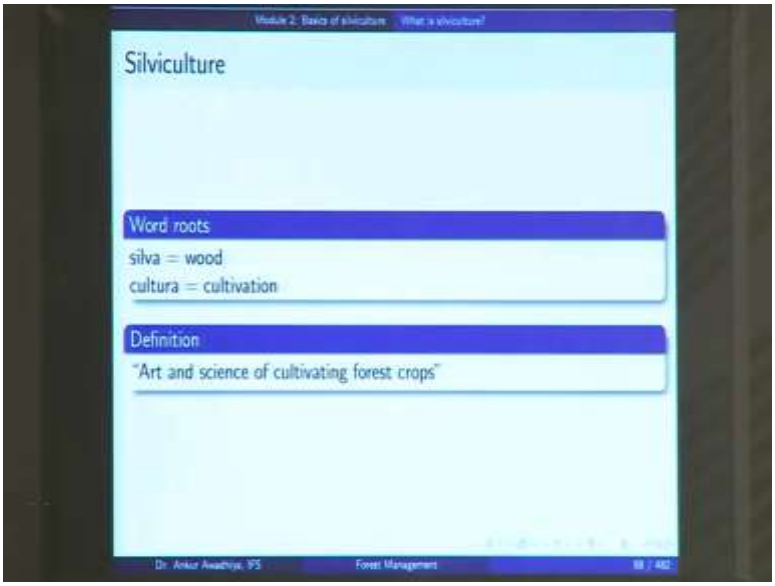

So, ‘silva’ refers to ‘wood.’ ‘Cultura’ is ‘cultivation.’ So, we defined silviculture as the art and science of cultivating forest crops. Then, we looked at its relationship with silvics.

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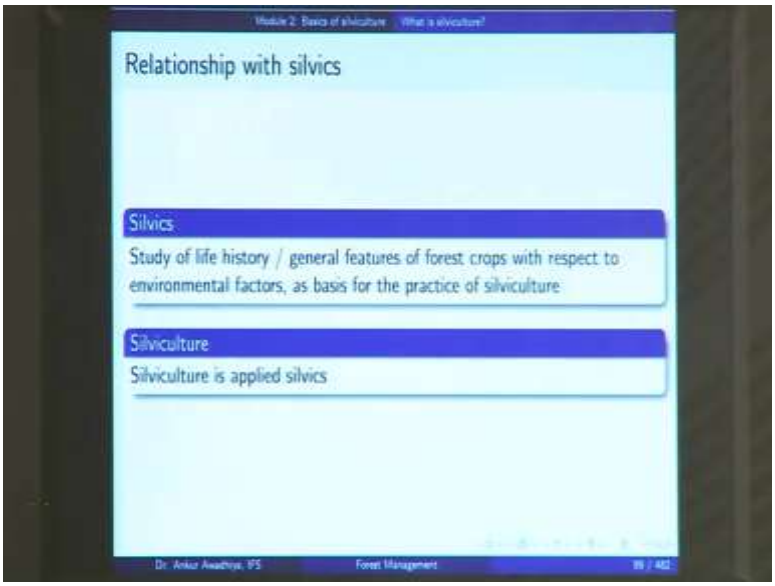

So, silvics is the study of life history or general features of forest crops with respect to environmental factors, as a basis for the practice of silviculture. So, we said that silviculture is applied silvics,; silvics is the theoretical aspect and silviculture is the practical aspect.

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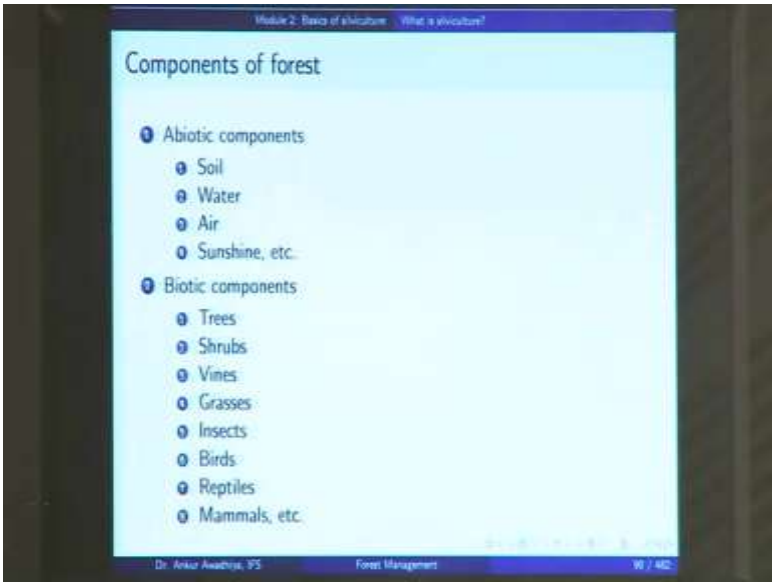

Then, we described the components of a forest. So, a forest comprises of abiotic and biotic components. Abiotic components are the nonliving components, such as soil,

water, air, sunshine and so on. And, biotic components are trees, shrubs, vines, grasses, insects, birds, reptiles, mammals and so on; the living components.

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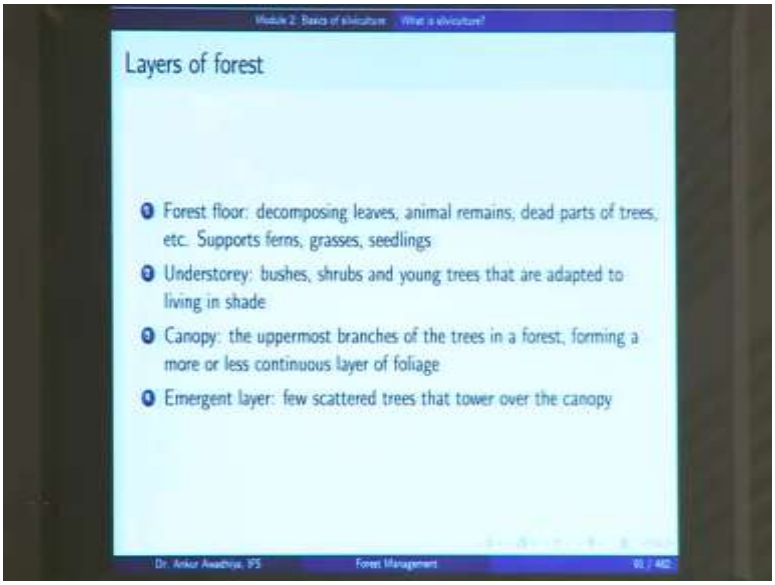

Then, we saw that a forest is comprised of several layers. You have the forest floor which has decomposing leaves, animal remains, dead parts of trees etcetera. It supports ferns, grasses and seedlings. Then, you have the understorey comprised of bushes, shrubs and young trees that are adapted to living in the shade. Then, you have the canopy which is the uppermost branches of the trees in a forest that forms a more or less continuous layer of foliage. Followed by, the emergent layer on the very top, which is a few scattered trees that tower over the canopy.

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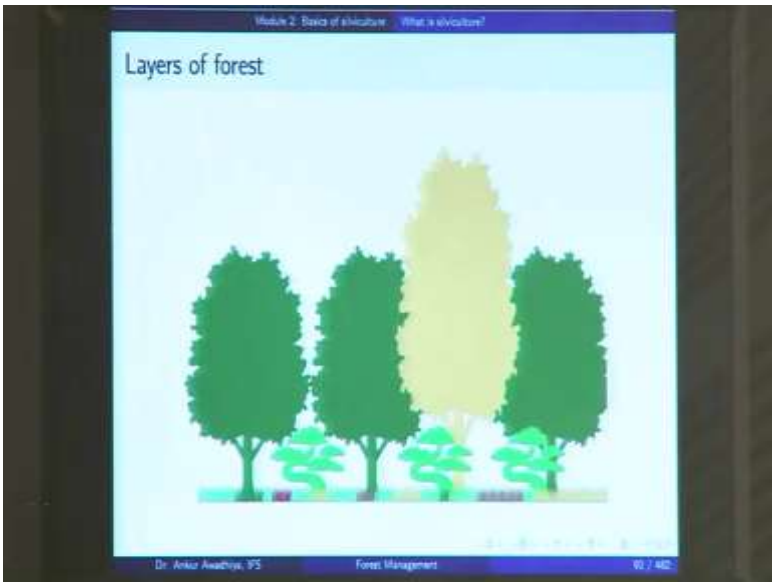

So, here we are seeing that, you have a canopy, you have the emergent layer, you have the understorey, and you have the forest floor.

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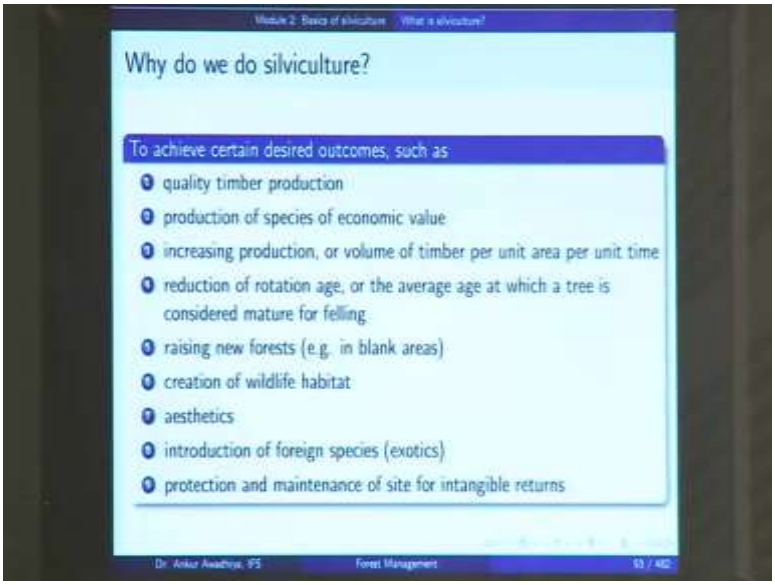

Then, we looked at why do we do silviculture at all? So, silviculture is done to achieve certain desired outcomes, and you can have different outcomes; you can have different objectives such as timber such as quality timber production. Production of species of economic value, increasing the production or volume of timber per unit area per unit time, reduction of rotation age or the average age at which a tree is considered mature for

felling, raising of new forest in blank areas, creation of wildlife habitat, aesthetics introduction of foreign species; also known as exotics, or protection and maintenance of site for intangible returns.

So, you are doing the cultivation of forest crops to achieve one or more of these objectives. So, this is why we are doing silviculture.

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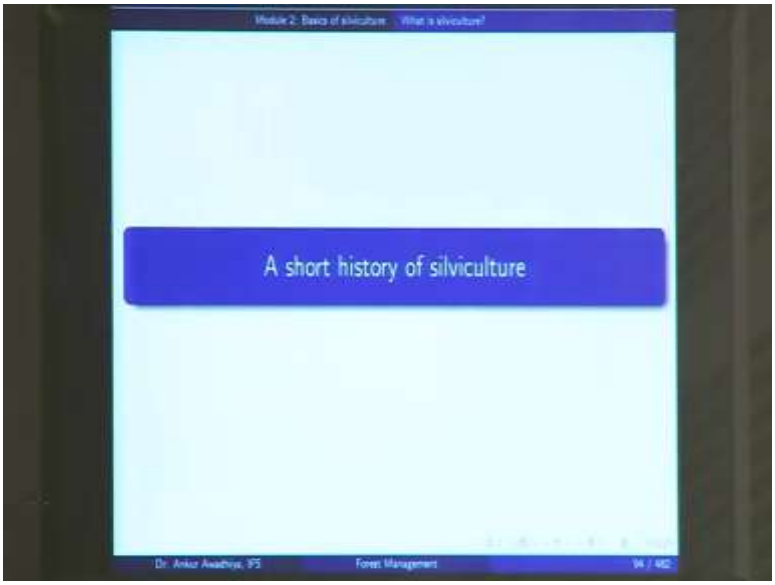

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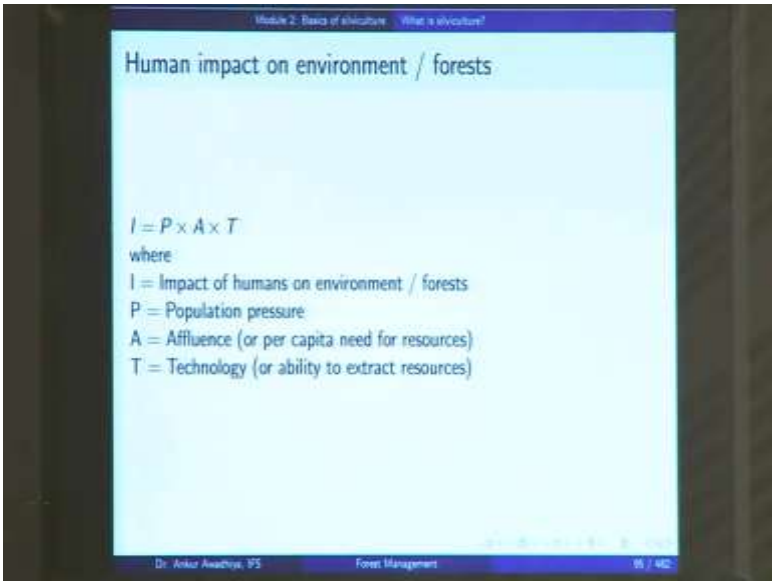

Then, we looked at a short history of silviculture and we began by looking at the impact of human beings on the environment or the forest. And, here, we came up with this

equation that I is equal to P into A into T. Where, I is the impact that the humans are making on the environment or on the forests, P is the population pressure, A is the affluence level or the per capita need for resources, and T is the amount of technology or the ability to extract the resources.

So, suppose, you have a society that has a small population and as and has less use for resources, and does not have the technology to extract the resources. So, in such as a situation, your resources will remain as such and there will be hardly any impact on the resources. On the other hand, if you have large number of people and all of those people require large amount of resources, and the society also has the technology to extract those resources. In that case, you will find that is the amount of impact of the human beings on the environment or on the forests will be very large.

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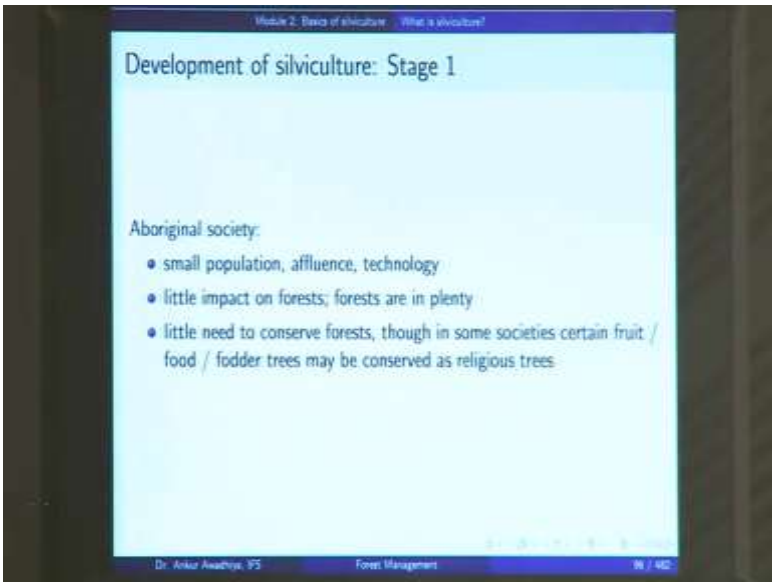

So, we saw that development of silviculture occurred in several stages. We began by the abori we began with the aboriginal society; the early society with small population affluence and technology. There was little impact on forests; forests were in plenty and so there was little need to conserve the forests. But even then in certain societies, certain food fruit trees, food trees or fodder trees were considered religious trees, and they were conserved.

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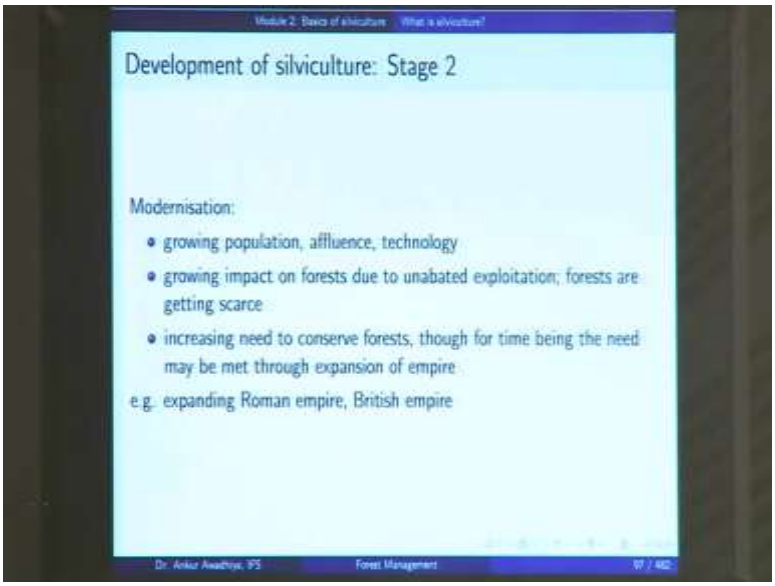

Now, in the second stage, we started to modernize; the population started to grow; there was increase in affluence and technology. So, people started feeling a need for more amount of resources, and they also developed the ability to extract those resources. Now, with the modernization what happened was that the impact of the society on the resources increased, and the forest and the forest started getting scarcer every day.

So, there was an increasing need to conserve the resources, but then because you have areas that were left. So, one option was that you expand your empire; you in place of cutting trees in your local areas only, you started to move out and you started to increase the size of your empire, so that you get access to resources in other places as well. Now, good examples of this stage include the expanding Roman empire and the expanding British empire.

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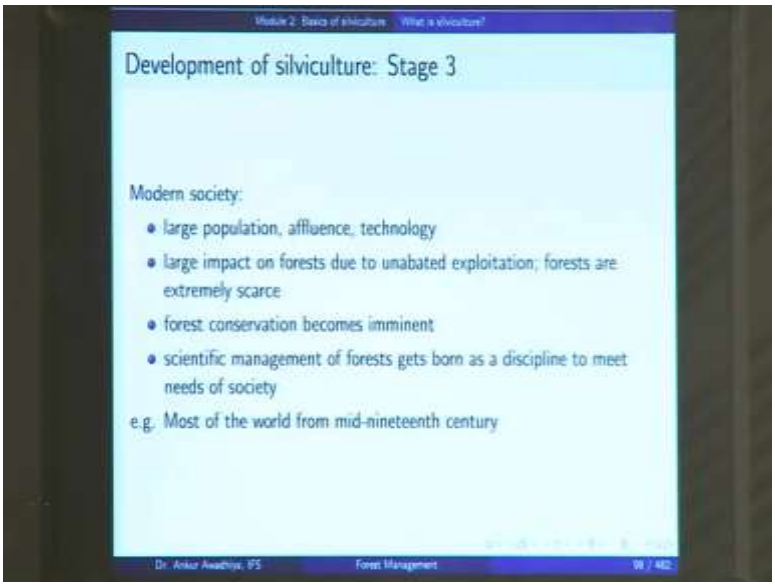

Now, in the 3rd stage; now, in the third stage, we have a modern society with large population, large affluence, large technology.

So, now, we are having a large impact of forests due to unabated exploitation; forests are getting scarcer every day. But we do not have more spaces to expand our societies, because all the areas that could be cut have already been cut. So, there is hardly any scope that is left for the society to increase and so, the forest conservation has now become imminent. The scientific management of forests gets born as a discipline to meet the needs of the society, and the example is most of the world from the mid nineteenth century.

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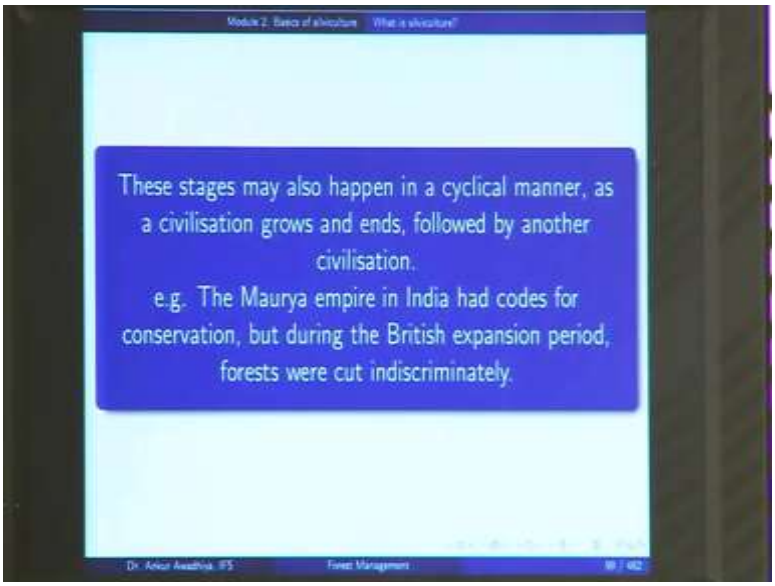

Now, these stages can also happen in a cyclical manner, in which case, a civilization in an early stage is more inclined towards conservation, than a civilization in the later stage. So, an example is the Maurya empire in India that had codes for conservation, but during the British expansion period, the forests were cut indiscriminately.

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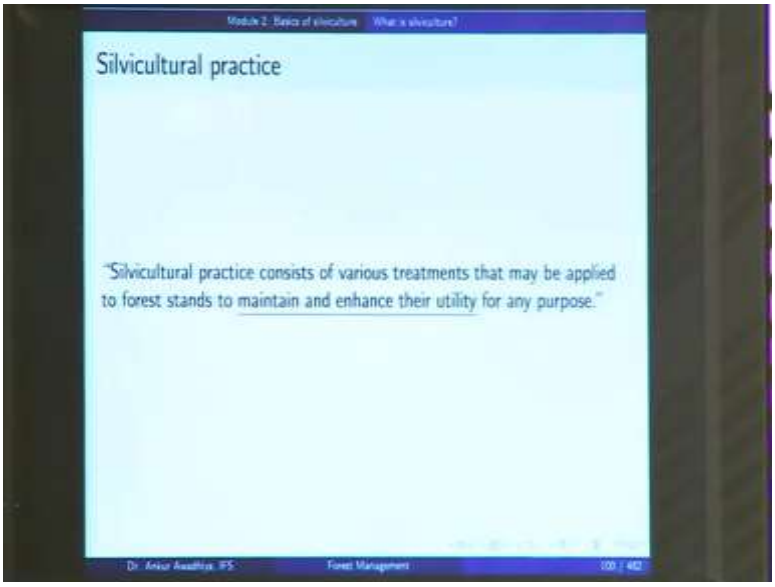

Next, we had to look at the silvicultural practice. So, silvicultural practice consists of various treatments that may be applied to the forest stands to maintain and enhance their utility for any purpose.

So, silvicultural practices are various treatments that are applied to the forests stand, and for two purposes; to maintain their utility and to the enhance their utility, for any purpose.

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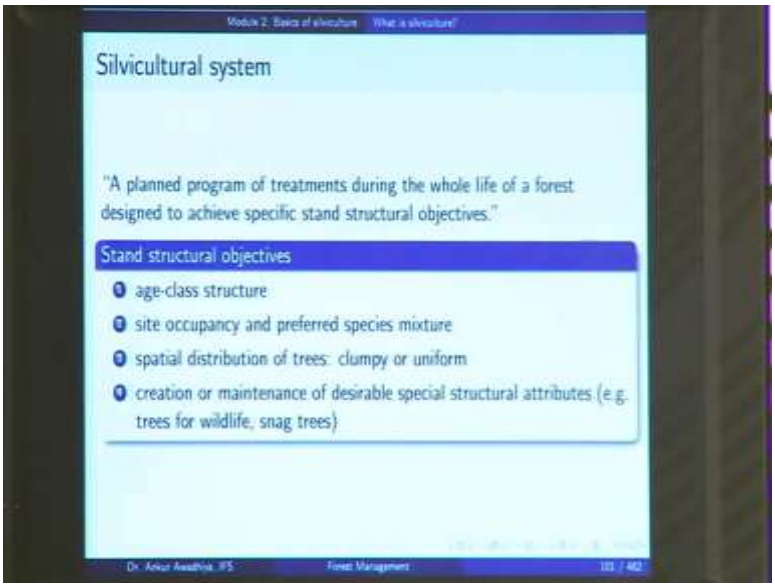

So, next we had a look at silvicultural system. A silvicultural system is a planned program of treatments during the whole life of a forest designed to achieve specific stand structural objectives. And, we saw that the stand structural objectives could be the creation or maintenance of a specific age-class-structure, site occupancy, preferred species mixture, spatial distribution of trees; weather clumpy or uniform, or creation or maintenance of desirable special structural attributes; such as trees for wildlife, or the snag trees.

Now, as we saw there the snag trees are those trees that are old in age. In most cases, they are dead trees, but then there are hollows in this tree that act as habitats; that act as nesting sites; that act as breeding sites, for several organisms and so, we maintain these trees, if we want to maintain an area as a wildlife habitat. Though, in one of the lectures, we also saw that these snag trees also act as a fire hazard because, if you have a fire that is moving under the ground and if it gets a snag tree; then because its a hollow tree; it is a dead tree; it is a dry tree; so, it catches a fire.

So, snag trees also so, basically the whether or not you will be having snag trees or you will prefer to have a snag tree will depend on what is your objective of management in any area.

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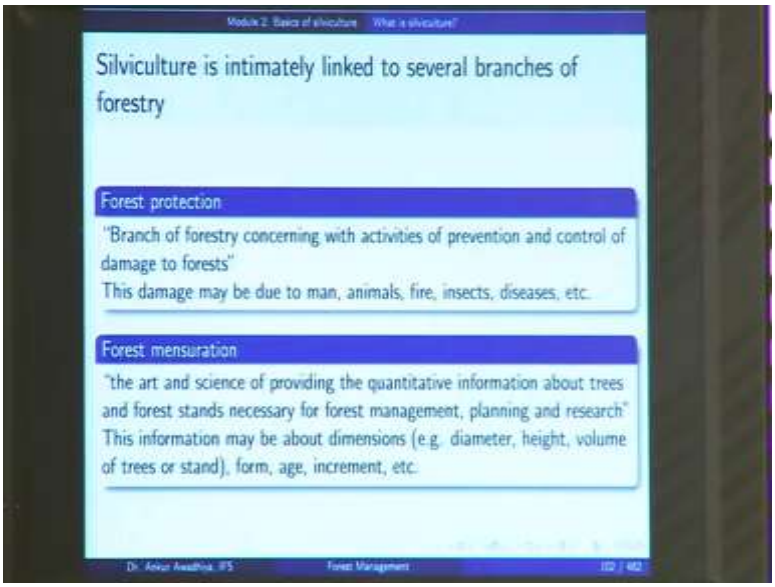

Now, silviculture is intimately linked to several branches of forestry, such as forest protection, which is the branch of forestry concerned with activities of prevention and control of damage to the forest. Now, damage to the forest may be due to man, animals, fire, insects, diseases and so on. Then, for silviculture you also require forest mensuration which is the art and science of providing the quantitative information about trees and forest stands, that is necessary for the forest management planning and research.

Now, this information may be about dimensions; example, diameter, height, volume of trees or a stand, form, age, increment and so on. So, if you want to do silvicultural, you have you will have to look at the protection of forests, you will have to look at the measurement of these forests, so that you have data to manage these forests.

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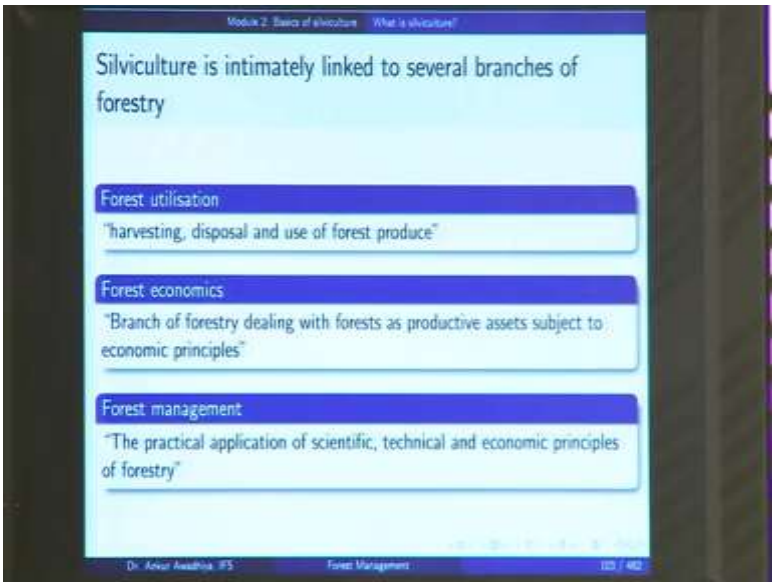

Then, you also need to have an idea of forest utilization which is the harvesting, disposal and use of the forest produce. So, in the case of forest utilization, you are harvesting trees; you are disposing them in certain ways; you are using them to make certain things, and this is known as forest utilization. Then, you also need to have an idea of forest economics which is the branch of forestry dealing with forests as productive assets that are subject to economic principles.

So, in the case of forest economics, you are dealing with forest as a productive asset in a very similar way as you would consider say a factory or an industry. And, because this is a productive asset, it is subject to the economic principles. Then, you we you also required to have a knowledge of forest management which is a practical application of scientific technical and economic principles of forestry.

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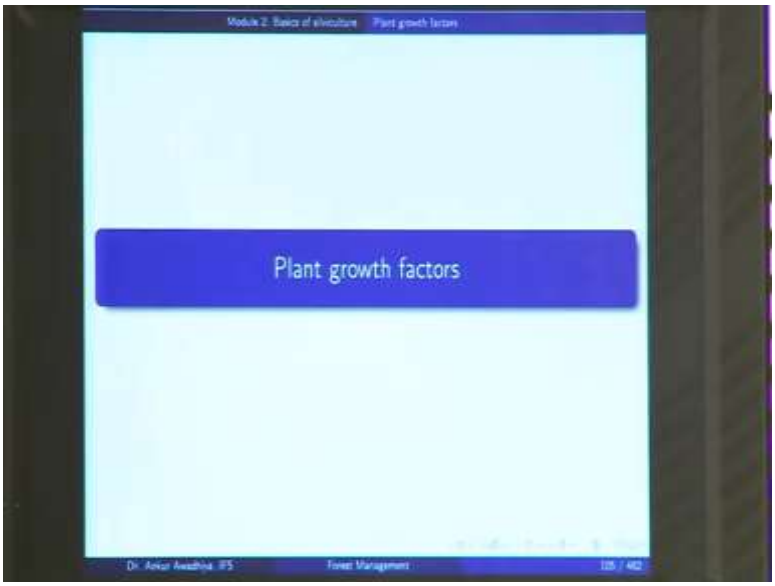

Now, in the next lecture, we had a look at the plant growth factors.

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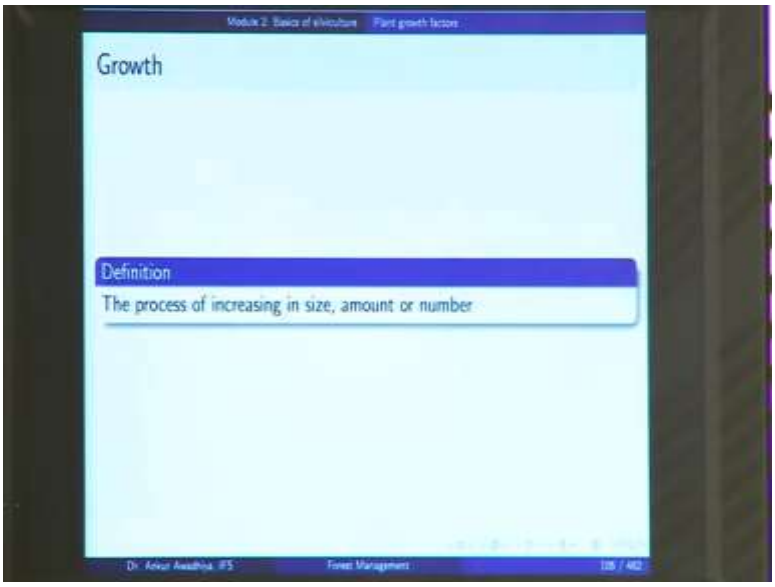

Now, growth is defined as the process of increasing in size or amount or number.

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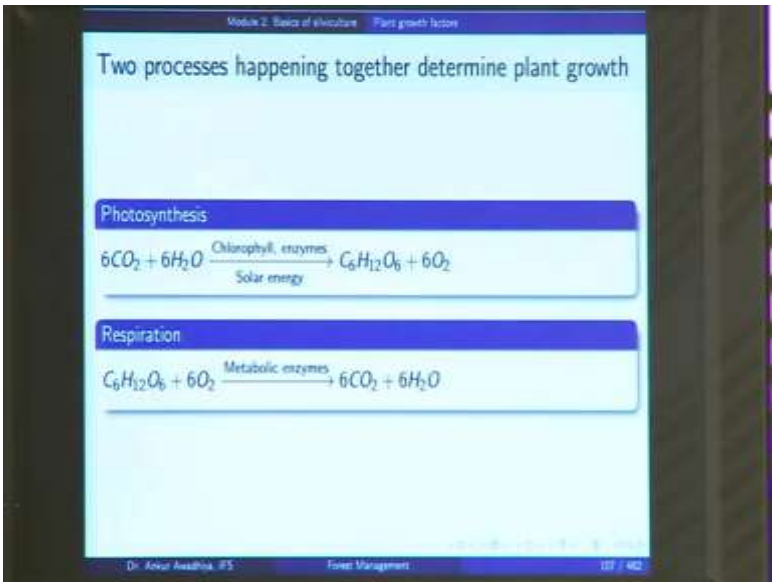

Now, in this case, there are two processes that are happening together. One is photosynthesis; in which case carbon dioxide and water are being converted into carbohydrates. And, the second process is that of respiration; in which case, the carbohydrates are getting burnt using oxygen to give out carbon dioxide and water.

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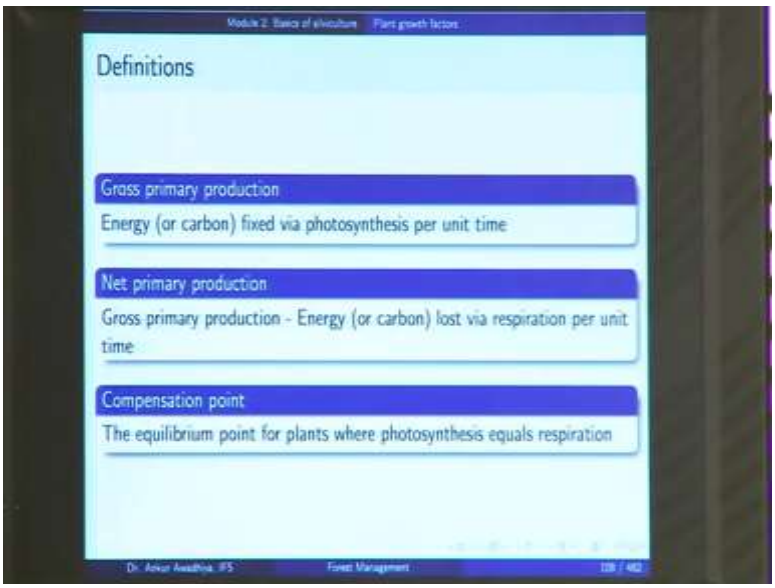

Next, we looked at the definitions of gross primary production, net primary production and the compensation point. Now, net primary production is gross primary production minus the energy that is getting lost because of respiration. And, the compensation point

is the equilibrium point for plants where photosynthesis is equal to respiration. And, typically, you reach the compensation point two times in a day; in the morning and in the evening.

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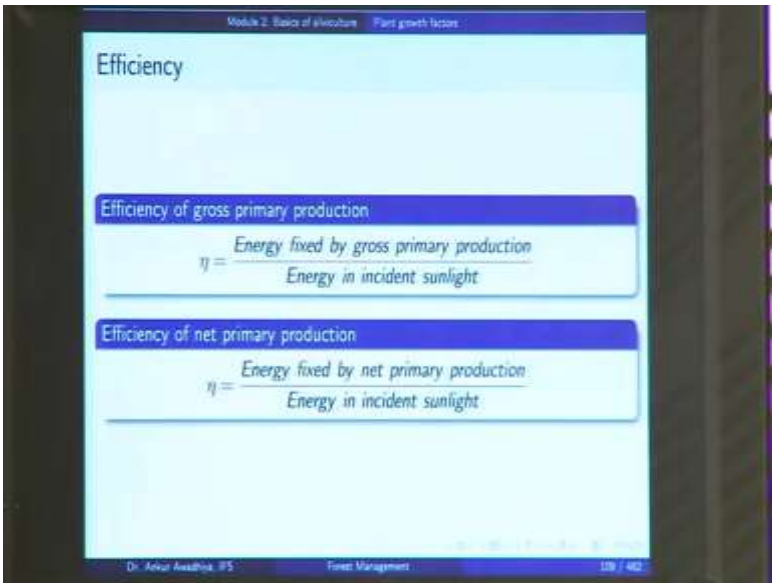

Now, we also define efficiency of gross and net primary production which is equal to the energy that is getting fixed divided by the energy in the incident sunlight.

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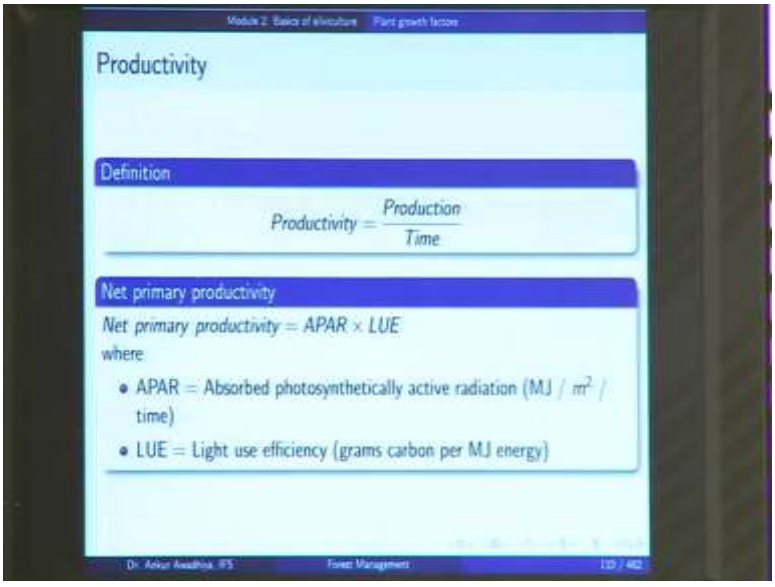

And, we also defined productivity as production per unit time. And, we defined that the net primary productivity is equal to APAR into light use efficiency, where APAR is the absorbed photosynthetically active radiation.

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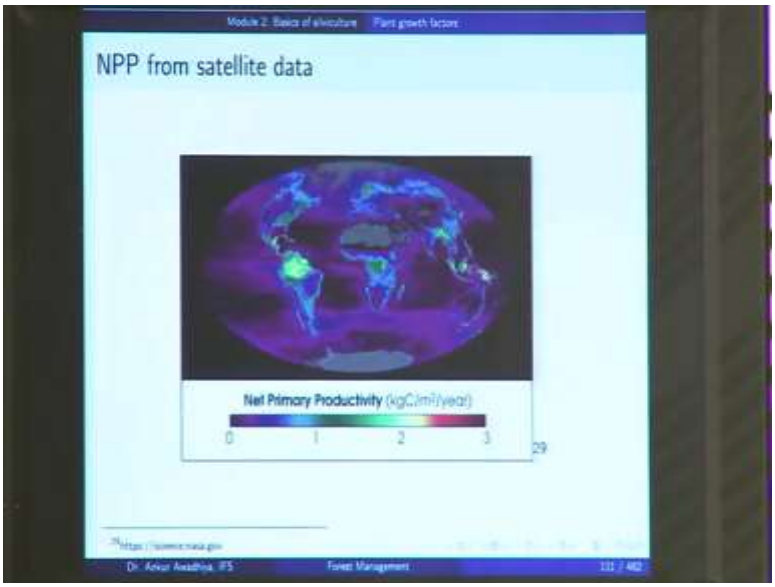

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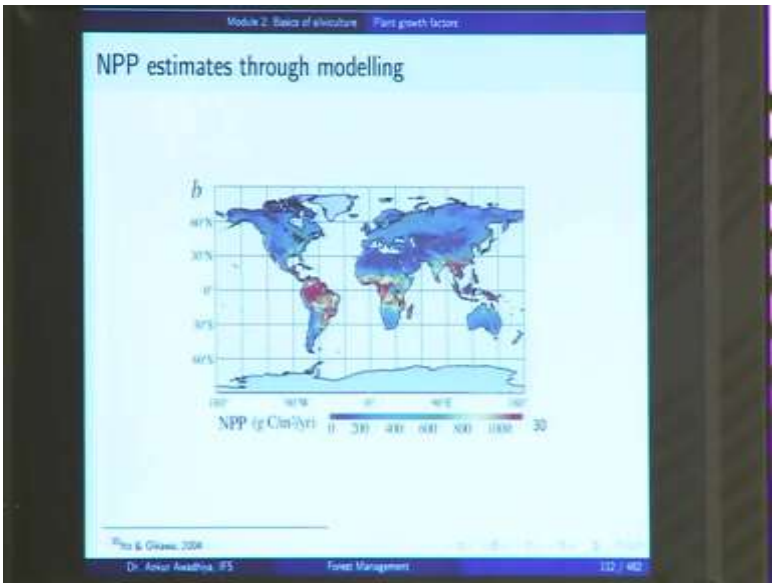

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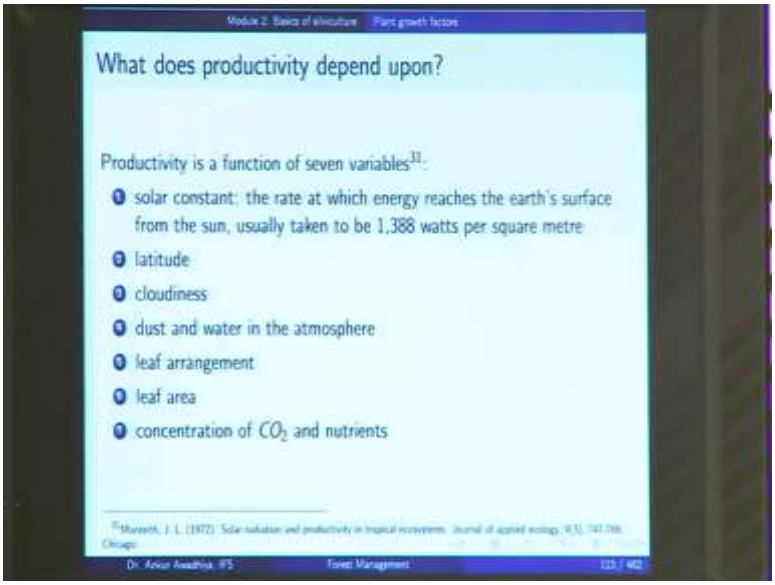

Now, the net primary productivity can be discerned from satellite data or through modeling. And, productivity depends on a number of things such as solar constant or the rate at which energy is reaching the earth's surface from the sun. It is usually taken to be 1388 watts per square meter. It depends on the latitude of the place; it depends on the cloudiness of the place; dust and water in the atmosphere, arrangement of leafs, area of leafs and the concentration of carbon dioxide and other nutrients.

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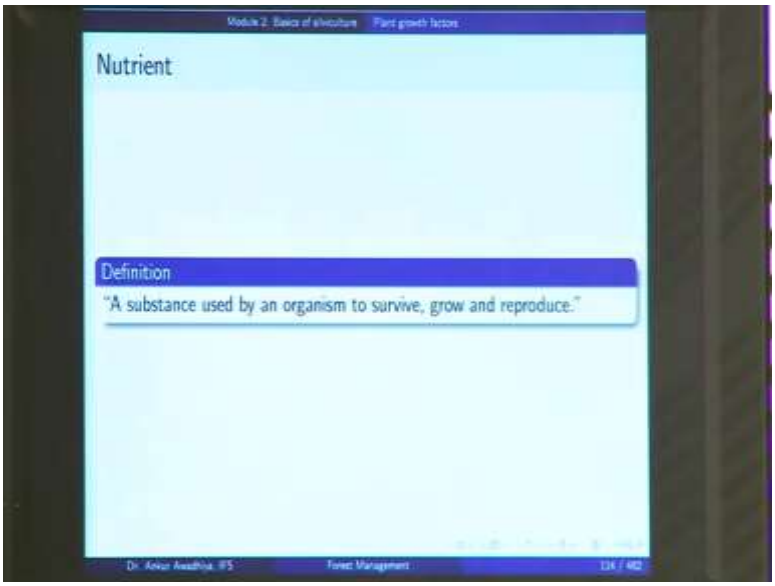

Where, nutrient is defined as a substance that is used by an organism to survive grow and reproduce.

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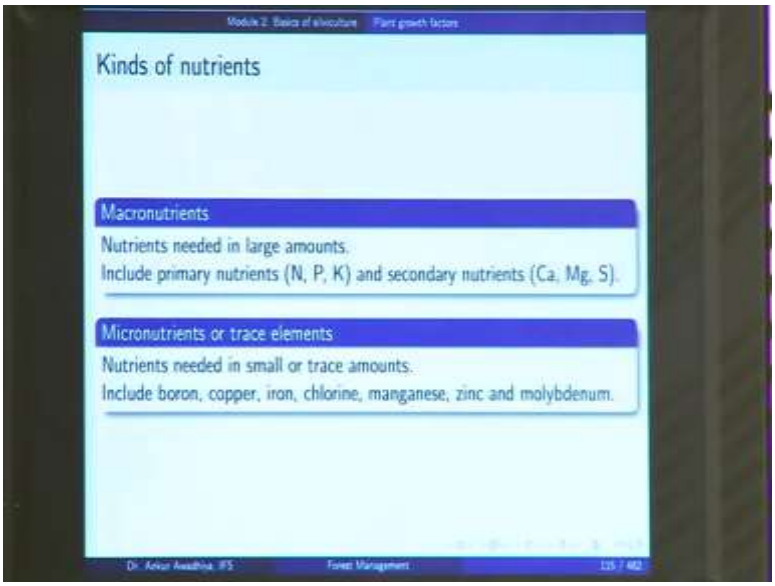

Then, we looked at different kinds of nutrients. You have macronutrients that are required in larger amounts, including both primary and secondary nutrients, and micronutrients or trace elements that are needed in smaller amounts.

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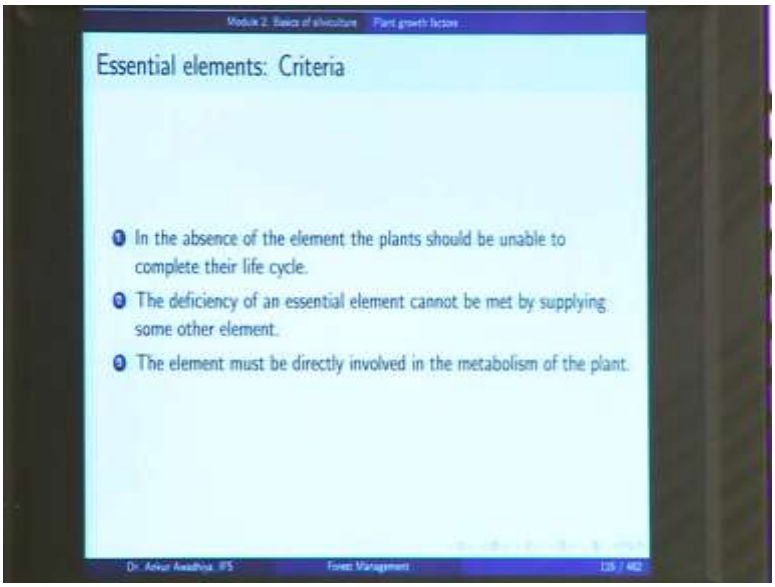

Then, we defined essential elements as those elements that that meets three criteria; one is that in the absence of the element the plants will be unable to complete the life cycle; two, the deficiency cannot be met by supplying some other element. So, you cannot

supply another element to meet up the needs for this element, and the third is that it must directly be involved in the metabolism of the plant.

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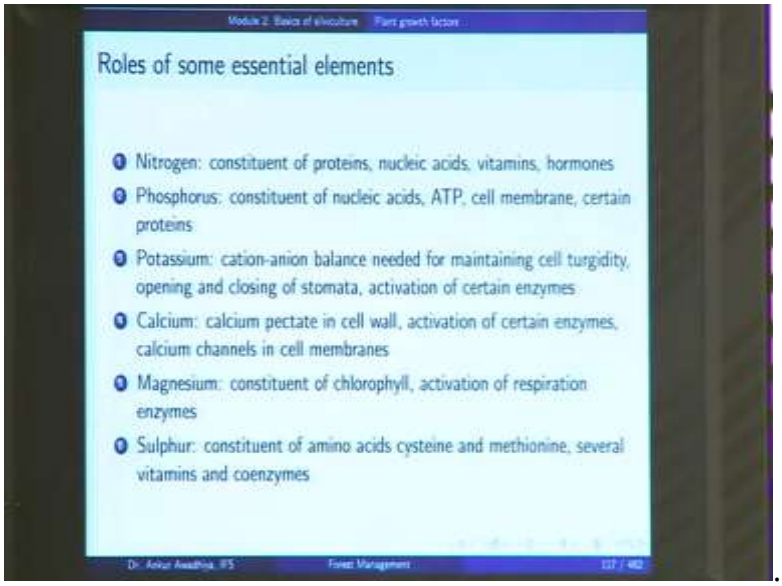

Then, we looked at the rules of several essential elements; nitrogen, phosphorus, potassium, calcium, magnesium and sulphur.

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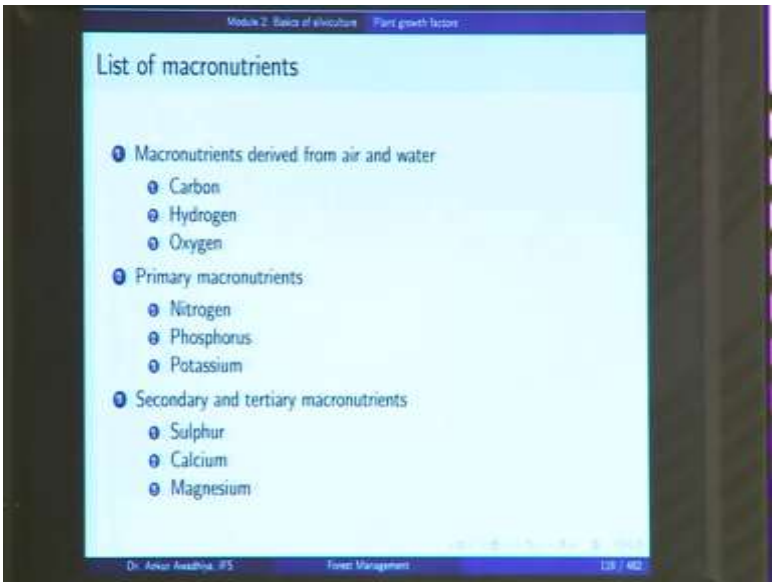

And then, we had this list of macronutrients; including the macronutrients derived from air and water, which is carbon, hydrogen and oxygen. The primary macronutrients; NPK,

and the secondary and tertiary macronutrients, which is sulphur, calcium and magnesium.

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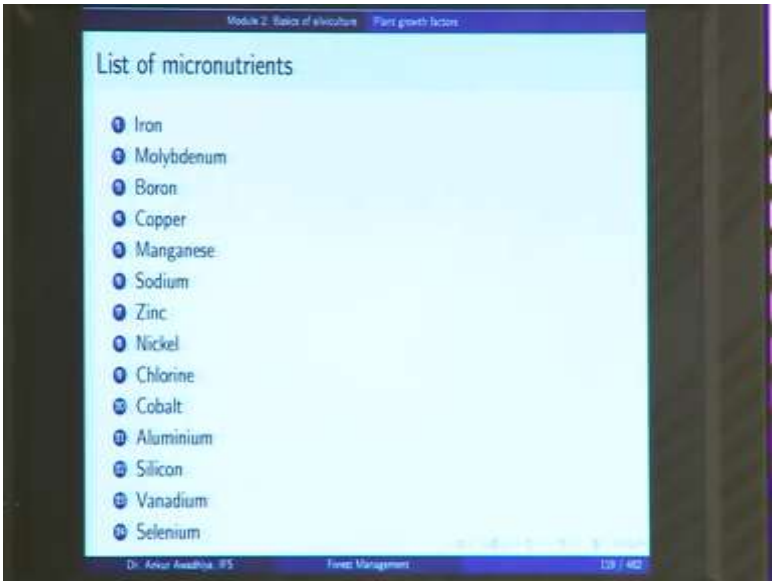

Then, we have the list of micronutrients; iron, molybdenum, boron, copper, manganese, sodium, zinc, nickel, chlorine, cobalt, aluminum, silicon, vanadium, selenium, and all of these are required in small or trace quantities.

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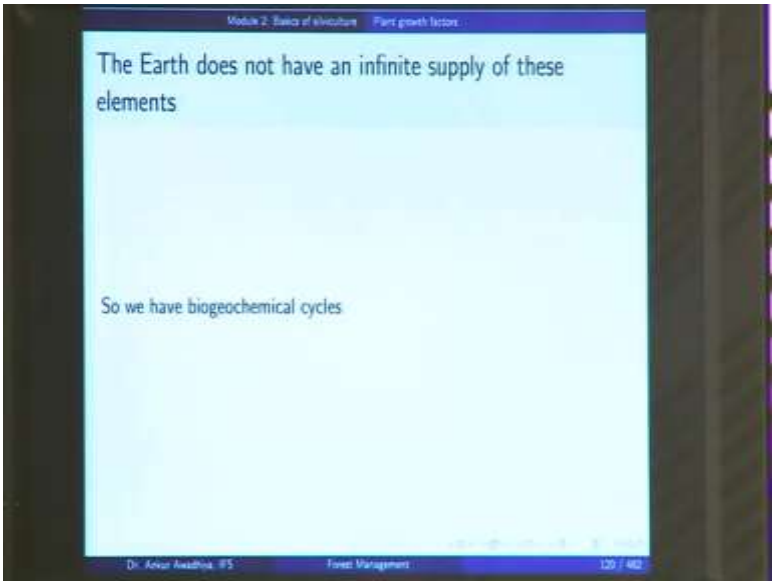

Now, because the earth does not have an infinite supply of these elements.

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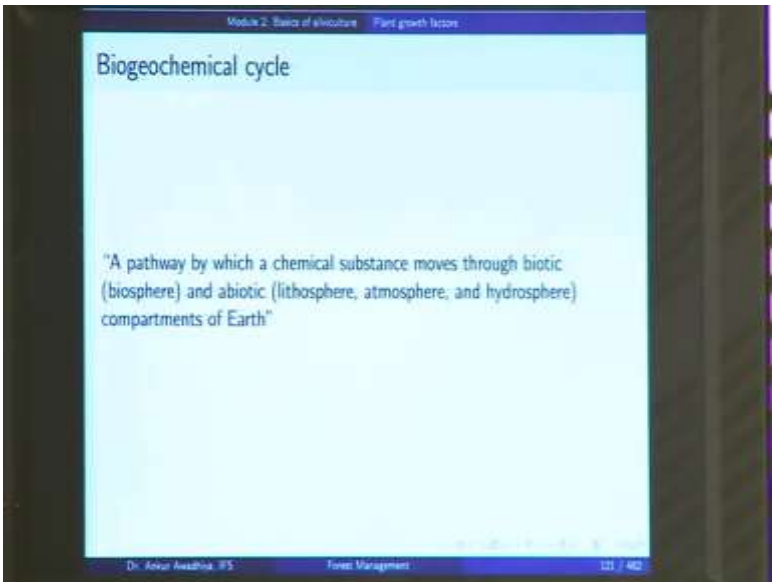

So, we have biogeochemical cycles. Now, a biogeochemical cycle is a pathway through which a chemical substance moves through the biotic and the abiotic components or compartments of the earth. Biotic compartment is biosphere, and abiotic compartment is lithosphere, hydrosphere and atmosphere.

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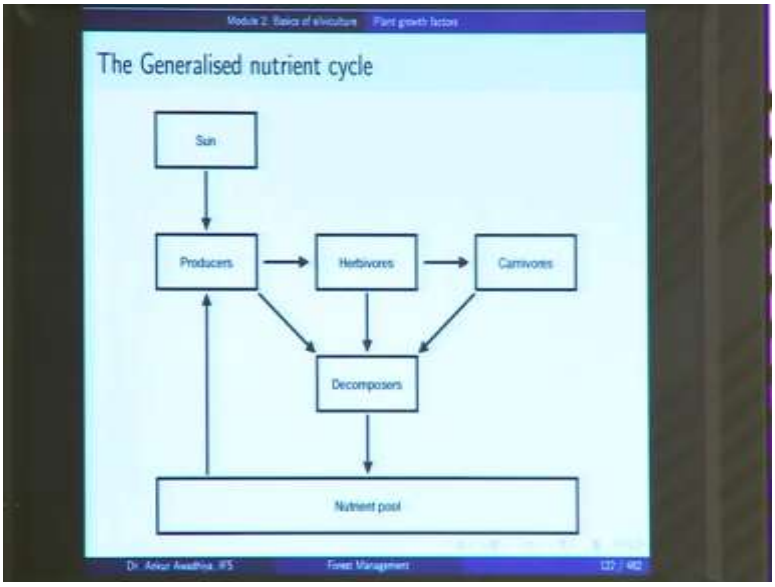

Now, this is the generalised nutrient cycle; in which case, the plants are taking nutrients from the nutrient pool, and using the energy of the sun to fix the energy, and the nutrients into their body mass, in the form of biomass; and this biomass then eaten up by the

herbivores; herbivores get eaten up by the carnivores, and whenever these plants or herbivores or carnivores; whenever they die or they give out excreta; so, in that case all of these are decomposed by the decomposers, and they release the nutrients back into the nutrient pool.

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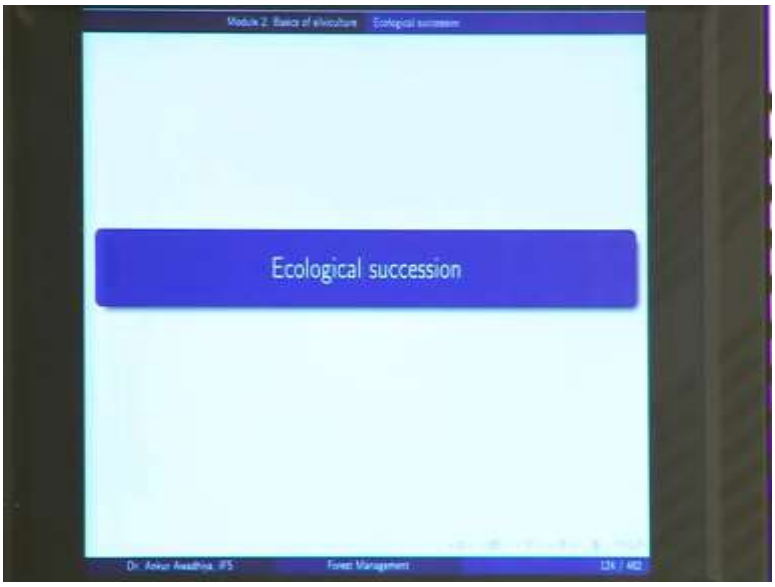

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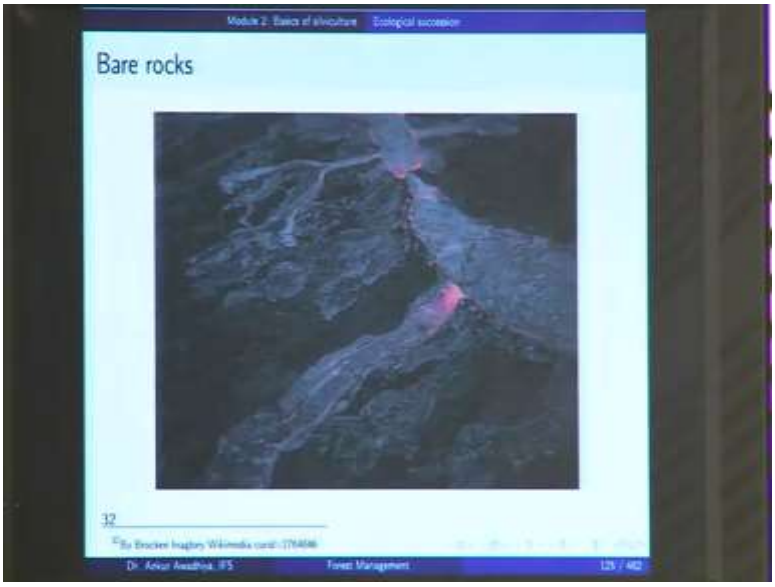

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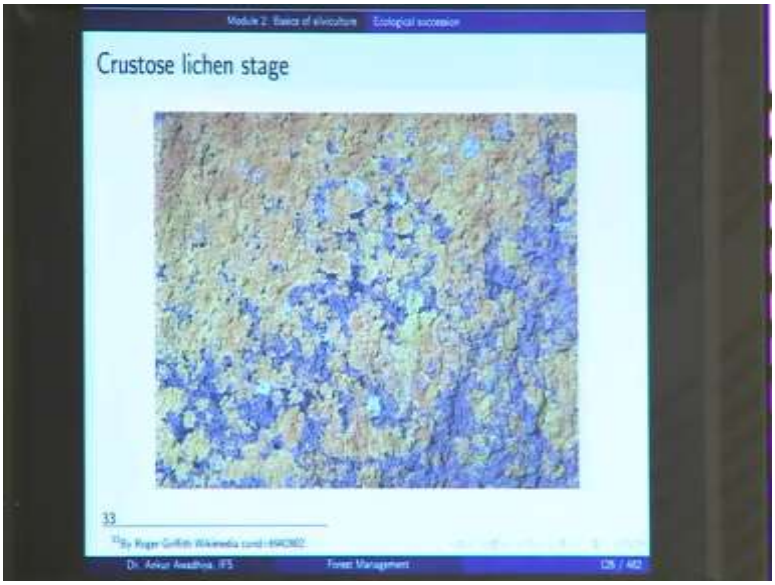

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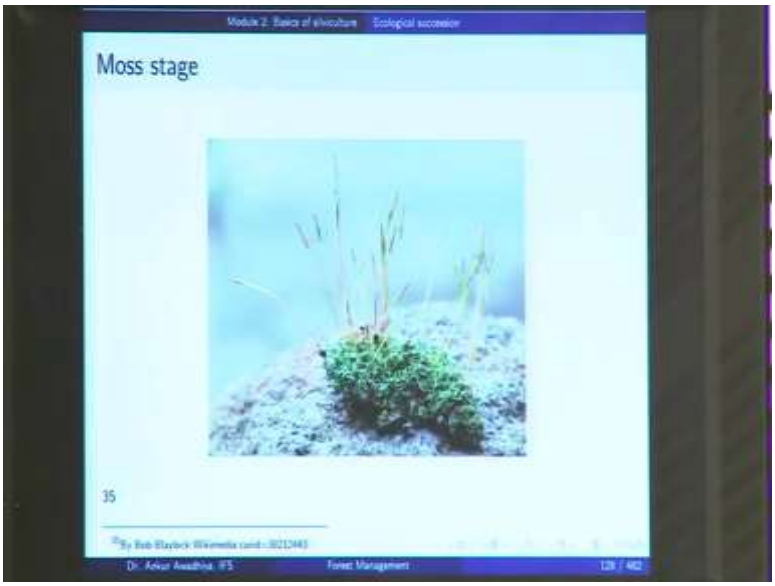

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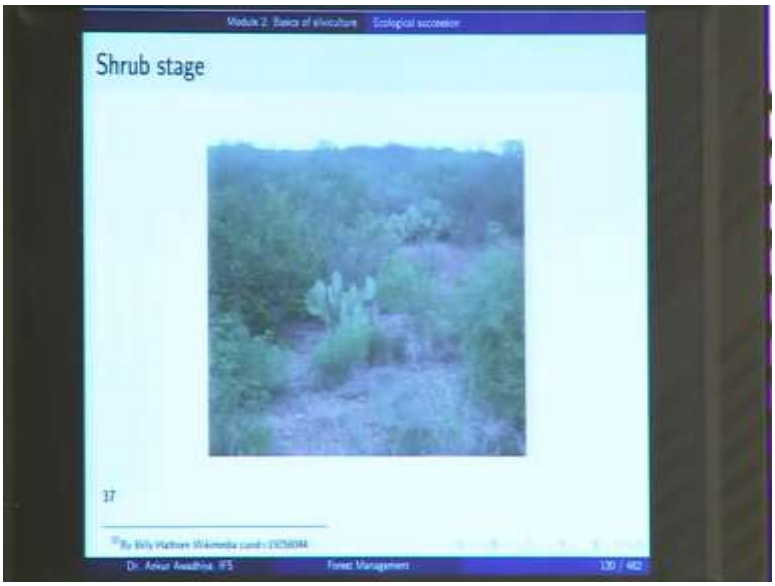

Next, we looked at ecological succession; how, it happens from bare rock to crustose lichen, to foliose lichen, to mosses to herb; herbs to shrubs to forest.

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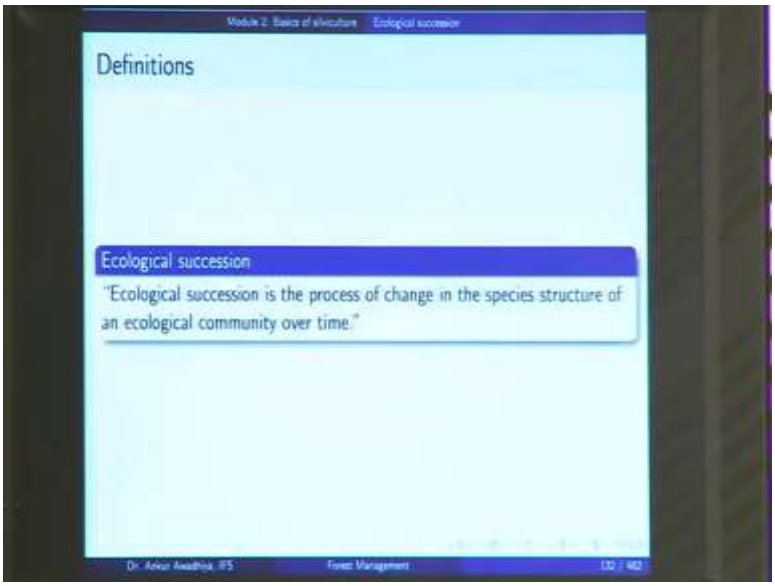

So, ecological succession is defined as the process of change in the species structure of an ecological community over time. So, we are seen the process of change in species structure of an ecological community over time.

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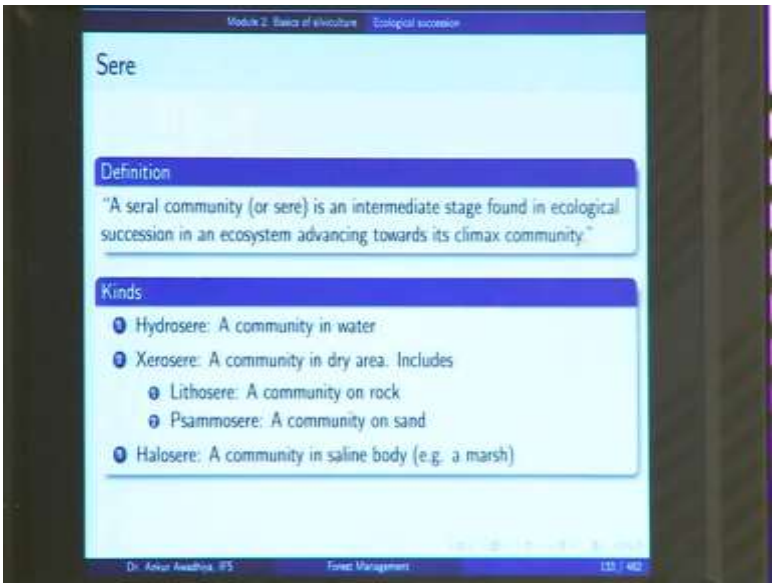

Where and. we defined sere as a seral community, or a sere is an intermediate stage that is formed in ecological succession in an ecosystem advancing towards its climax community.

We defined different kinds of sere. So, we have the hydrosere which is a community in water. Xerosere which is a community in dry area, such as lithosere and psammosere. And, a helosere which is a community in a saline body such as a marsh.

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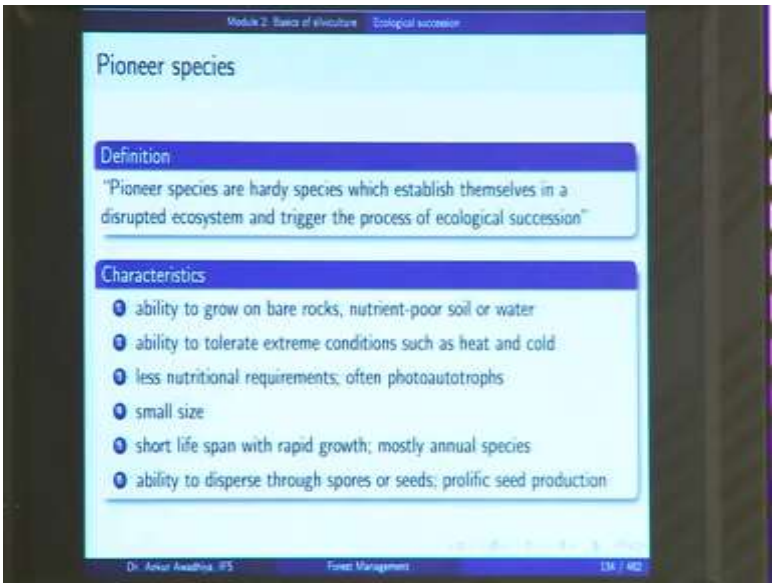

Then, we defined pioneer species as those hardy species which establish themselves in a disrupted ecosystem and trigger the process of ecological succession. The characteristics are ability to grow on bare rocks, nutrient, poor soil, water; ability to tolerate extreme conditions, less nutrient requirements - often photoautotrophs, small size, short life span, rapid growth, and the ability to disperse through spores or seeds with a prolific seed production.

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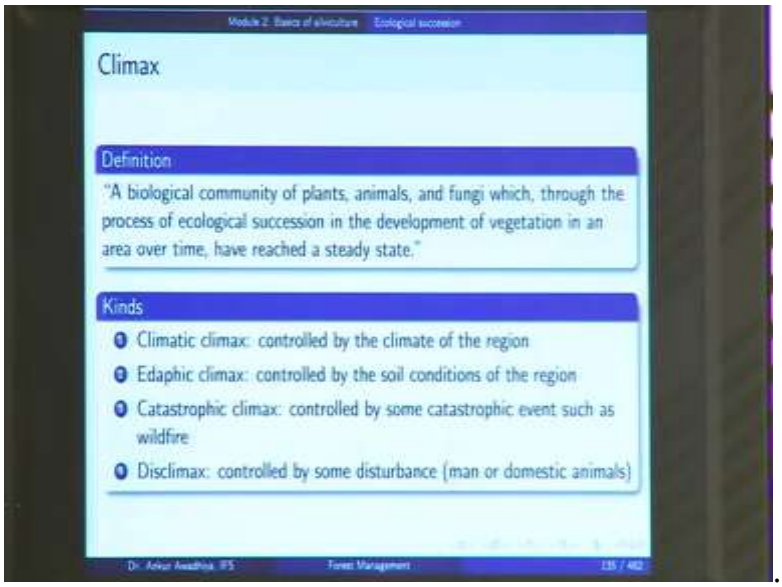

And then, we also looked at a climax community which is the final community of biological community of plants, animals and fungi; which through the process of ecological succession, in the development of vegetation, in an area over time have reached a steady state. And then, there are different kinds of climaxes; you have climatic climax controlled by climate; it affect climax controlled by soil; catastrophic climax controlled by catastrophic events such as forest fires; and disclimax which is controlled by certain disturbances such as man or domestic animals.

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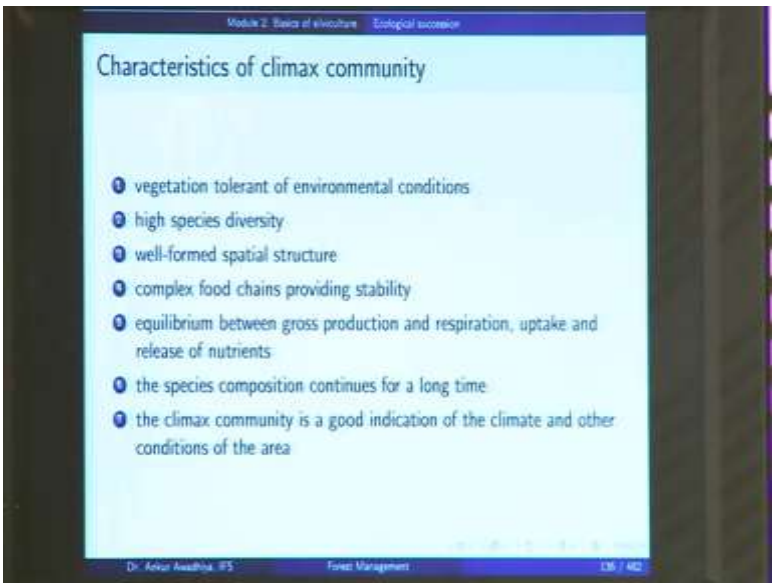

Then, we looked at the characteristics of climax community or mostly these are opposite of those of the pioneer communities.

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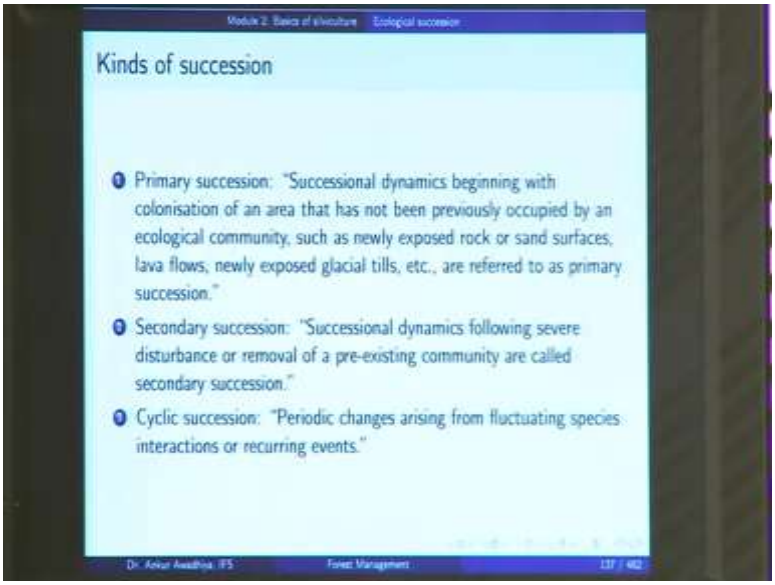

Now, there are three kinds of successions; primary succession which begins ab initio. Secondary succession which in which case you have successional dynamics that are following severe disturbance or removal of preexisting community. And, cyclic succession in which you are having cyclical circumstances that are leading to the succession again and again.

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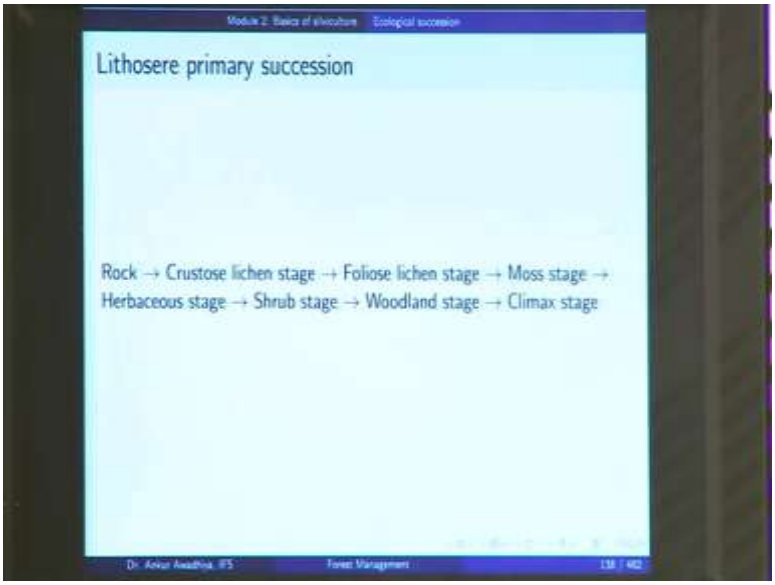

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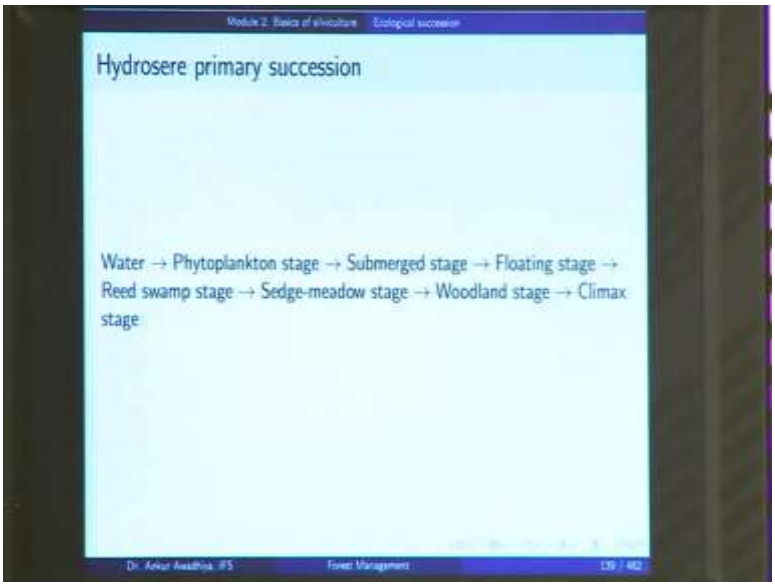

Then, we looked at the lithosere primary succession and the hydrosere primary succession. Now, in the case of hydrosere primary succession, you have water, followed by phytoplanktons, submerged state, floating stage, reed swamp, sedge meadow, woodland, and finally/followed by the climax stage.

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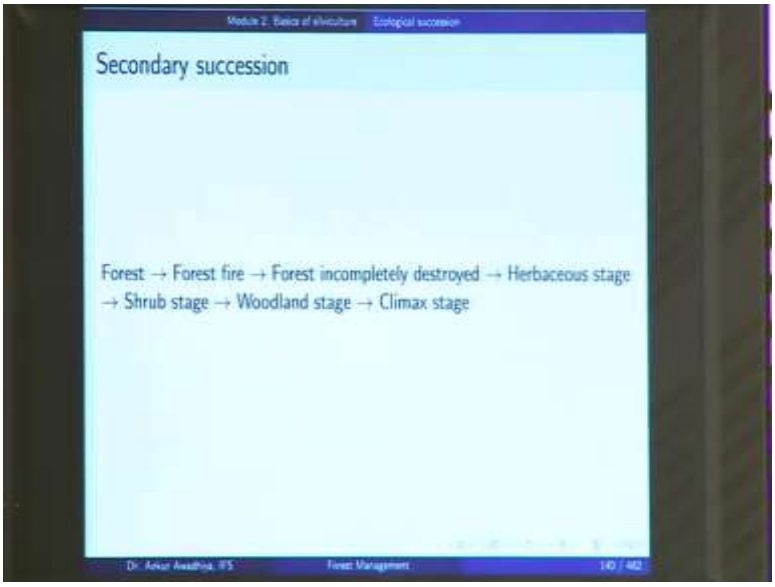

Now, in the case of secondary succession, you have forest fire. Now, if there is a forest fire, then the forest get incompletely destroyed, followed by a herbaceous stage, shrub stage, woodland stage and a climax stage.

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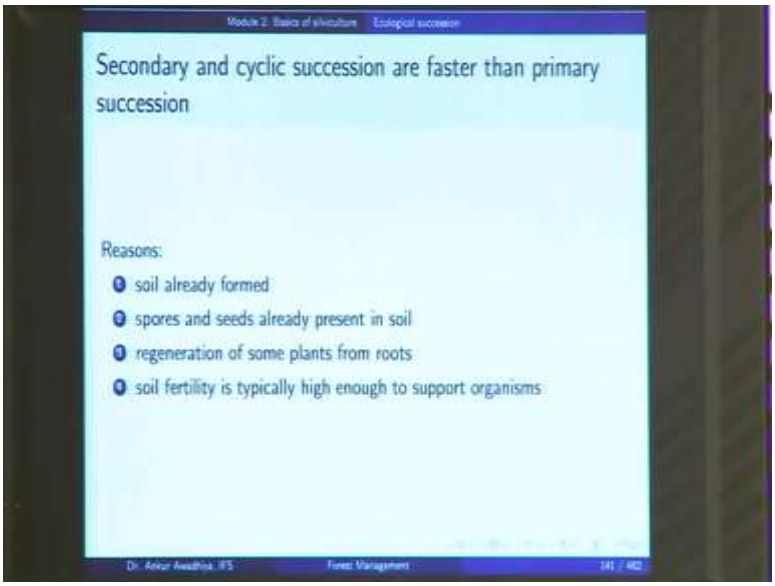

Now, typically, secondary and cyclic successions are faster than the primary successions because the soil is already formed, spores and seeds are already there, regeneration of some plants from the roots can also occur, and the soil fertility is high enough.

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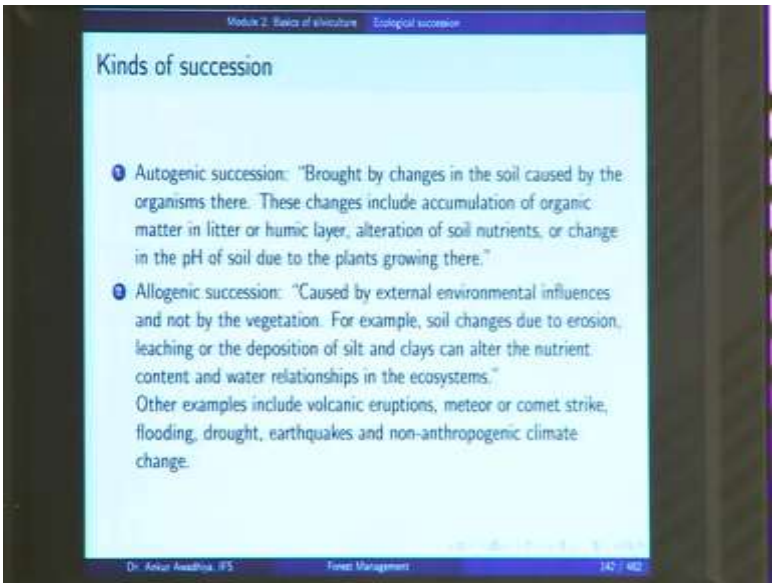

Now, another classification of succession is autogenic or allogenic. Autogenic is brought by changes in soil caused by the organisms; and allogenic is caused by external environmental influences and not by the vegetation itself.

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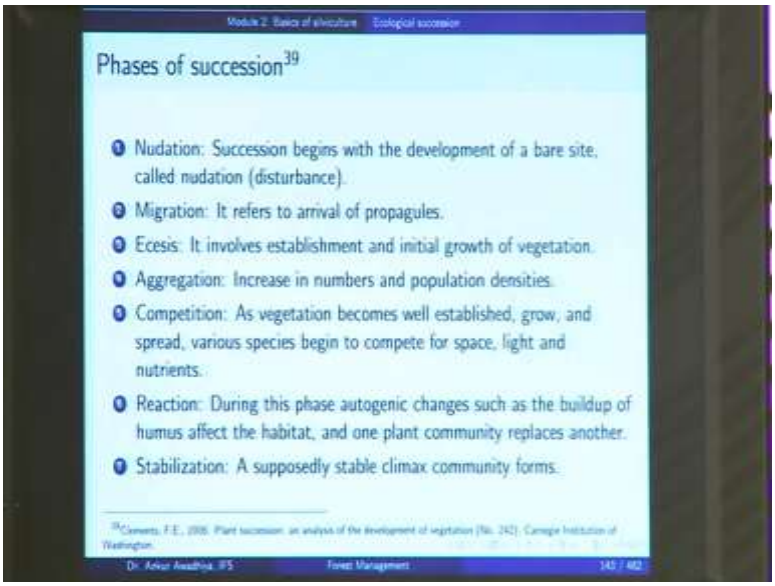

Then, we looked at the phases of succession. So, you have nudation, in which the surfaces made bare; followed by migration; ecesis, which is establishment; aggregation, in which the numbers increase; followed by competition, reaction and stabilization.

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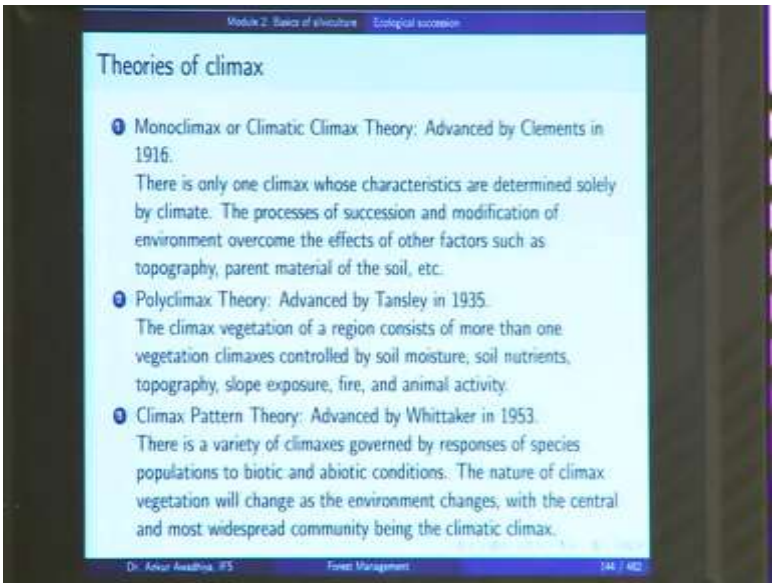

And, there are three theories of climax; monoclimax or climatic climax theory, polyclimax theory, and the climax pattern theory.

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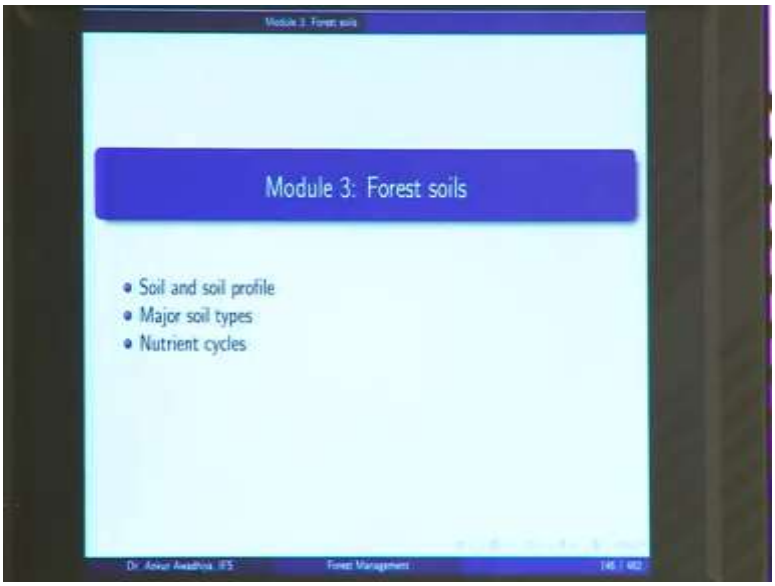

Now, in the third module, we had a look at the forest soils.

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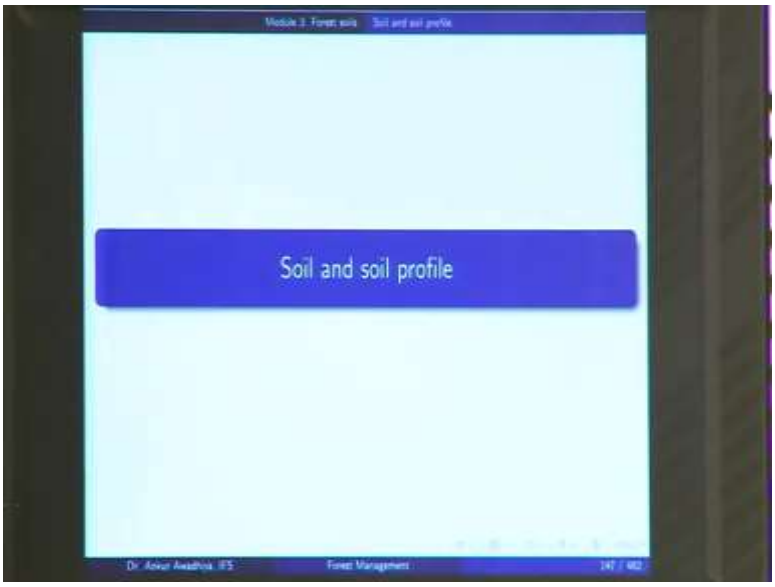

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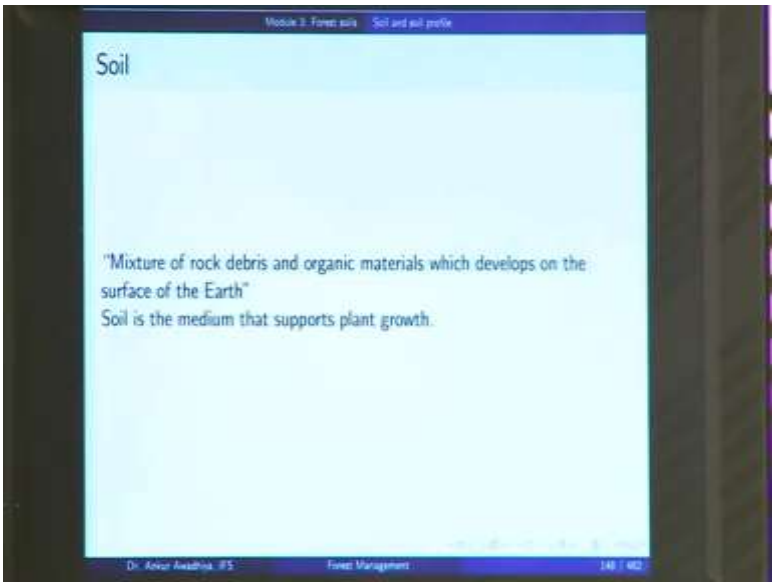

So, we began with soil and soil profile. So, soil is a mixture of rock, debris and organic materials which develops on the surface of the earth. It is the medium that supports plant growth.

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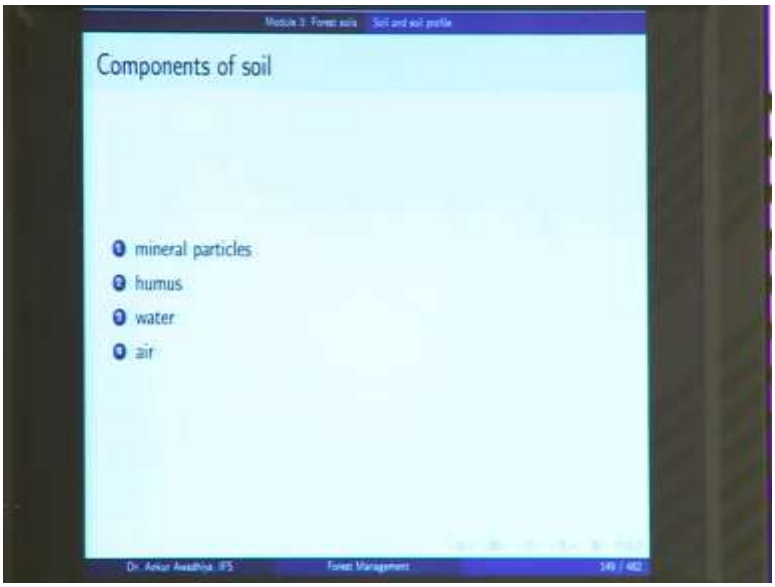

Then, we looked at components of soil. So, you have mineral particles, humus, water and air. So, you have these four different components of the soil.

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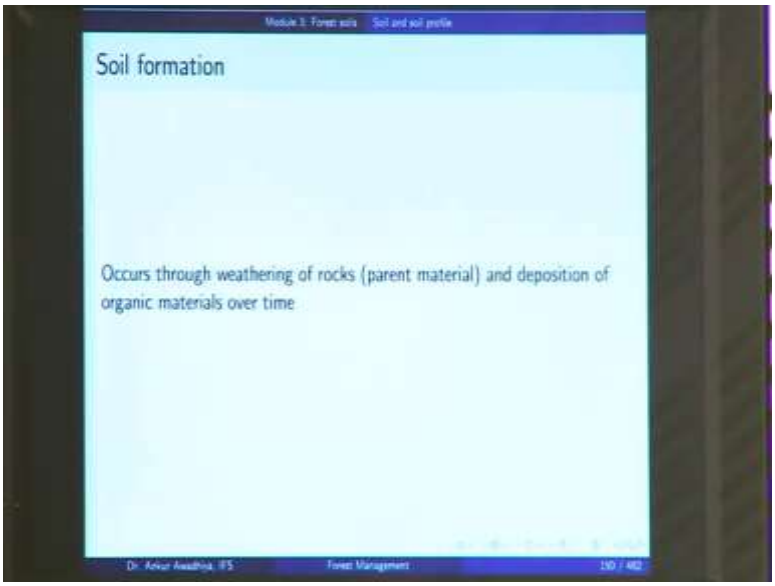

Soil is formed because of weathering and deposition of organic materials over time.

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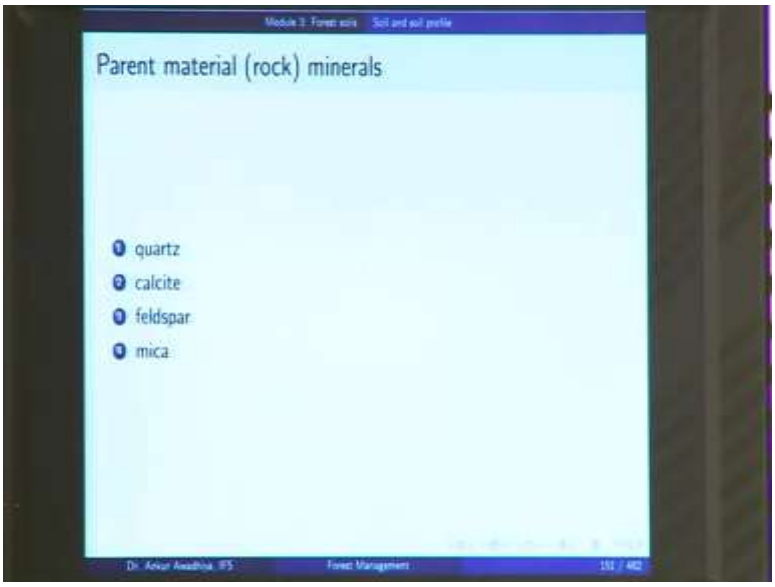

Then, we looked at parent rock material/minerals. These are four that are that are found in majority; quartz, calcite, feldspar and mica.

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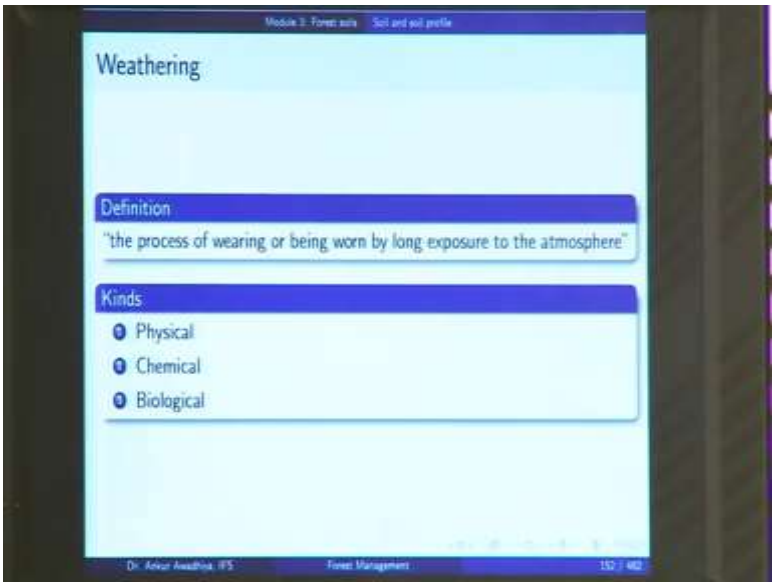

Now, weathering is defined as the process of wearing or being worn by long exposure to the atmosphere. Now, weathering is the process in which a rock is getting broken apart, and it is being worn out. There are three different kinds of weathering; physical, chemical and biological weathering.

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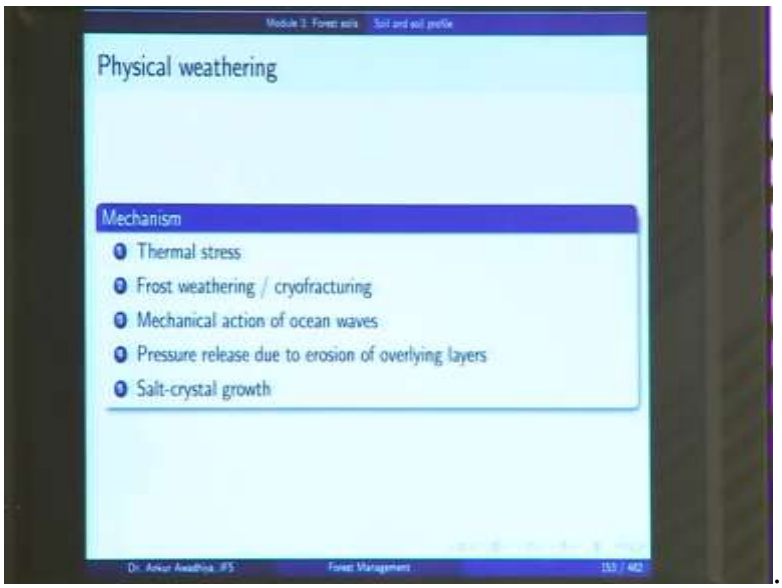

Now, physical weathering can be because of thermal stresses, such as heat and cold, during day and night times. You can have frost weathering or cryofracturing. You can

have mechanical action of ocean waves, pressure release due to erosion of overlying layers, and the salt crystal growth, and we looked at all of these in detail in that lecture.

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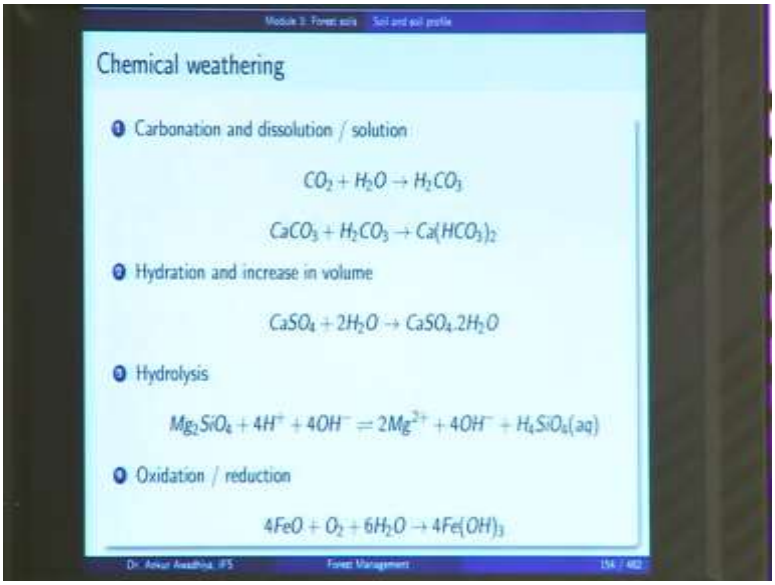

Whereas, chemical weathering is because of certain chemical reactions, such as carbonation, dissolution, solution, hydration, hydrolysis, oxidation and reduction.

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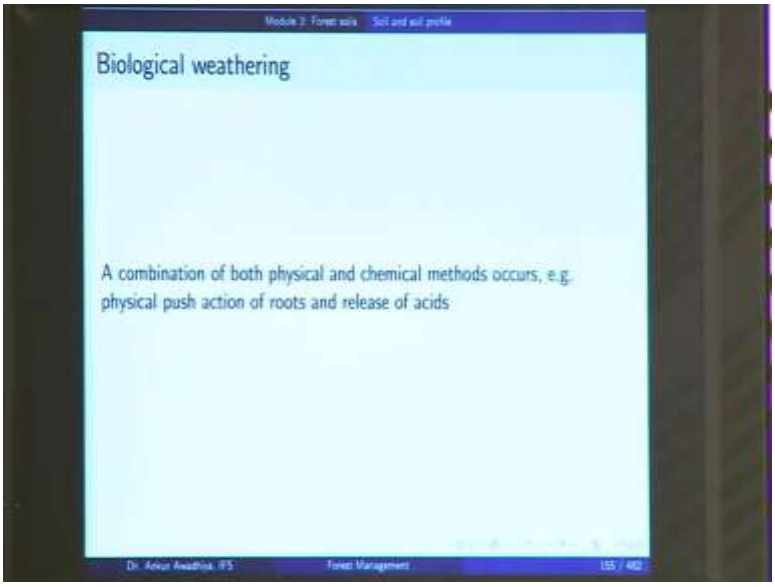

And, a biological weathering is a combination of both physical and chemical weathering methods.

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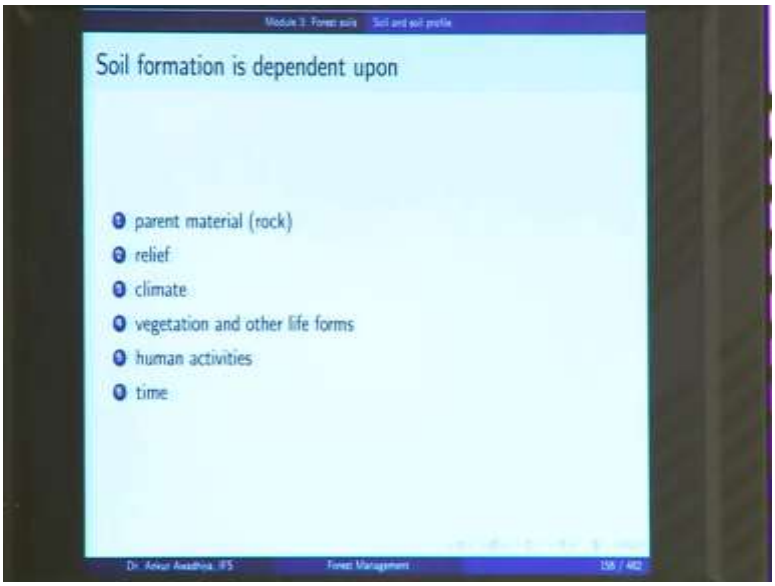

What does soil formation depends on? It depends on the parent material or the rock, relief, climate, vegetation and other life forms, human activities, and also time.

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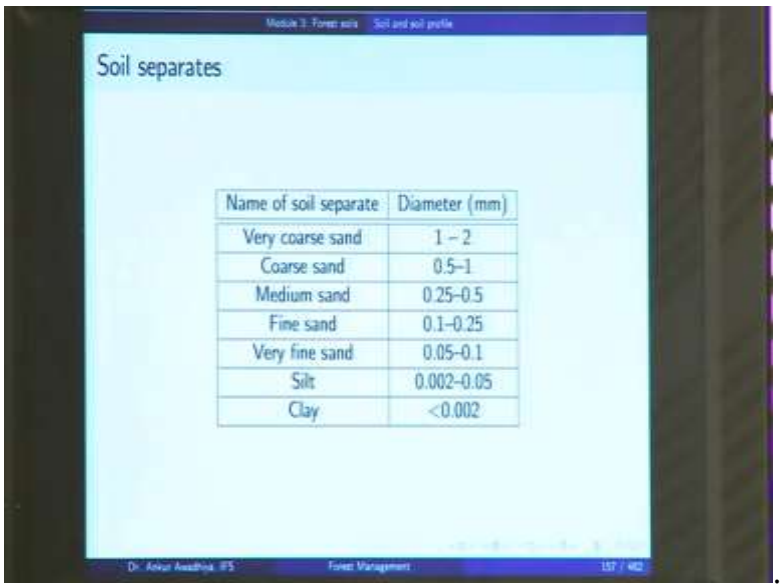

Then, if you look at a sample of soil; if you separate it according to the size, you will find these different soil separates varying from, clay which is of a very fine size, through silt, very fine sand, fine sand, medium sand, coarse sand, and very coarse sand which is of the largest size which is 1 to 2 millimeters.

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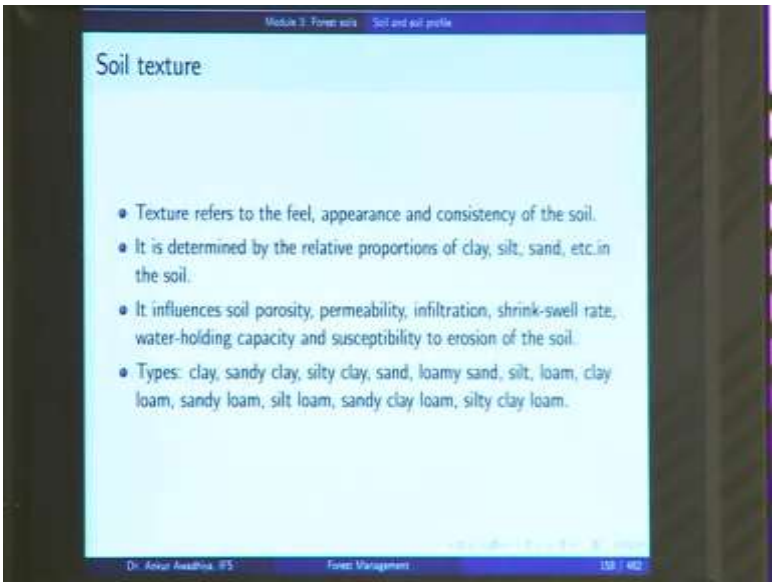

Next, we looking at soil texture. So, texture is the feel, appearance and consistency of the soil, determined by the relative proportions of clay, silt, sand etcetera in the soil. And, it influences porosity, permeability, infiltration, shrink swell rate, water holding capacity and susceptibility to erosion of the soil.

Now, the types include clay soil, sandy soil, silty clay soil, sand, loamy sand, silt, loam, clay loam, sandy loam, silt loam, sandy clay loam and silty clay loam.

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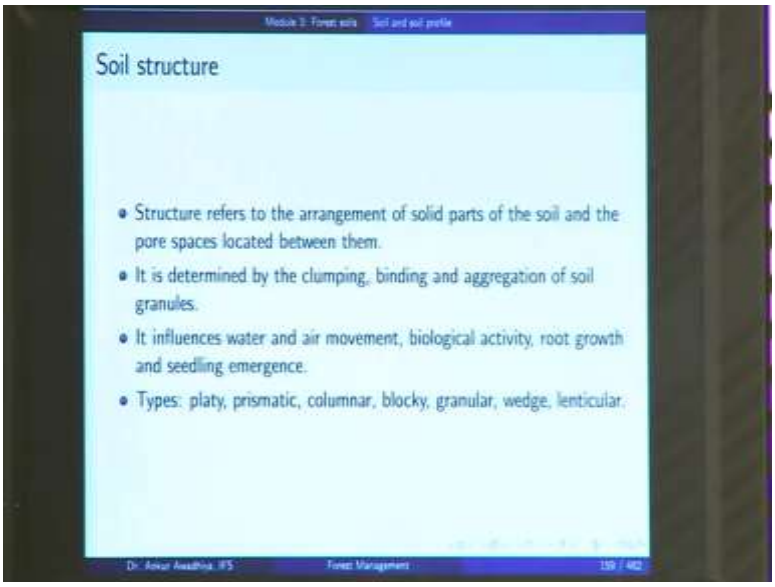

On the other hand, structure refers to the arrangement of solid parts of the soil and the pore spaces that are located in them. It is determined by the clumping, binding and aggregation of soil granules. And, it influences air and water movement, biological activity, root growth and seedling emergence. So, we looked at different types of soil structure such as platy, prismatic, columnar, blocky, granular wedge and lenticular.

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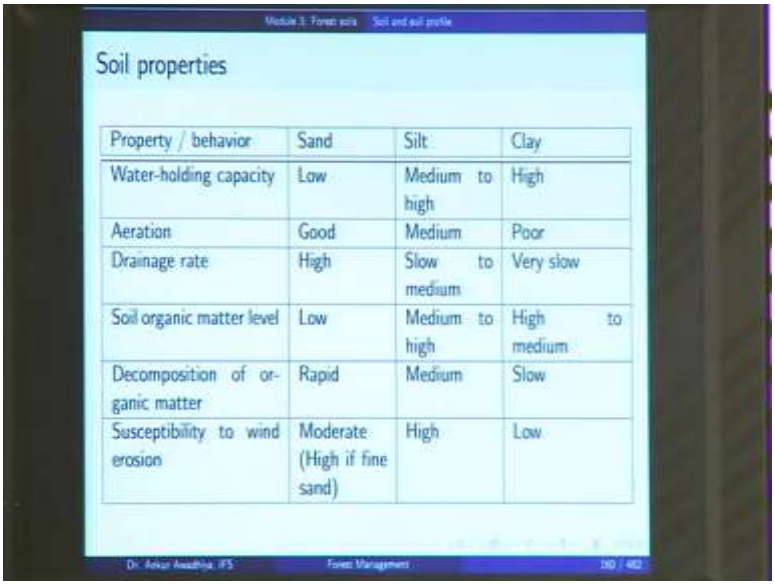

And then, we saw that the properties of the soil depends a lot on the constituents of the soil. So, basically the amount of sand, silt and clay that you have in the soil will determine various properties such as water holding capacity, aeration, drainage, soil organic matter level, decomposition susceptibility to erosion; whether wind erosion or water erosion, shrink swell potential, sealing potential, suitability for tillage, pollutant leaching, ability to store plant nutrients and the ability to resist changes in the pH.

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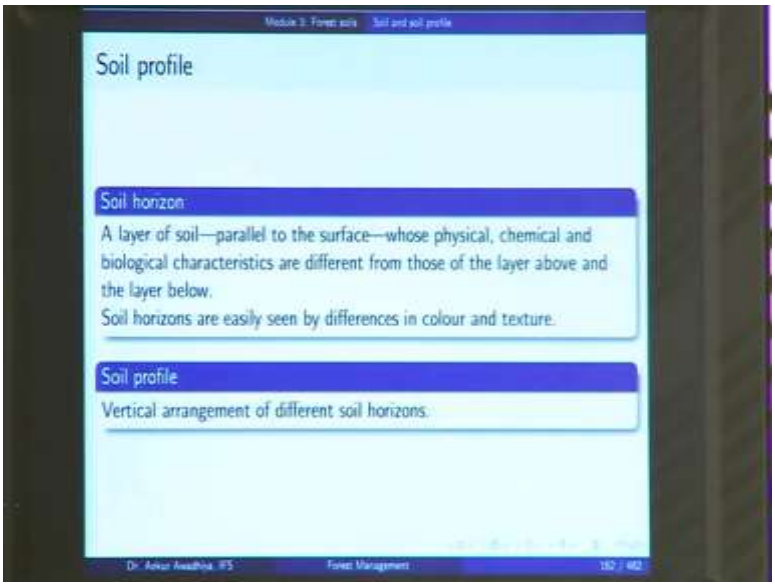

Next, we looked at the soil profile. So, soil profile is vertical arrangement of different soil horizons. And, a horizon is defined as a layer of soil that is parallel to the surface, whose physical chemical and biological characteristics are different from those of the layer above and the layer below, and these are easily seen by differences in colour and texture.

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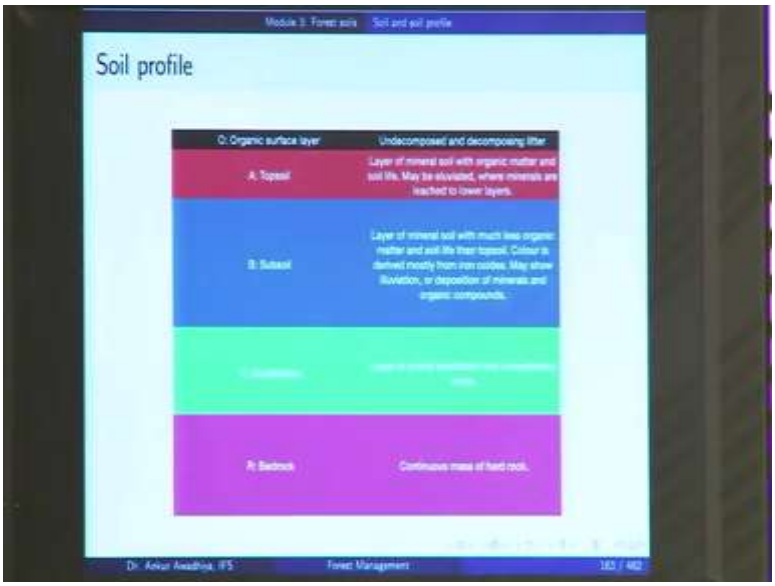

And so, we saw that we have these 5 major soil horizons you have the O layer or the organic surface layer, followed by A which is top soil, B which is subsoil, C that is substratum, and R that is the bedrock.

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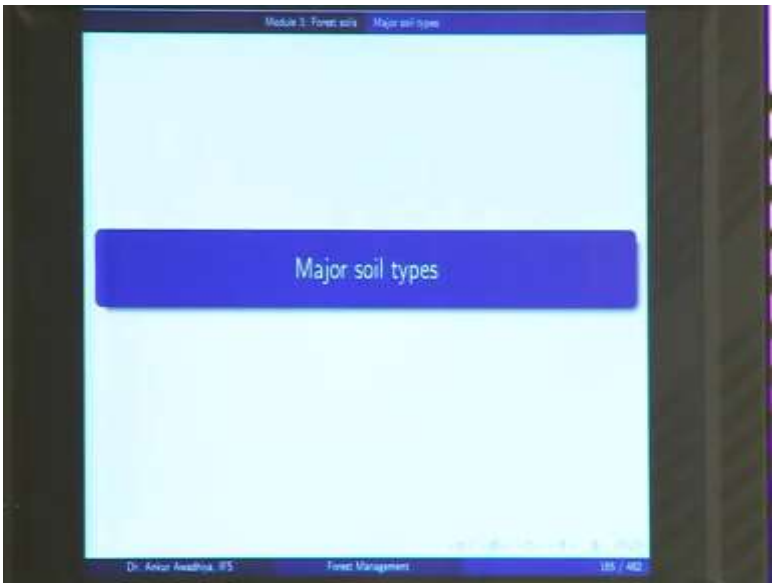

Now, in the next lecture, we had to look at major soil types.

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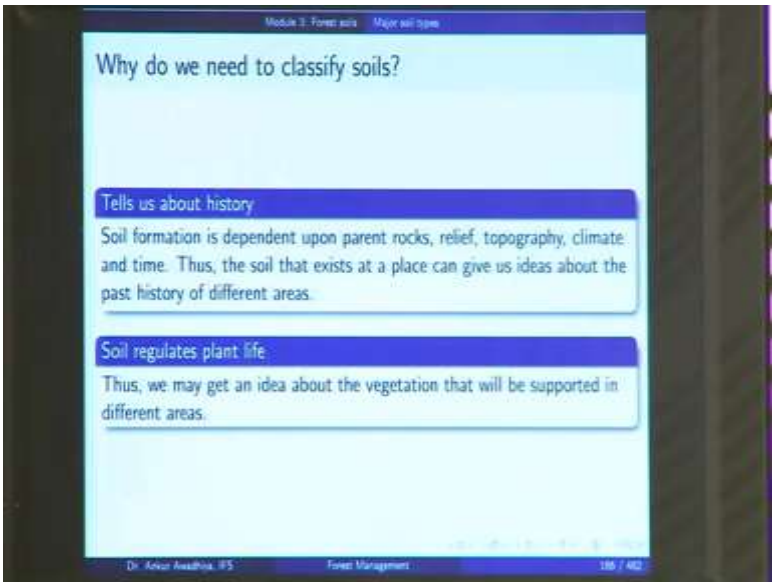

So, we need to classify the soils because it tells us a lot about the history of that area and it regulates the plant life. So, you also get an idea of how to perform a certain management in your particular area.

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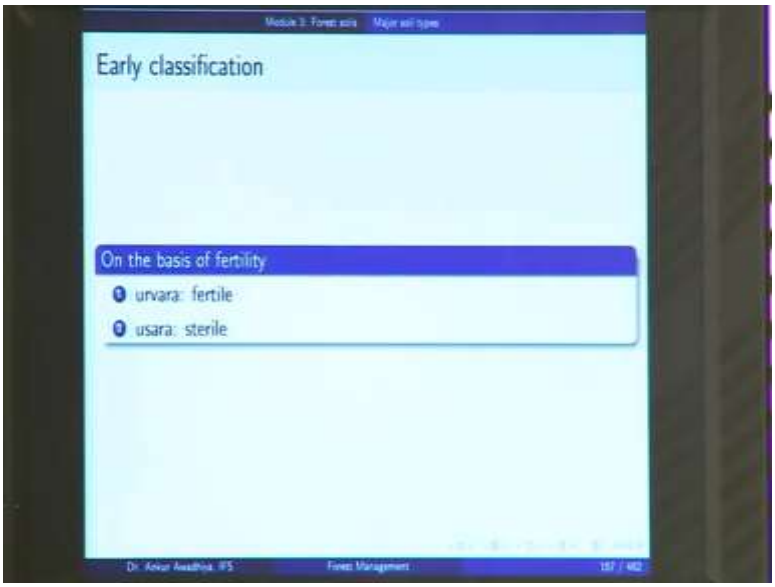

Now, the early classification defined the differentiated between fertile and sterile soils; or you had differentiations on the basis of texture, such as clay, silt sand and loam; or on the basis of colour, red, yellow, black and so on.

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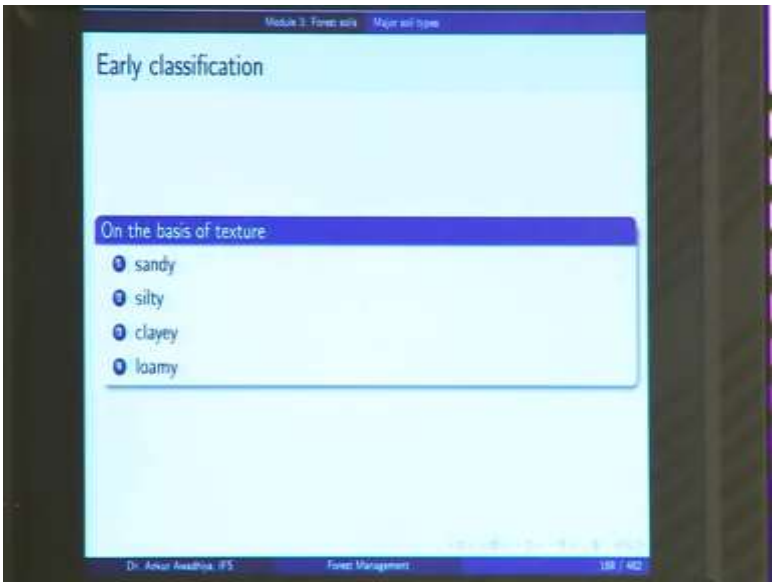

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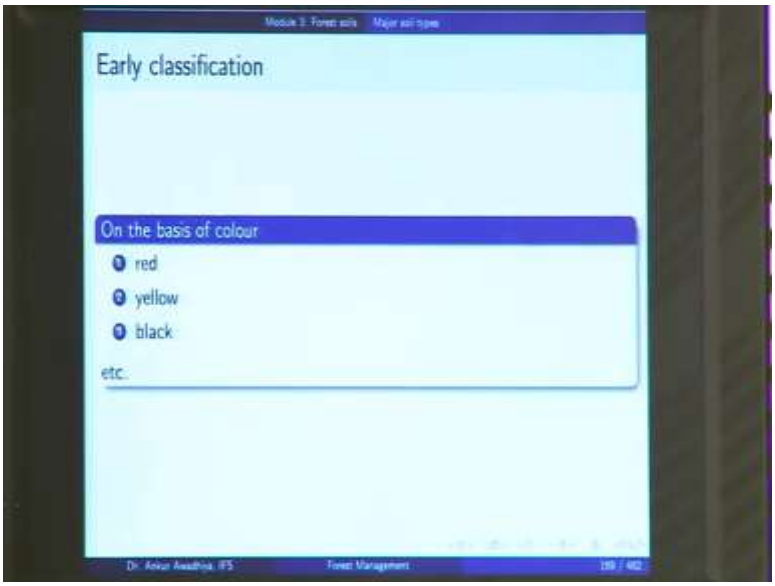

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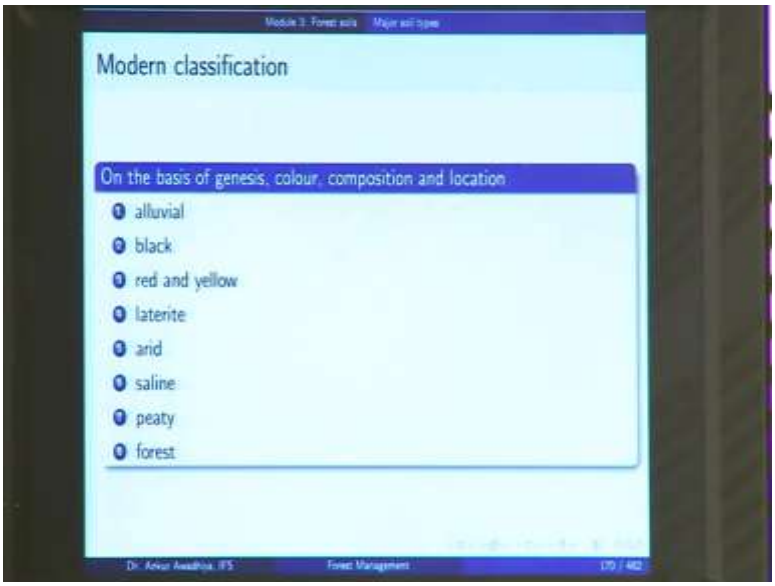

But now, in the modern classification, we look at a number of different characteristics, such as genesis, colour, composition and location. So, on the basis of this modern classification, we have 8 different classic categories of soil.

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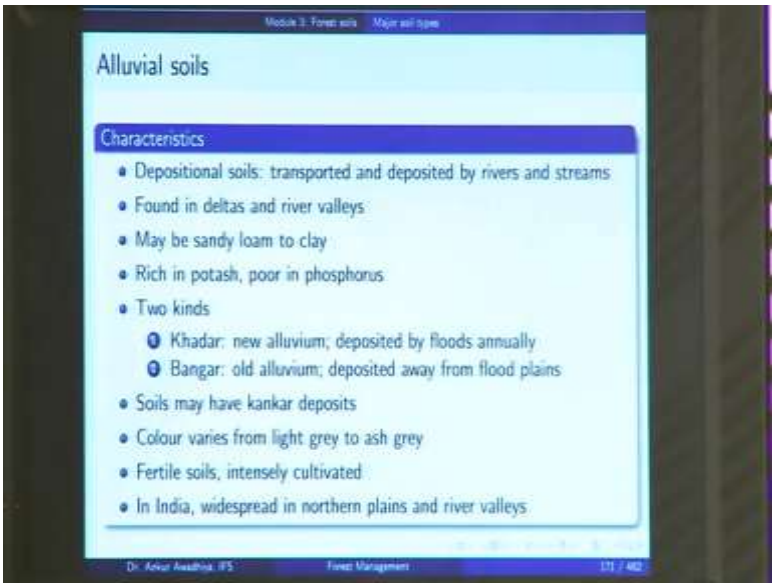

So, we began with the alluvial soils which are depositional soils soil found in deltas and river valleys. It can be sandy loam to clay; rich in potash, poor in phosphorus. Two kinds; Khadar and Bangar soil. Khadar is the new alluvium, Bangar is the old alluvium.

The soils may have conquered deposits; the colour varies from light grey to ash grey. These are fertile soils, intensely cultivated, and widespread in northern plains and the river valleys.

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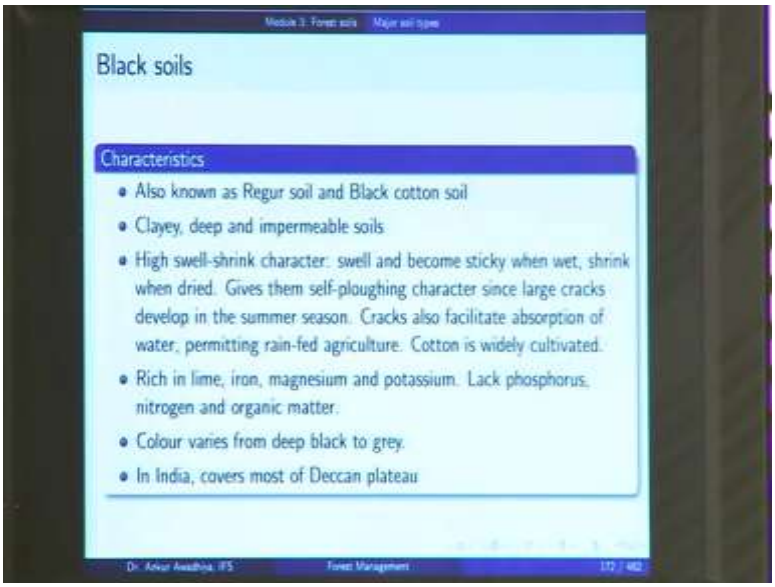

Next, we had a look at the Black soil, also known as the Regur soil or the Black cotton soil. These are clayey, deep, impermeable with high swell and shrink character. So, it becomes swell; it swells and becomes sticky when it is wet and shrink. When it is dried which gives it a self-ploughing character, because cracks develop in the summer season. Now, these cracks facilitate absorption of water which permits rain-fed agriculture. And, cotton is widely cultivated in these crops in these soils.

Now, these soils are rich in lime, iron, magnesium and potassium; they lack phosphorus nitrogen and organic matter. The colour varies from deep black to grey. And, in India, it covers most of the Deccan plateau.

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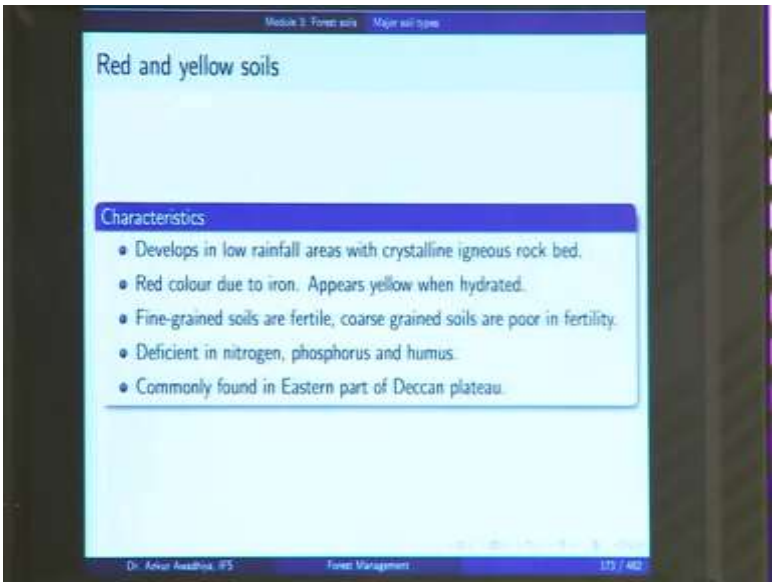

Next, we looked at red and yellow soils which develops in low rainfall areas with crystalline igneous rock bed. The red is the red colour is because of iron and when it is hydrated it becomes yellow in colour. These are fine grained soil, then these are fertile. If these are coarse grained soils, then the fertility is even poorer.

Now, these soils are deficient in nitrogen, phosphorus, and humus, and are commonly found in Eastern part of the Deccan plateau.

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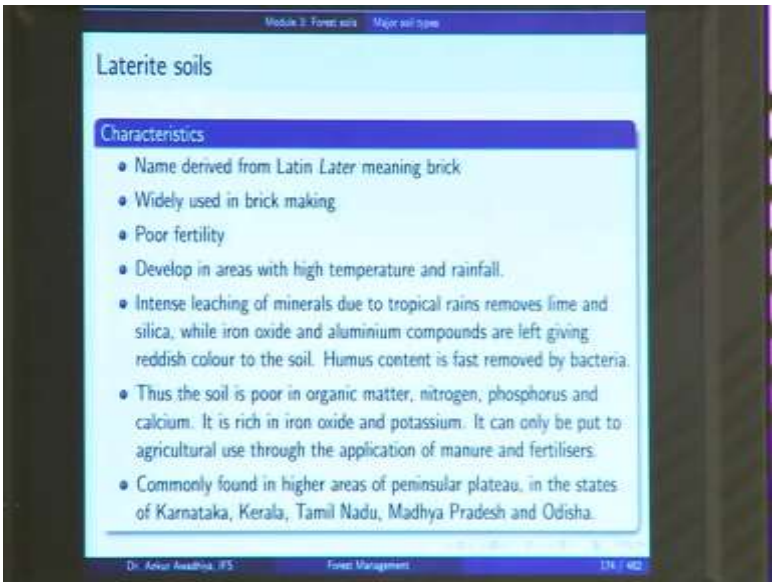

Then, we have laterite soils; the name is derived from the Latin word, ‘later’ which means ‘brick.’ So, these are widely used for brick making. Now, if you are using it for brick making, it typically means that it does not have good fertility. These develop in areas with high temperature and rainfall, intense leaching of minerals. And, these soils are poor in organic matter, nitrogen, phosphorus, and calcium, and these are commonly found in Karnataka, Kerala, Tamil Nadu, Madhya Pradesh and Odisha.

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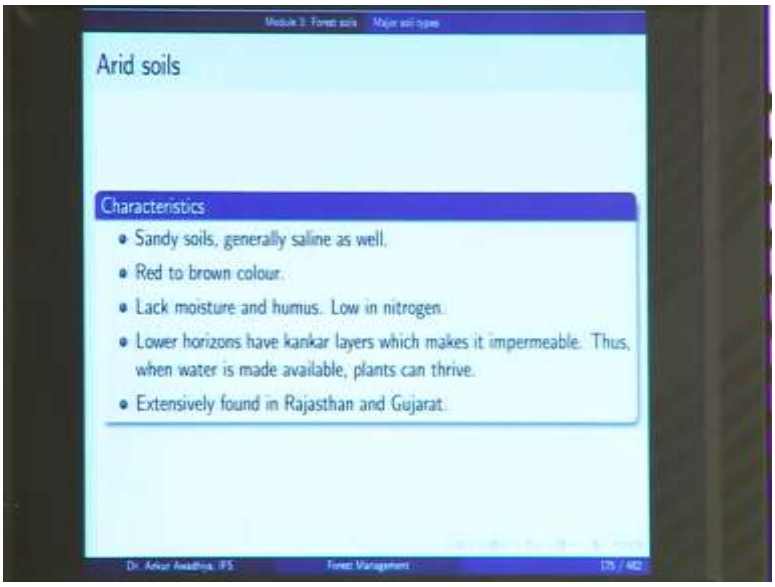

Arid soils are soils in dry areas. Generally, sandy soils. Also, at times, these are saline in well in nature as well; red to brown colour; they lack moisture and humus; low in nitrogen. The lower horizons have kankar layers, which makes it impermeable. So, if you add water, then water is made available to the plants and the plants can thrive. These are generally found in Rajasthan and Gujarat in our country.

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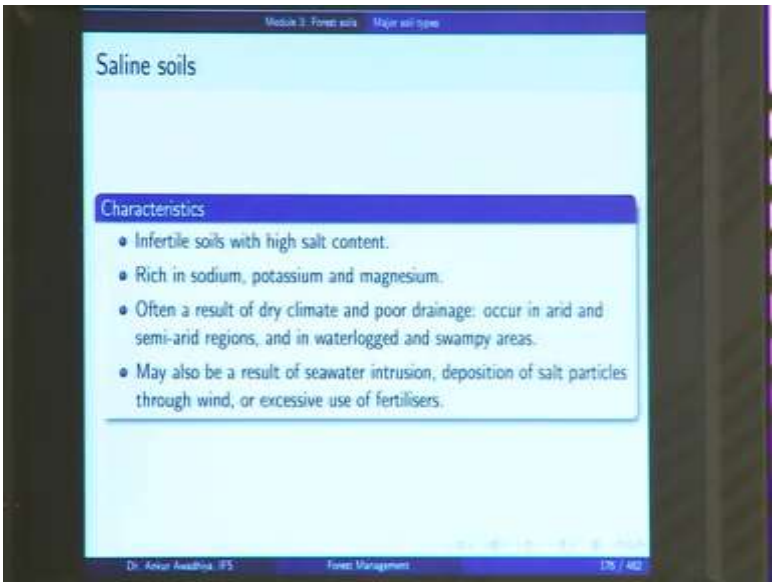

Then, saline soils are soils that are rich in salt content. Now, because they are high; there is a high salt content; so, these soils become infertile. They are generally rich in sodium, potassium and magnesium; often a result of dry climate and poor drainage. There could also be result of sea water intrusion, deposition of salt particles through wind, or excessive use of fertilizers.

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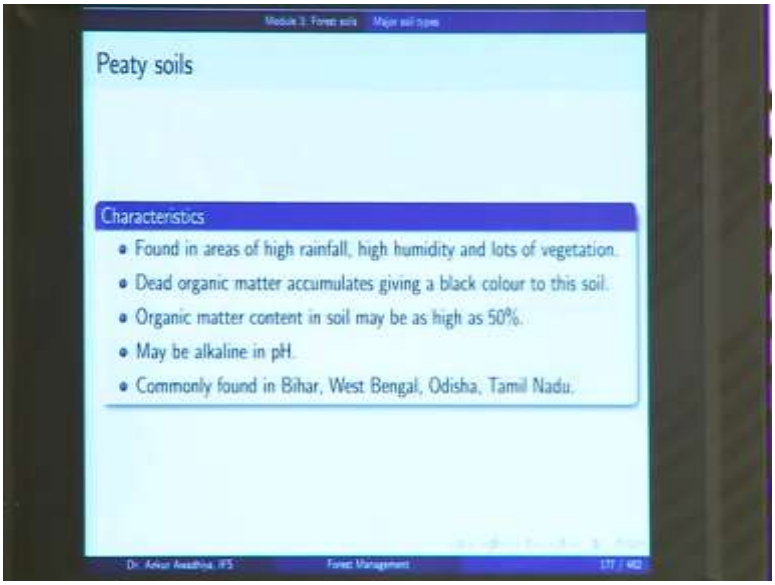

Then, we looked at peaty soils. Now, peaty soils are soils that are very rich in organic carbon. These are found in areas of high rainfall, high humidity, lots of vegetation. You

have dead organic matter that is accumulating giving it a black colour. Organic matter is as high as 50 percent. It maybe alkaline in pH; found in Bihar, West Bengal, Odisha and Tamil Nadu.

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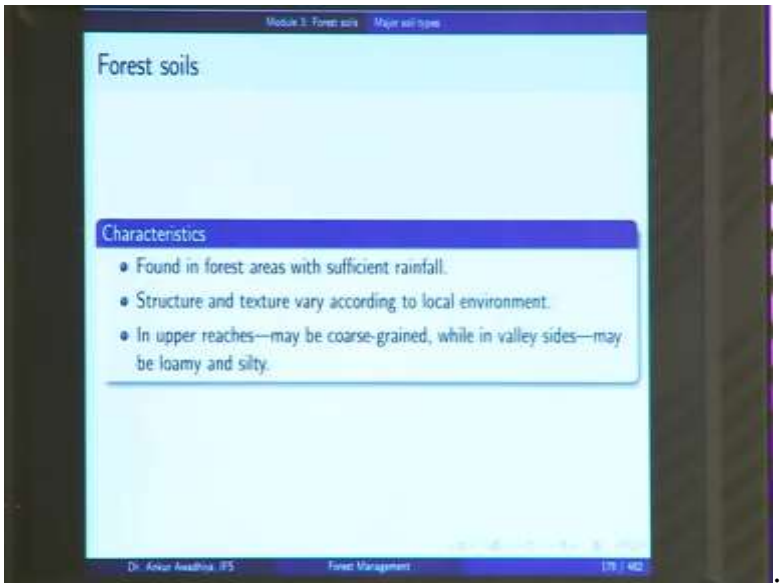

And, then forest soils, typically, those soils that are supporting the forest areas. Now, if these soils have still been left for forest, then it means that they are not very highly fertile. The structure and texture varies according to the local environment; in upper reaches; it may be coarse grained in the valleys sides it may be loamy and silty.

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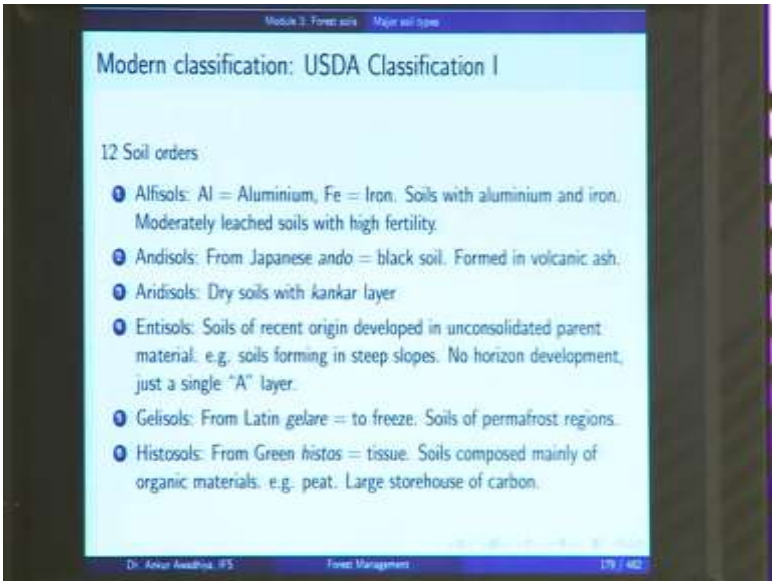

Then, we looked at the USDA classification of, the US department of agriculture, and we have 12 soil orders alfisol, andisol, aridisol, entisol, gelisol, histosol, inceptisol, molisol, oxisol, spodosol, ultisol and vertisols.

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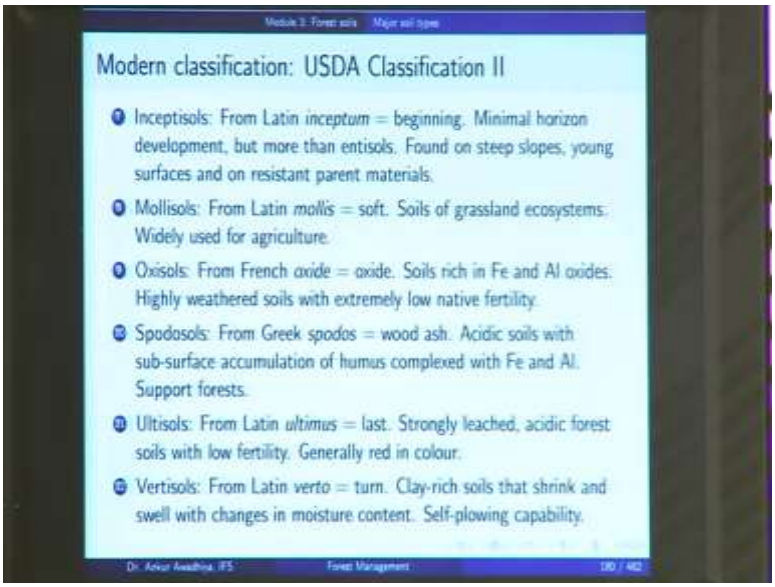

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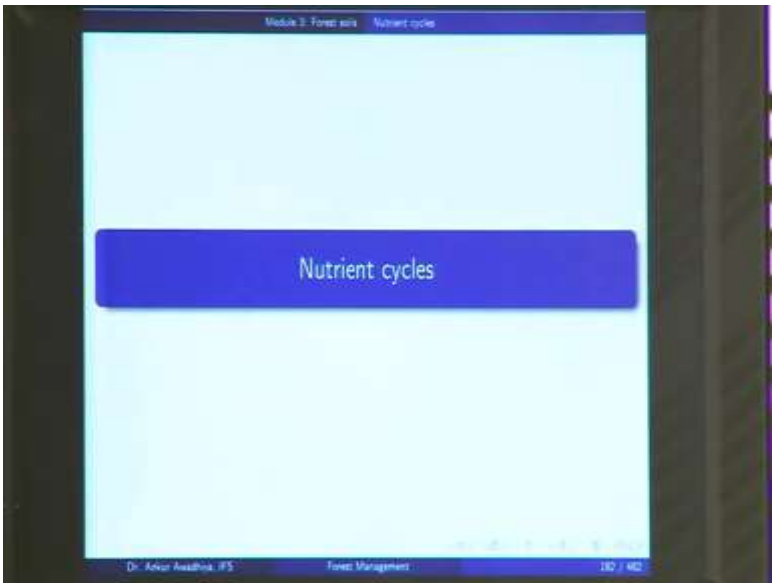

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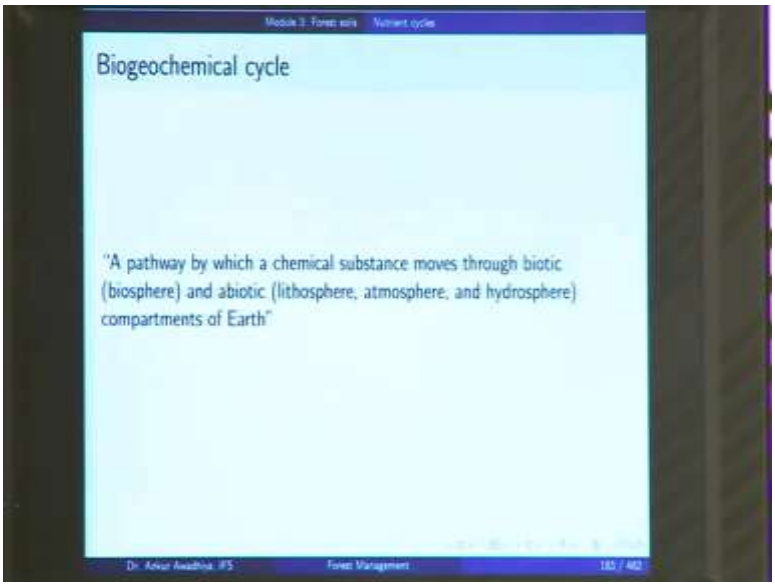

And, in the next lecture, we had a look at the nutrient cycles. As we have seen, biogeochemical cycle is the generalised nutrient cycle. So, in this case, we have the nitrogen cycle.

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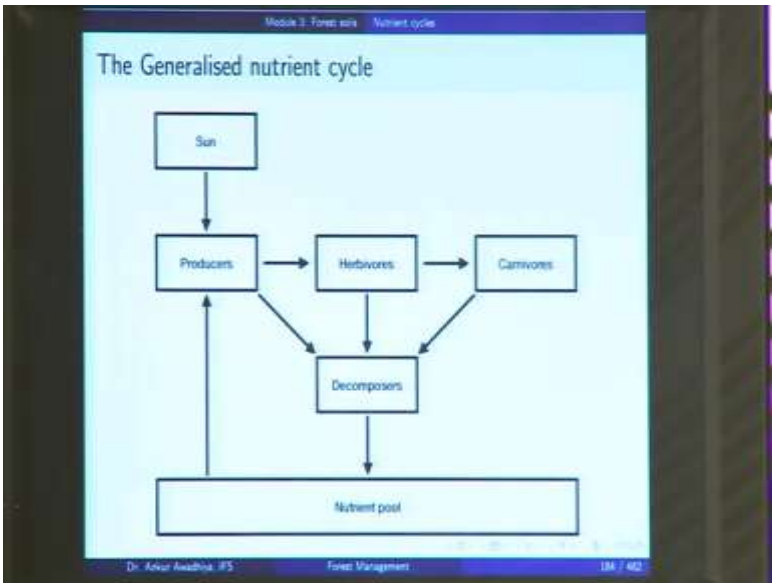

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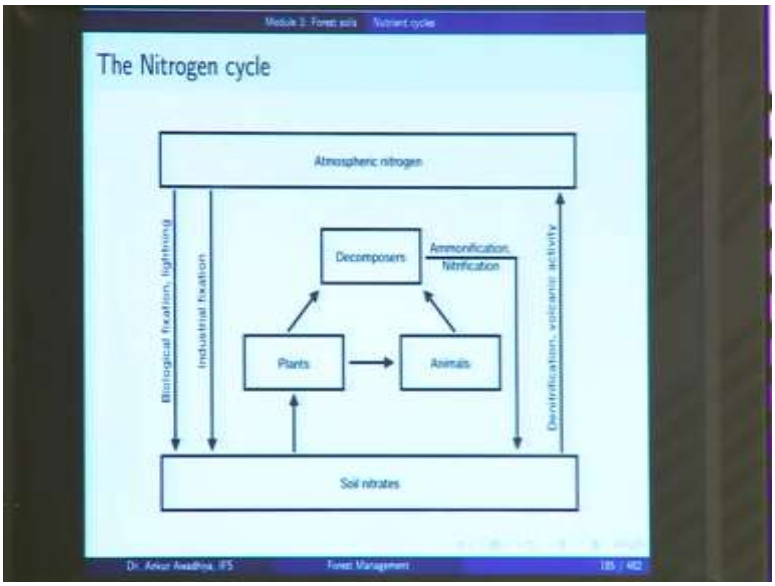

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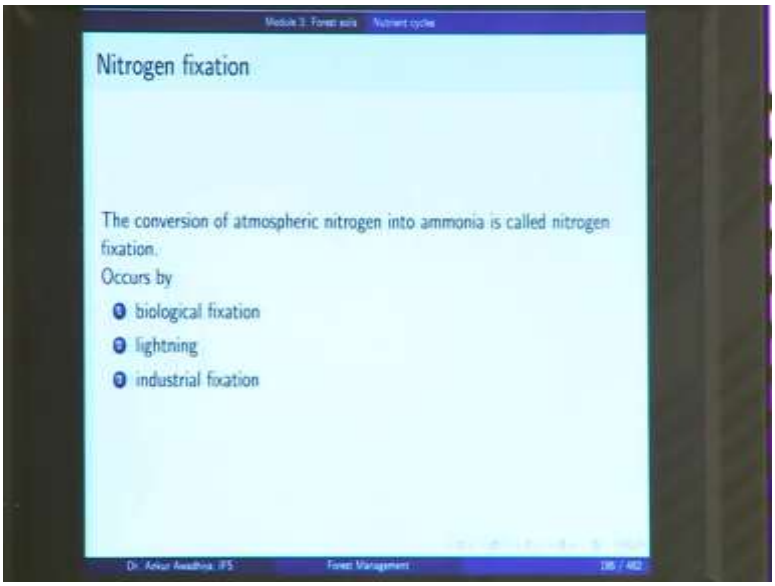

Now, in the case of nitrogen cycle, you have nitrogen fixation that is happening by either biological fixation or lightning or industrial fixation.

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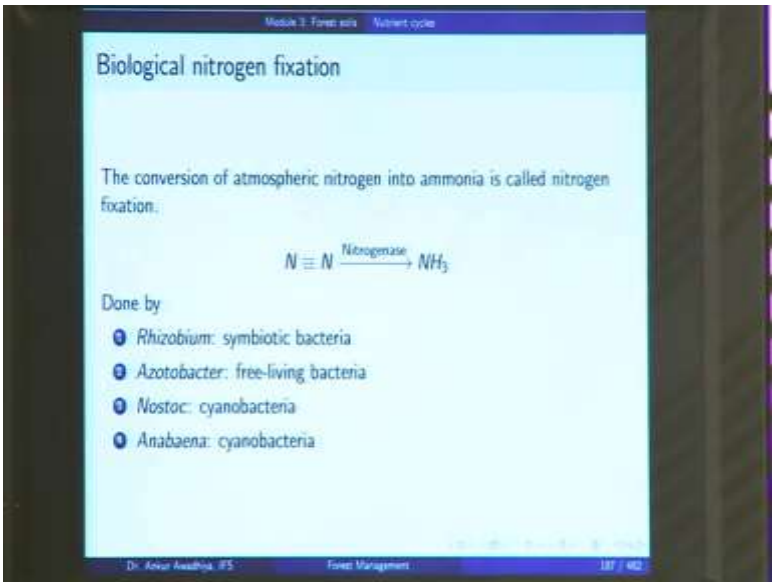

Now, biological nitrogen fixation is conversion of atmospheric nitrogen into ammonia. and, it is done by *Rhizobium*, *Azotobacter*, *Nostoc* and *Anabaena*. So, these are the common species that are doing biological nitrogen fixation.

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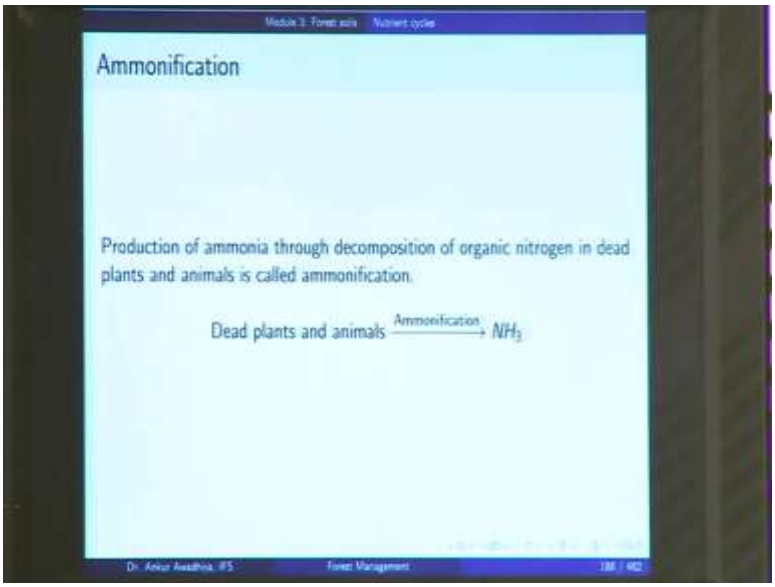

Next, we also have the production of ammonia; because of the process of ammonification, in which the organic nitrogen in dead plants and animals, is getting decomposed and is converted into ammonia.

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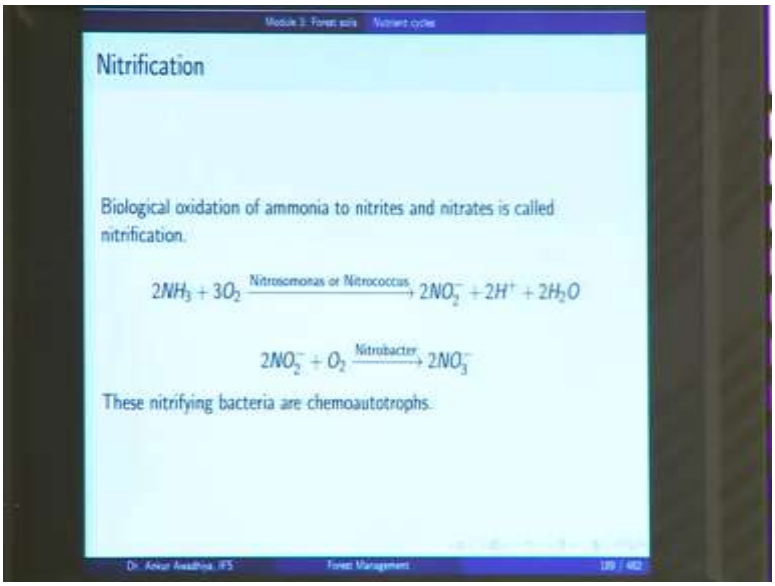

Now, once you have ammonia through either of these processes, the next process is nitrification in which the there is biological oxidation of ammonia into nitrites and nitrates. Generally done by *Nitrosomonas, Nitrococcus* and *Nitrobacter,* and these are chemoautotrophs.

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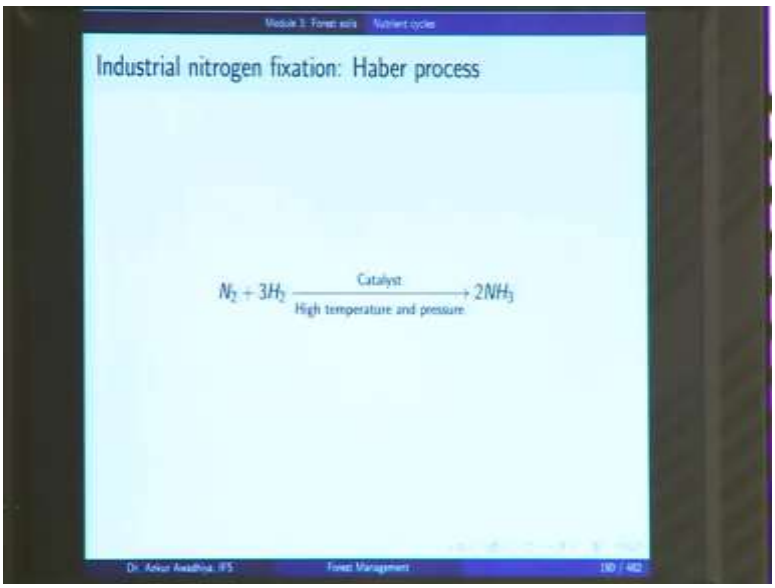

But because, we require nitrogen in large quantities; So, we have the industrial nitrogen fixation such as Haber's process which converts nitrogen into ammonia, and the Ostwald process which in turn oxidizes it to make nitric acid.

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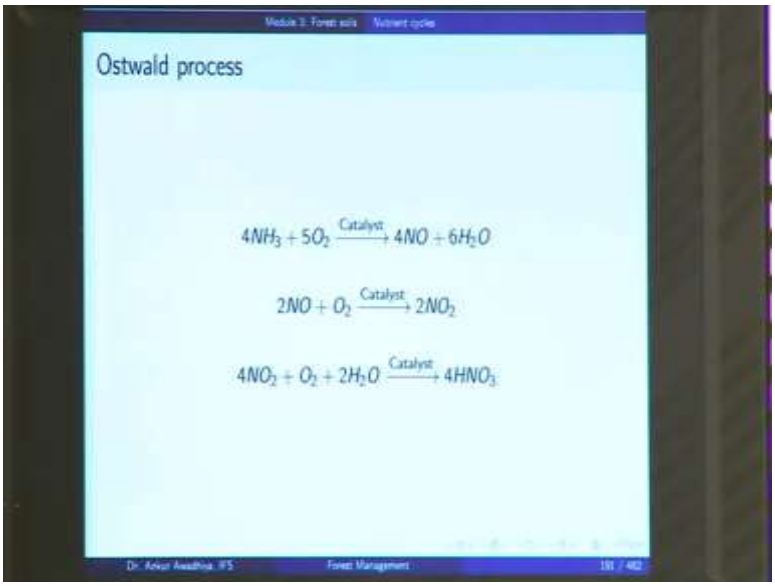

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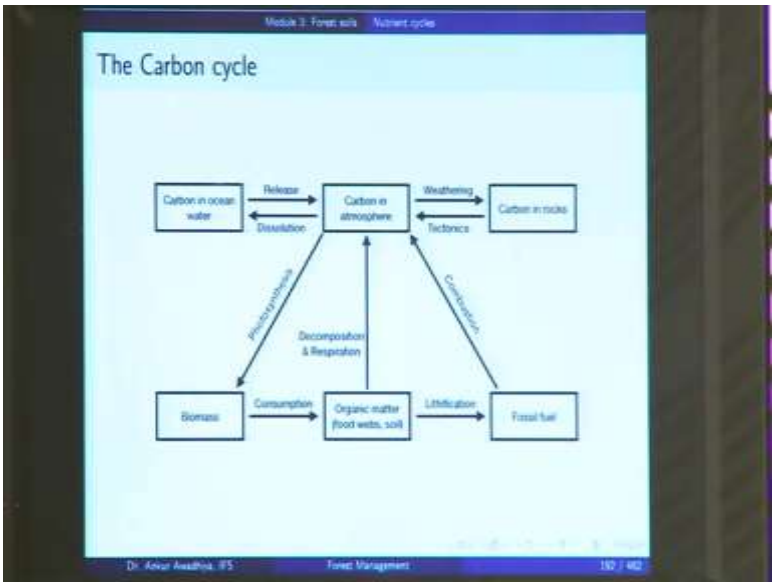

Then, we looked at carbon cycle. So, car carbon is there in a number of pools and all of these are interacting with each other. The carbon in atmosphere gets into carbon in ocean water; comes back goes into carbon in rocks; comes back goes into the biosphere through photosynthesis; and then through respiration and decomposition, it comes back; or it gets into the fossil fuels through the biosphere; and then when these fossil fuels are burnt, then you have the carbon dioxide that is released back into the atmosphere.

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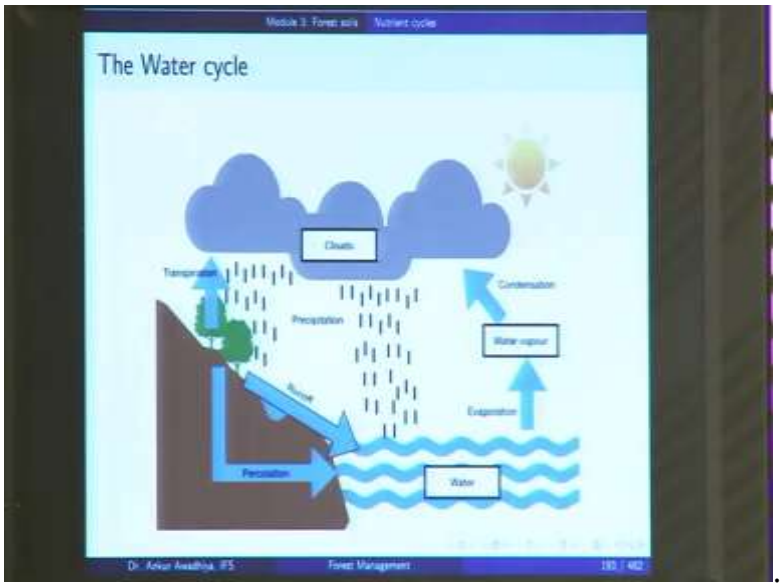

Next, we have the water cycle. So, water cycle you have conden you have evaporation of water, transpiration of water; that is bringing water from the liquid stage into the gaseous stage. Then, there is condensation which leads to the formation of clouds and the rains. And, when you have the rains, then this water then flows back into the pool.

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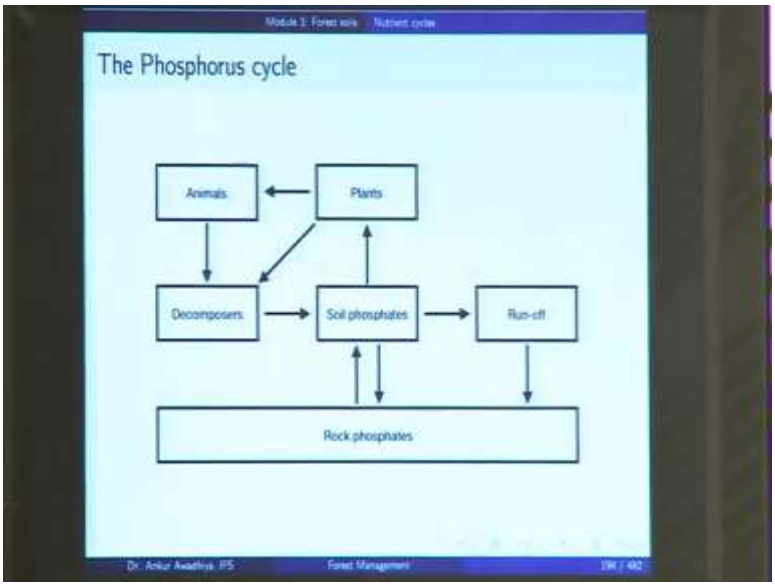

You also have the phosphorous cycle in which case there is continuous movement of phosphates between the rocks; between the rock phosphates and the soil phosphates. And, once your phosphate has reached into the soil, then it can be taken up by plants.

From plants, it goes to animals and to the decomposers, then comes back. And, if there is a runoff, then it can also reach into the new rocks that are getting formed.

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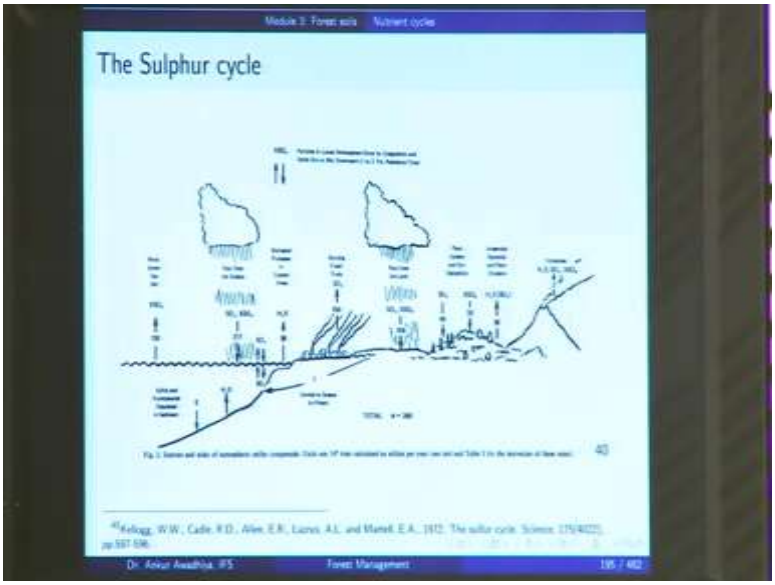

Next, we have the sulphur cycle. So, in the case of sulphur or as well, the sulphur is moving between the lithosphere, the hydrosphere, the atmosphere and the biosphere.

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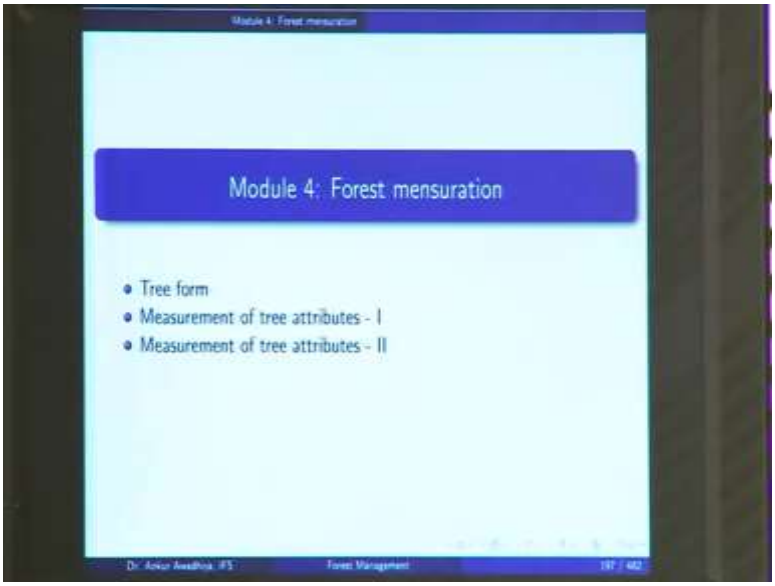

Now, in the next module, we looked at forest mensuration; we began with the tree form.

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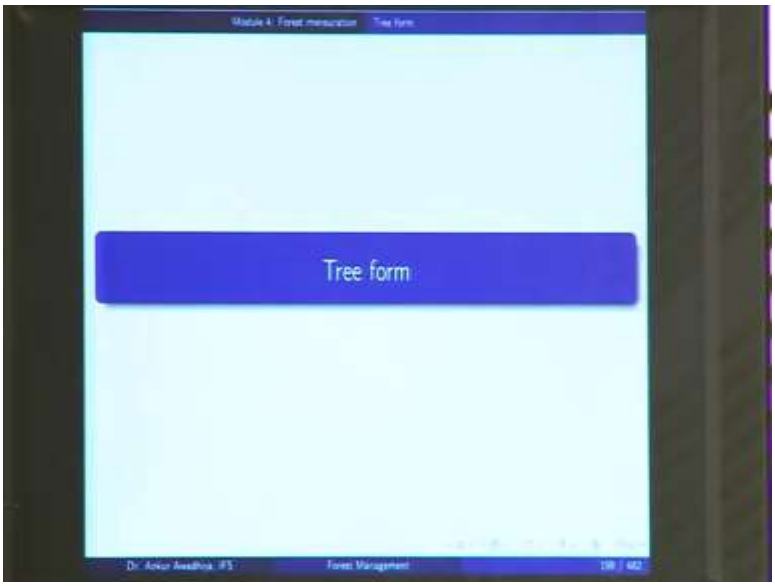

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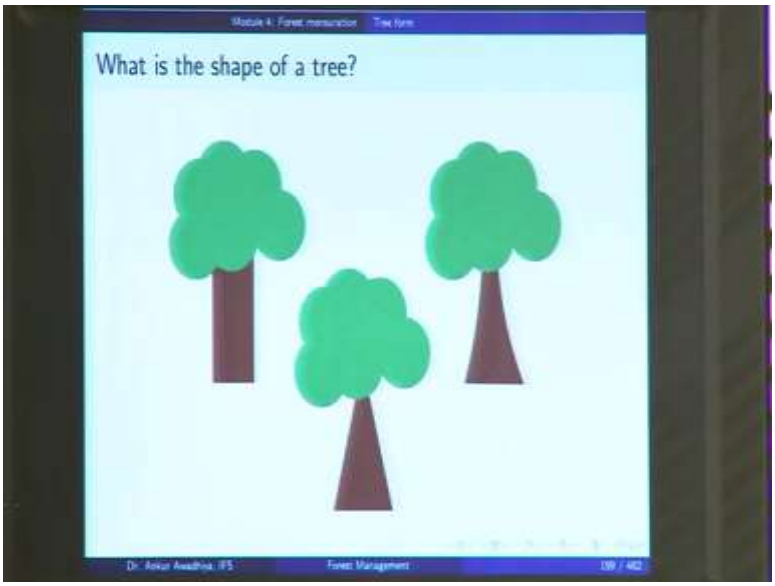

So, the shape of a tree is very different.

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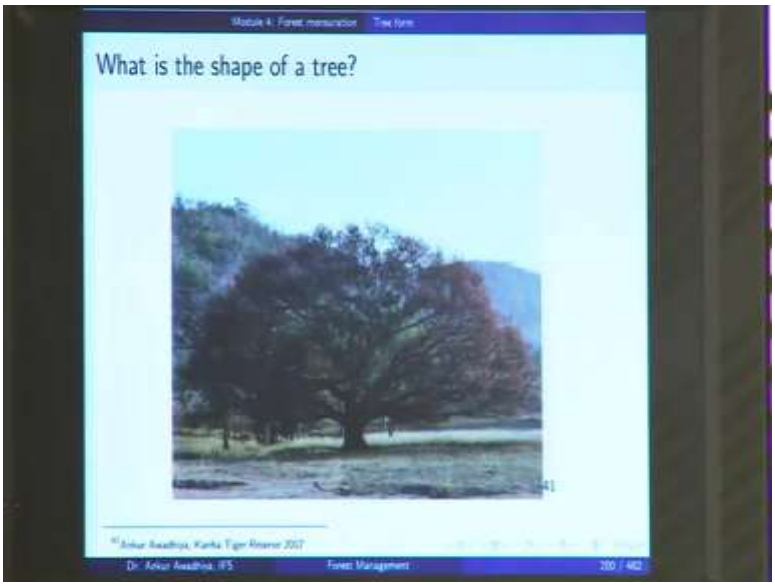

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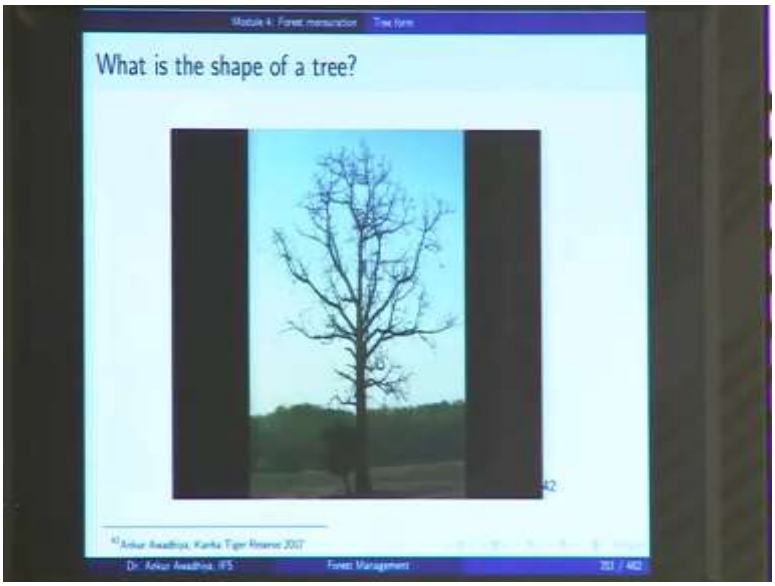

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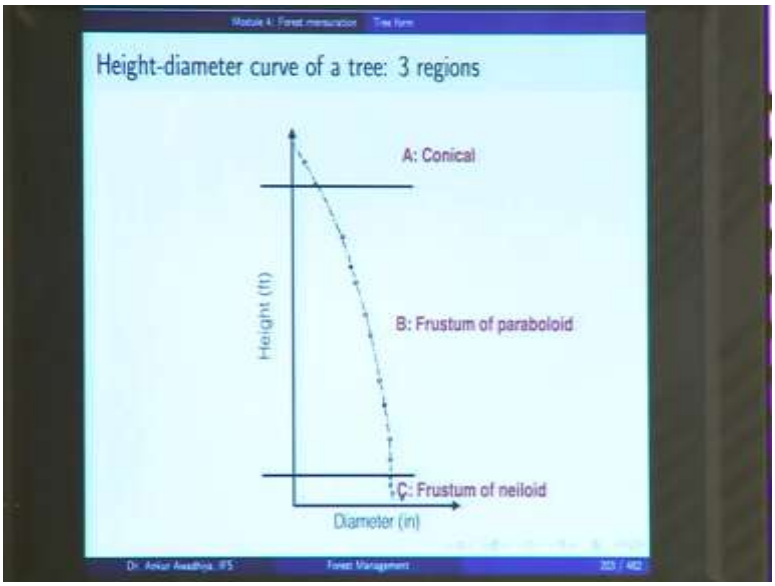

So, if we look at tree and if we draw a height versus diameter curve, we will find that the top portion is conical; the middle portion is frustum of a paraboloid; and the bottom portion is frustum of a neiloid.

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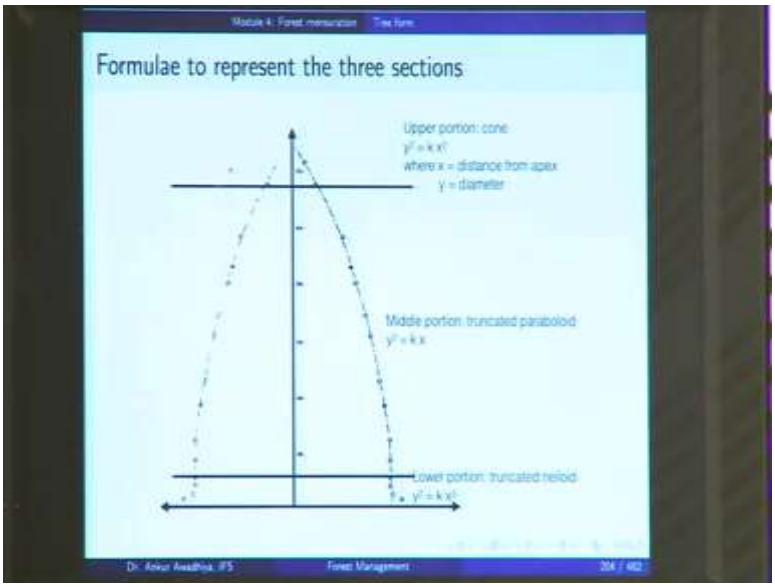

And, we define these by these equations; y square is equal to k x square for the upper portion, y square is equal to k x for the middle portion, and y square is equal to k x cube for the bottom portion.

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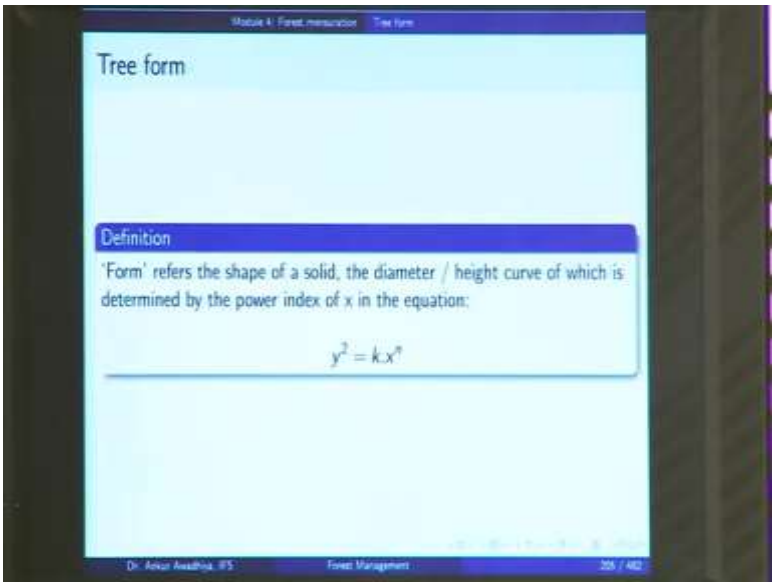

Now, tree form is; it means the shape of the solid. So, form is the shape of the solid or the diameter height curve of which is determined by the power of x in the equation y is y square is equal to k into x to the power n.

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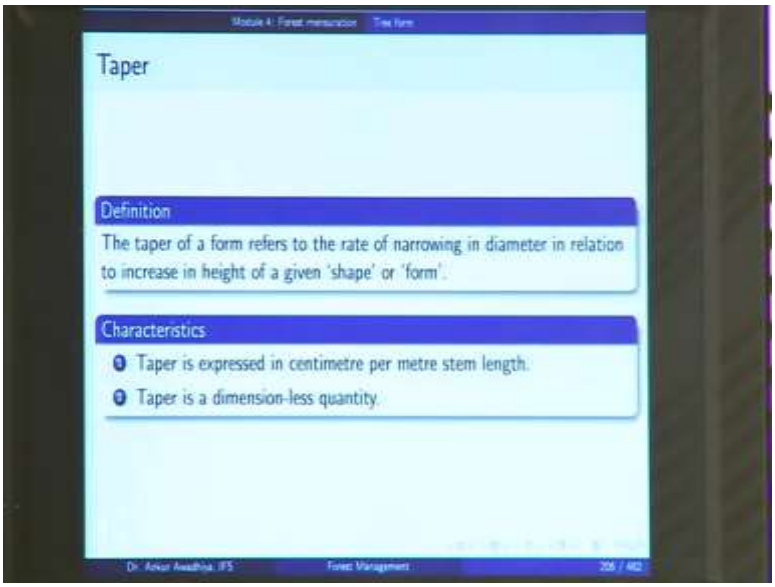

Then, we define taper as the rate of narrowing in the diameter; generally expressed as centimeter per meter of the stem length.

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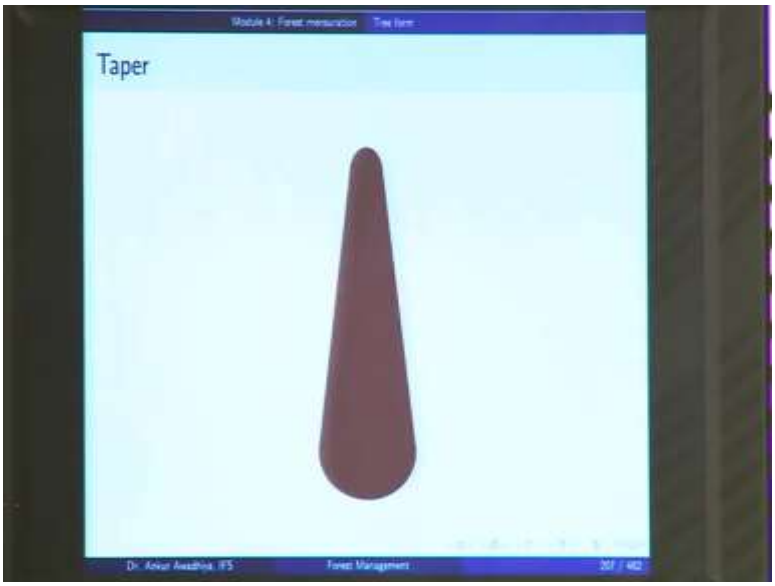

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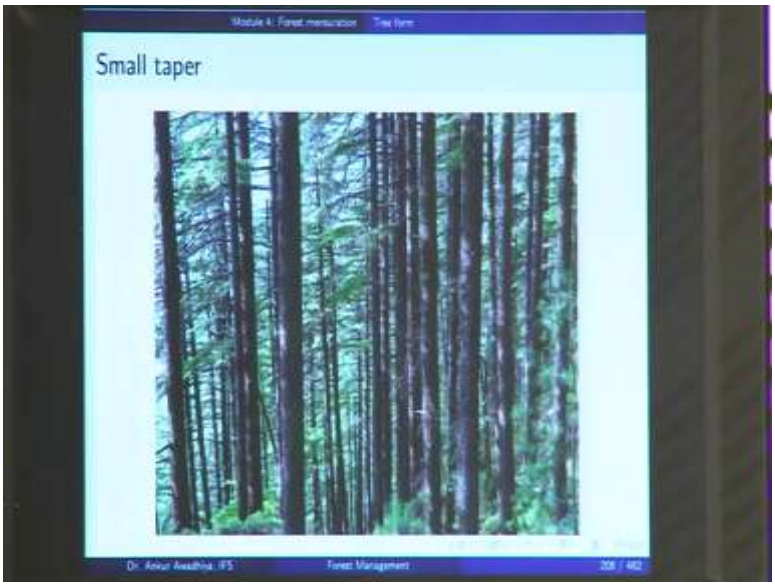

So, you can have trees with small taper, in which case they look very much like cylinders; or you can have trees with large taper. And, there is a difference between taper and form.

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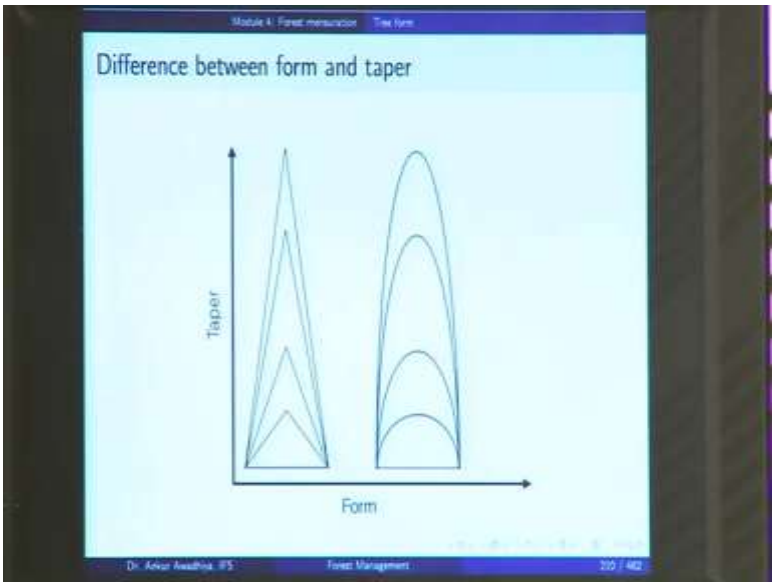

So, taper is telling you the rate at which in the diameters is decreasing, but the form is telling you the general shape of the tree.

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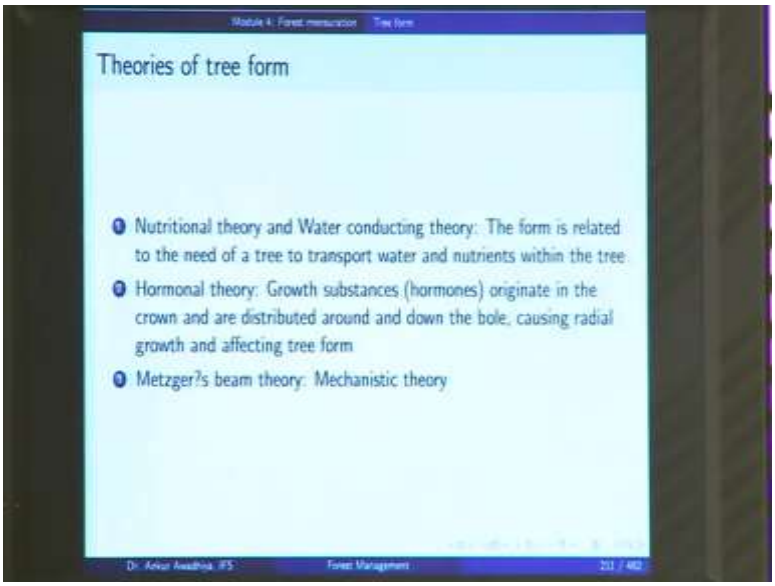

And, there are three theories of tree form; you have the nutritional theory or the water conducting theory, in which case we say that the form is related to the need of a tree to transport water in nutrients.

We have the hormonal theory which tells that you have some growth substances or hormones that are originating in the crown and then are distributed around and down the bole, which is changing the radial growth and is affecting the tree form.

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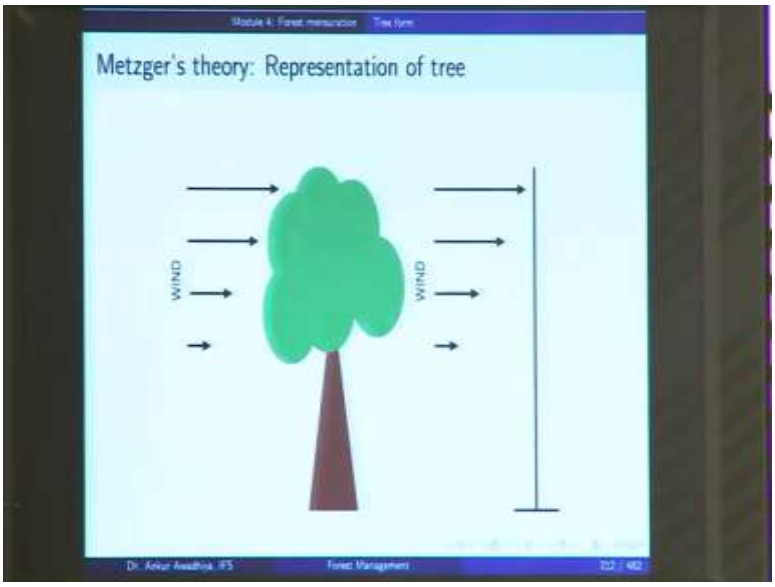

And, third is the Metzger's beam theory or which is a mechanistic theory; in which case, you represent your tree as beam of uniform resistance to the bending, which is anchored as the base.

So, it is a cantilever beam; the force is being applied by the wind and this bending force is leading to stresses and there is maximum stress at the base, where this is anchored. And, to protect itself against getting uprooted, because of this stress, the tree reinforces the base by adding more materials. As we move up the stresses are lower and so, lesser amount of reinforcement is needed which results in a taper in the tree.

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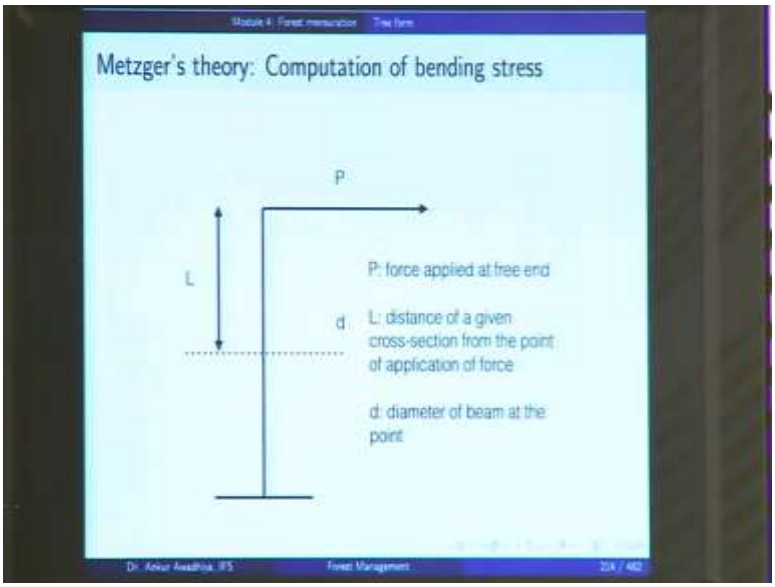

Then, we looked at the computation of the bending stress.

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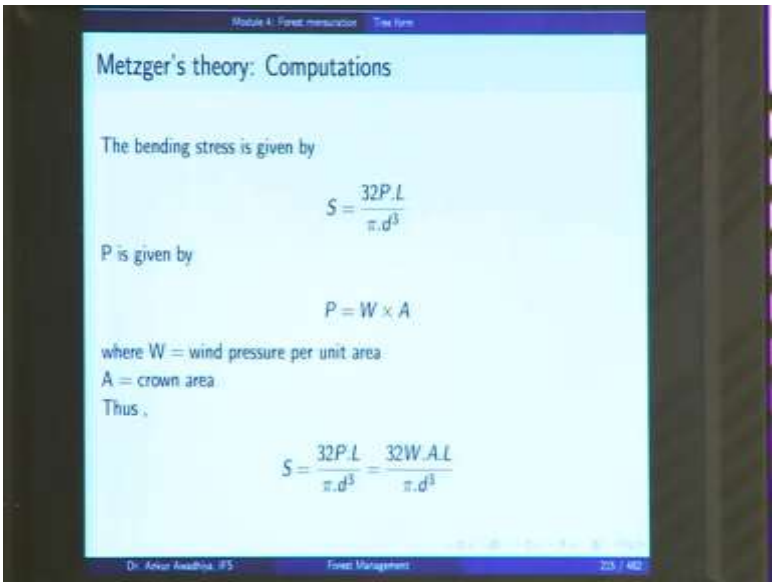

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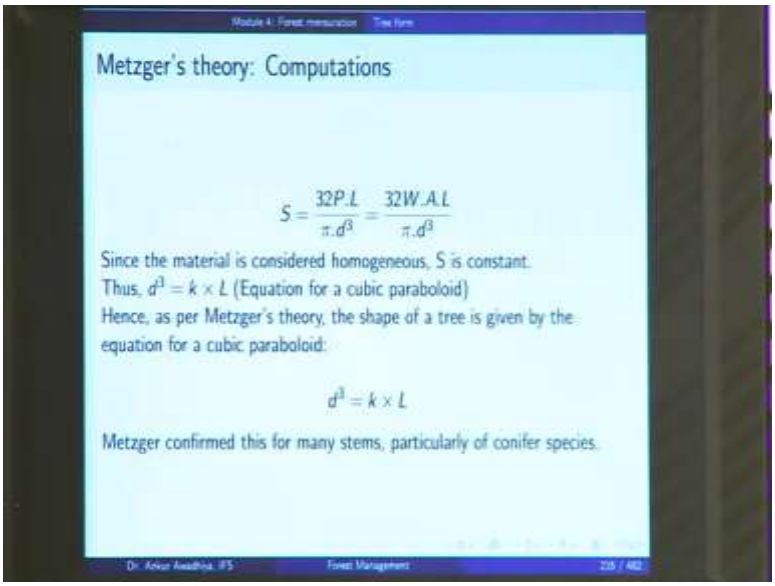

So, we have this derivation, and the Metzger's theory says that you have a relation of d cube is proportional to L, which is the equation of a cubic paraboloid. Now, as we saw before, the form of all the trees is not a cubic paraboloid, but Metzger did confirm this for a few coniferous species.

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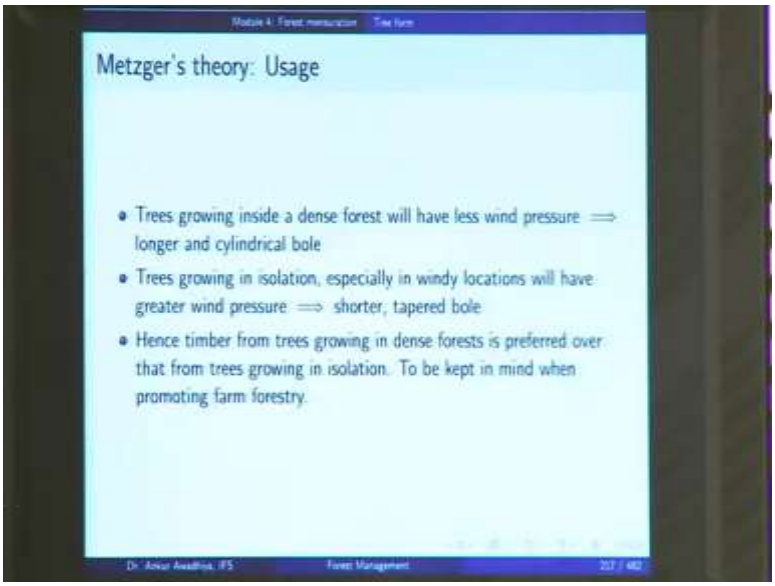

Now, the usage is that, if you have trees that are growing in a dense forest with less pressure, you have longer and cylindrical boles.

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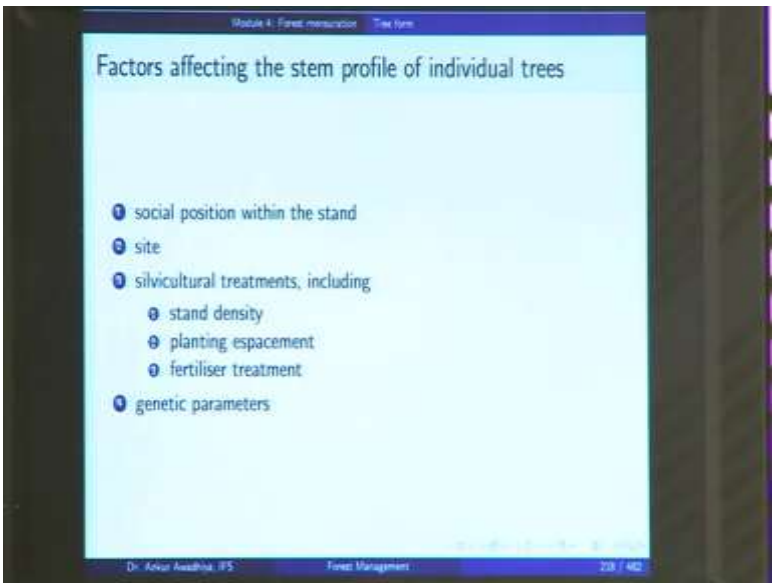

Whereas, if you have trees that are growing in isolation; in windy locations, then you will have shorter and tapered bole. And, there are several factors that affect the stem profile of individual trees; the social position within the stand, the site conditions, the silvicultural treatments, the genetic parameters. And then, we defined the form factor.

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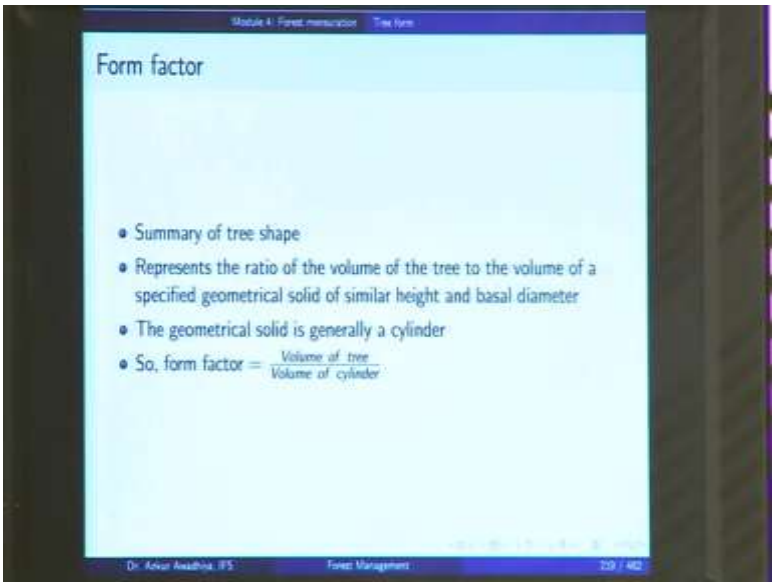

So, form factor is a single figure which gives you an indication of the tree shape. So, this so the form factor is the volume of the tree divided by the volume of a cylinder.

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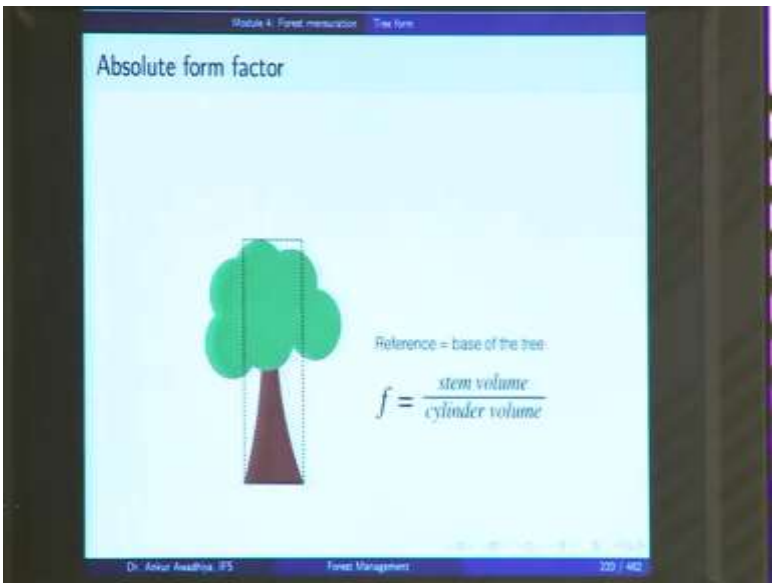

And, depending on where you are measuring the dimension of the cylinder, you can have the absolute form factor where the references is the base of the tree.

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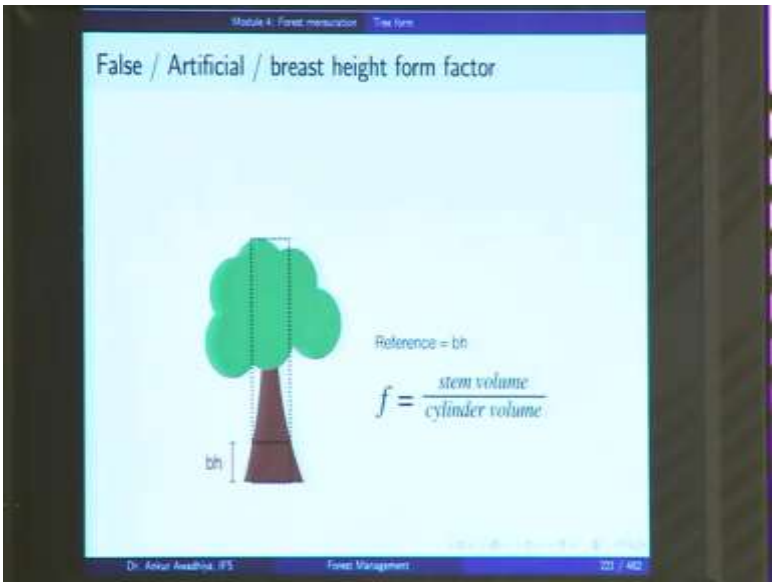

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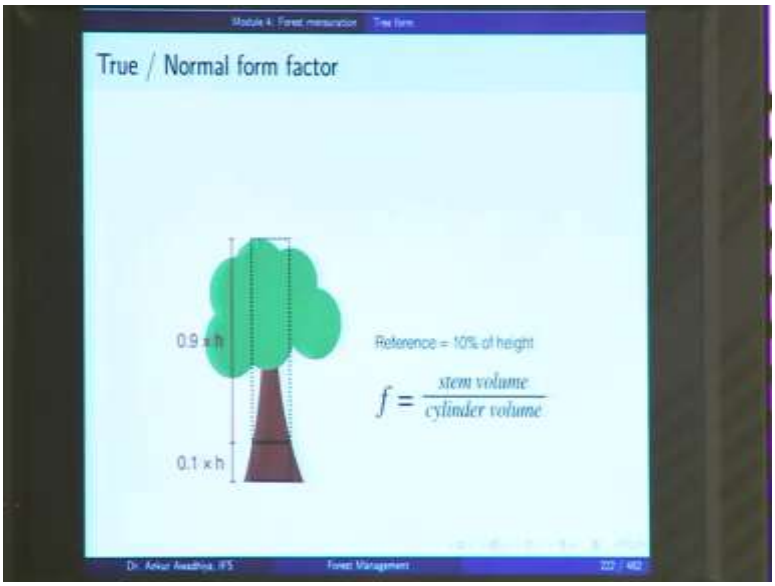

False form factor where the reference is the breast height; true form factor where the reference is 10 percent of the height.

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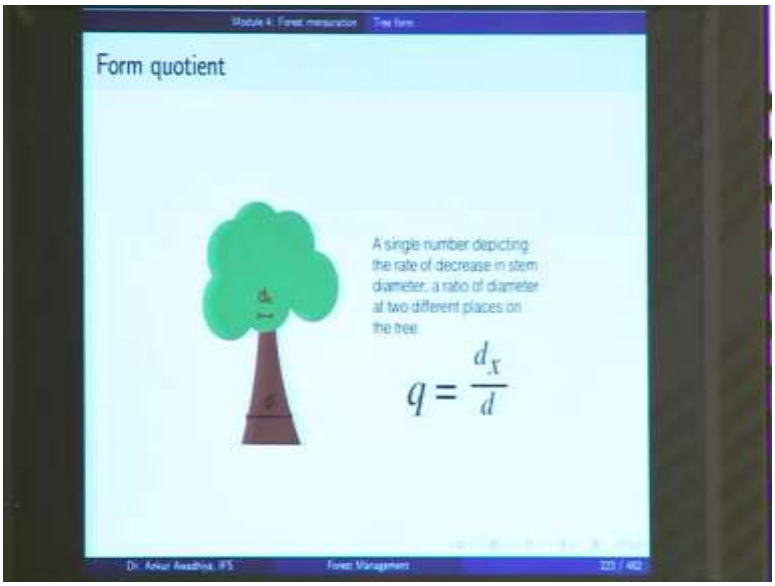

Then, we also defined form quotient which is a ratio of two different diameters.

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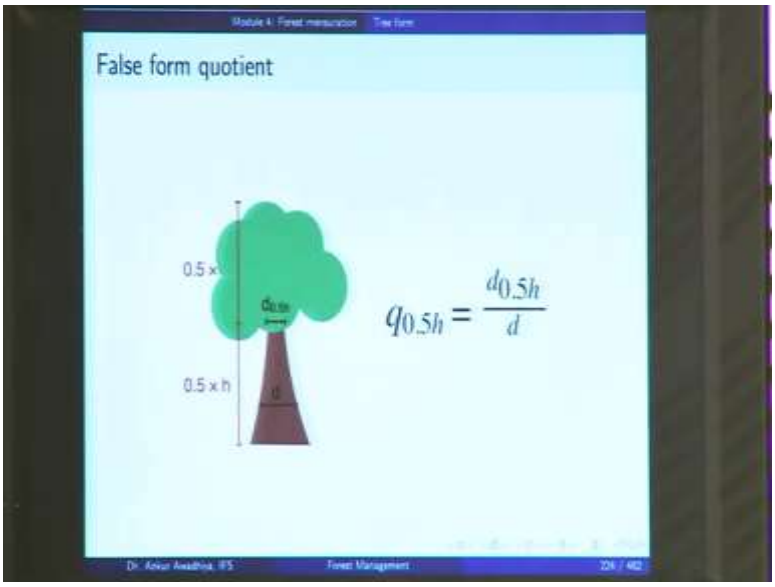

So, you have the false form quotient, which is d at 0.5height divided by the dbh.

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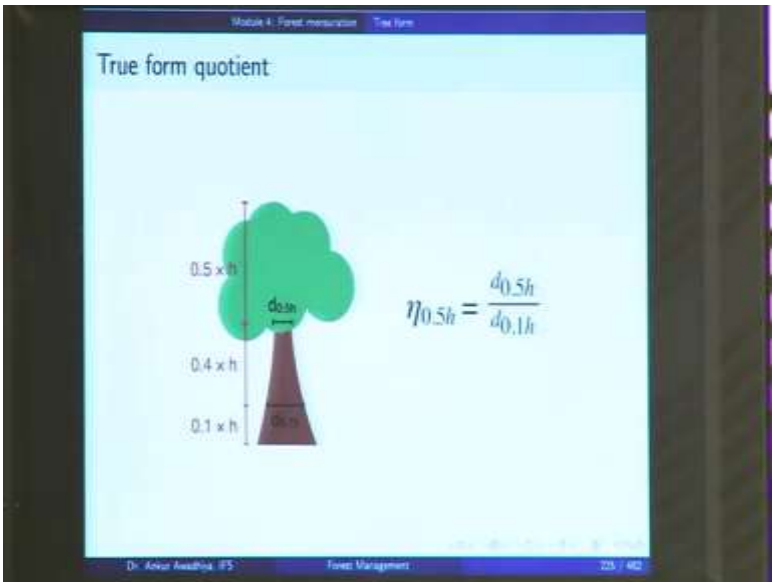

You also have the rue form quotient which is the diameter at 0.5 height divided by zero point divided by diameter at 0.1height.

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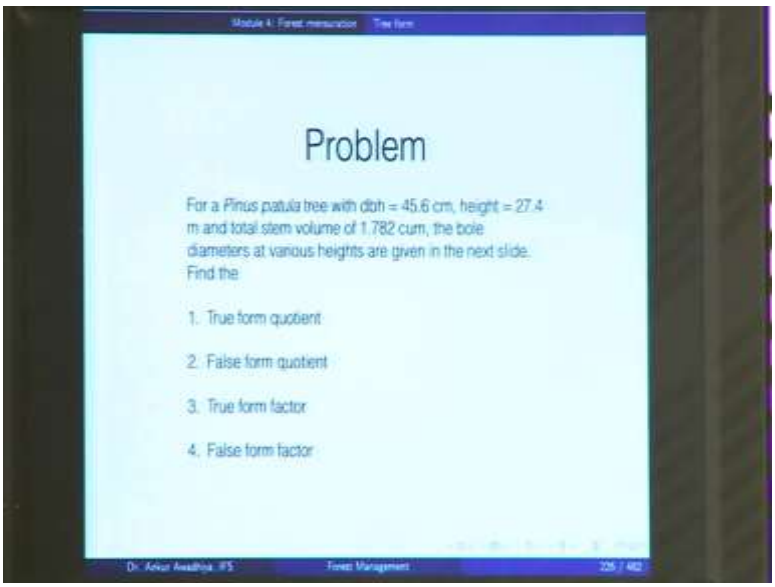

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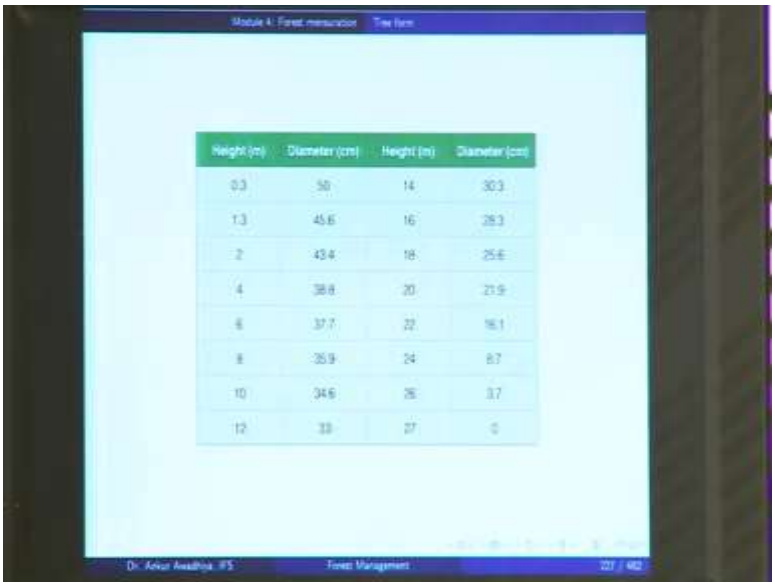

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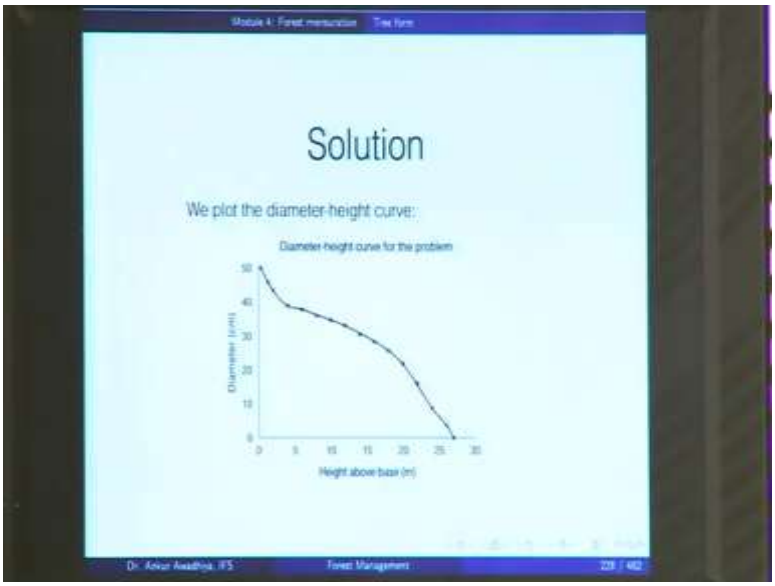

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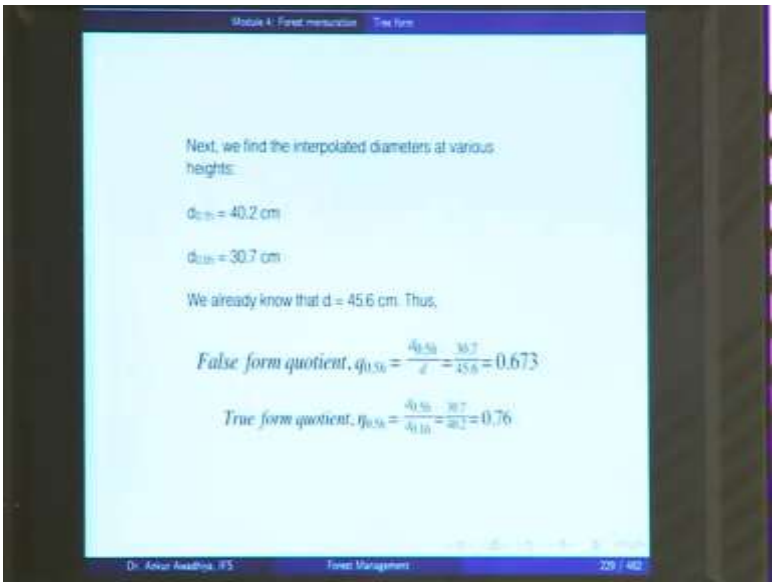

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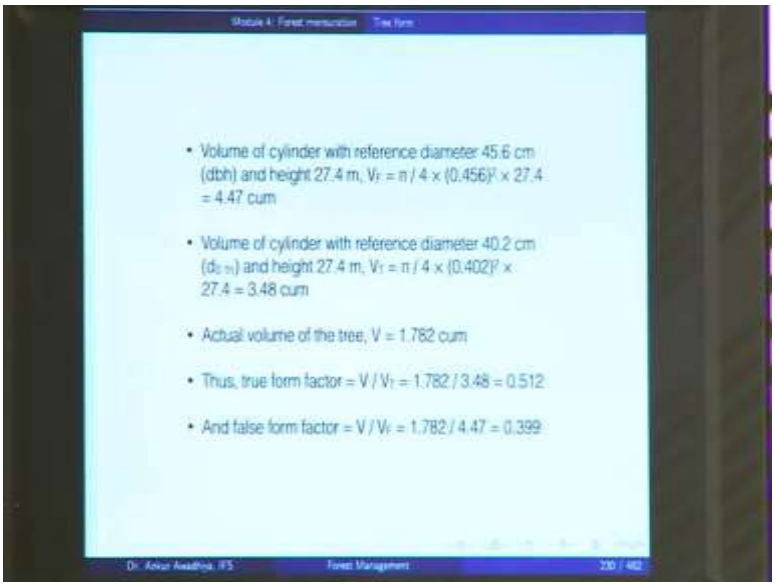

Then, we looked at a problem looked at how to compute true and false form quotients and the form factors.

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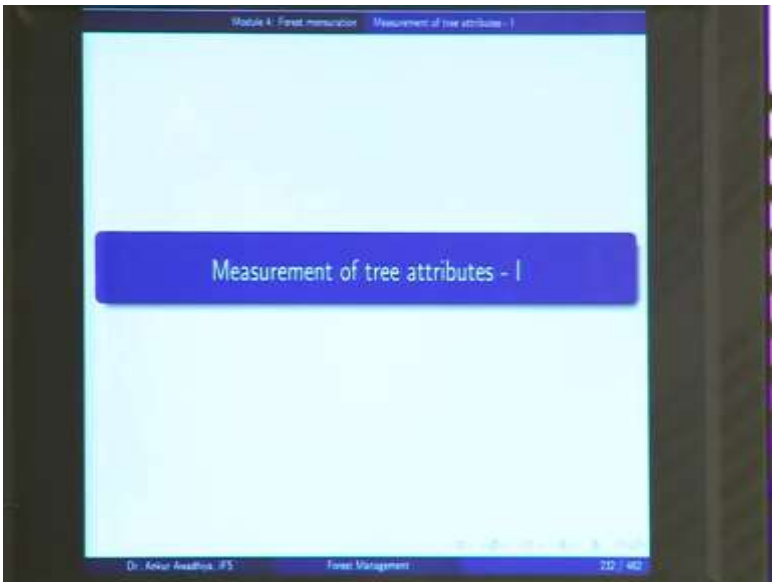

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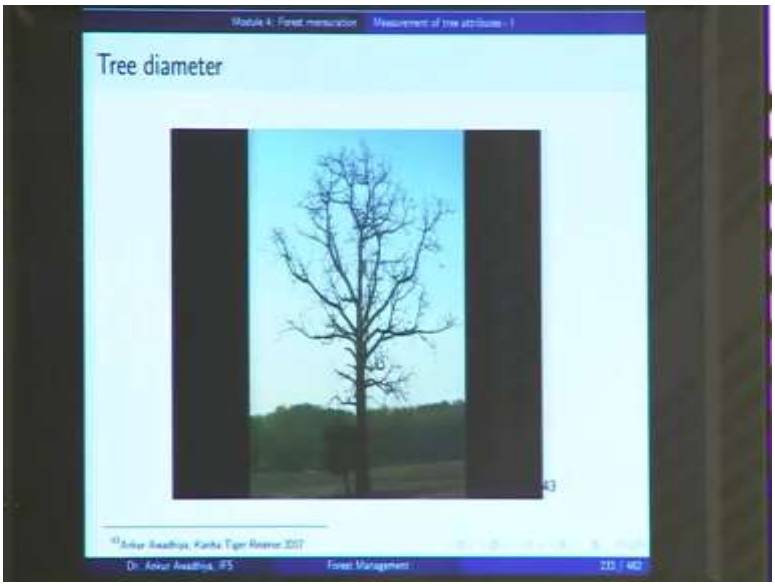

Next, we looked at measurement of tree attributes in terms of the diameter.

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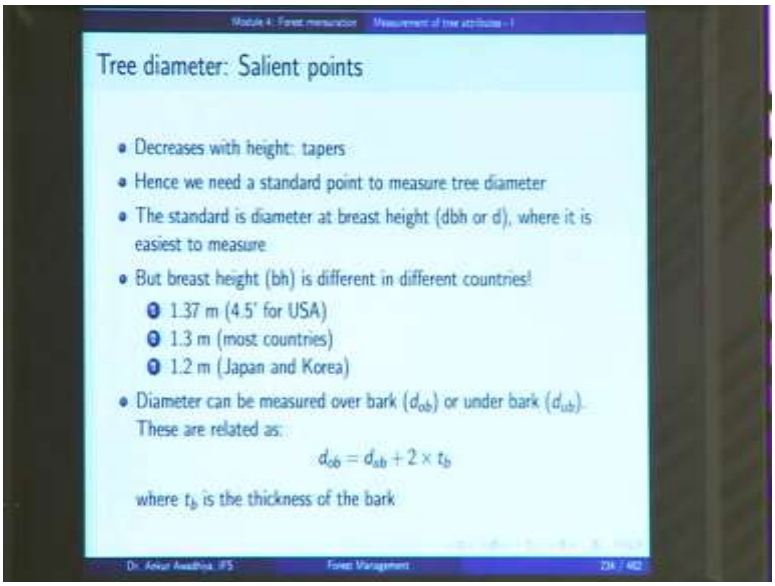

So, diameter is measured at the breast height. Breast height is different in different countries, and the diameter can be measured as diameter over bark or diameter under bark.

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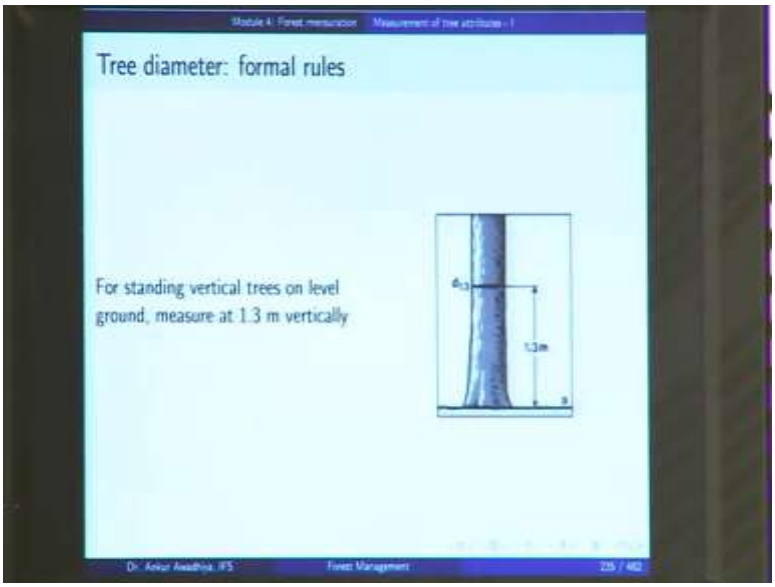

Now, we looked at different formal rules; whether if the tree is standing vertical on a flat ground or on a sloppy ground, if it has some irregularities, and so on so.

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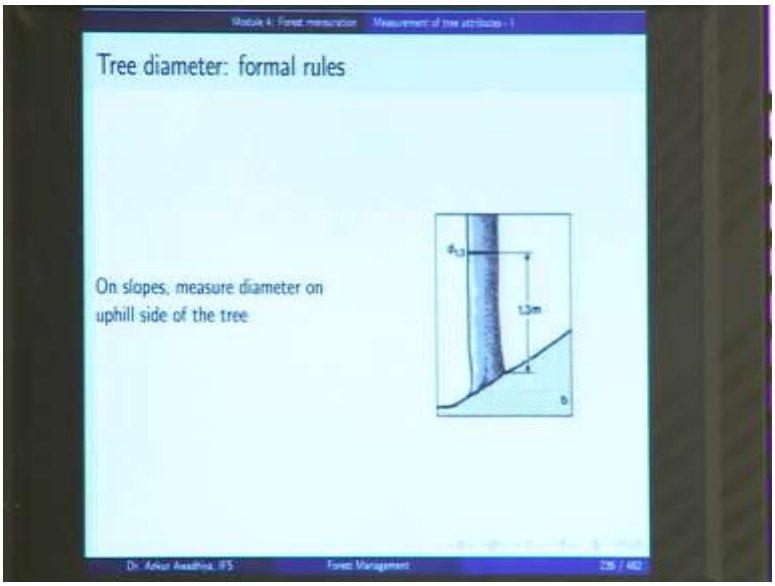

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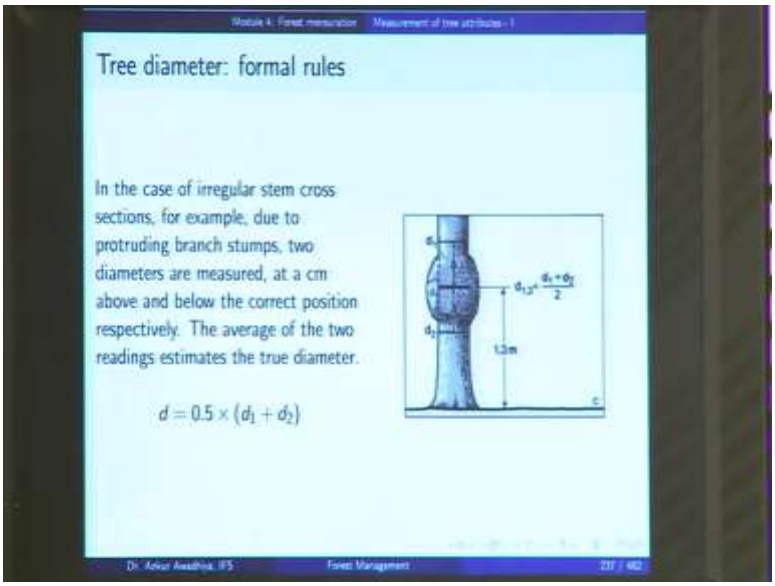

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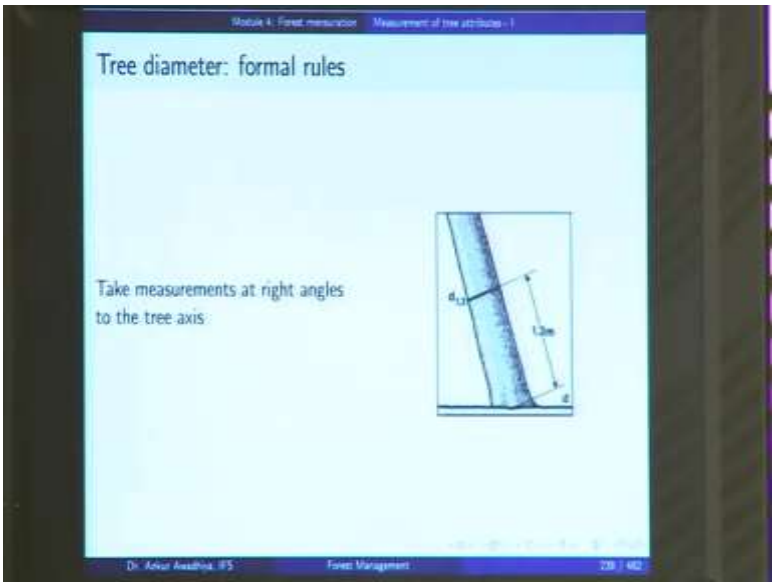

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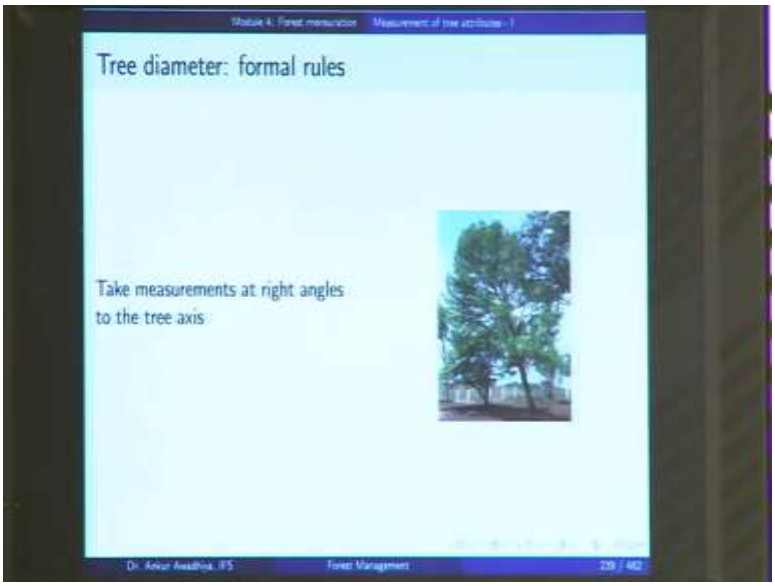

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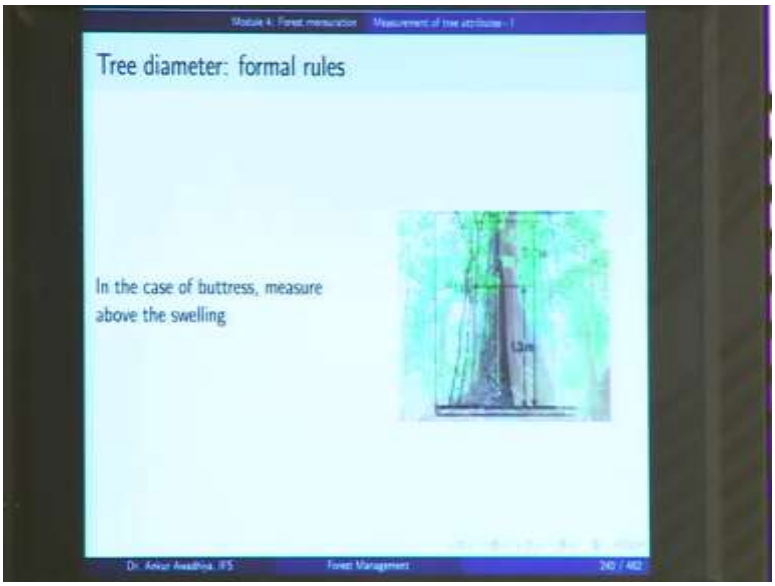

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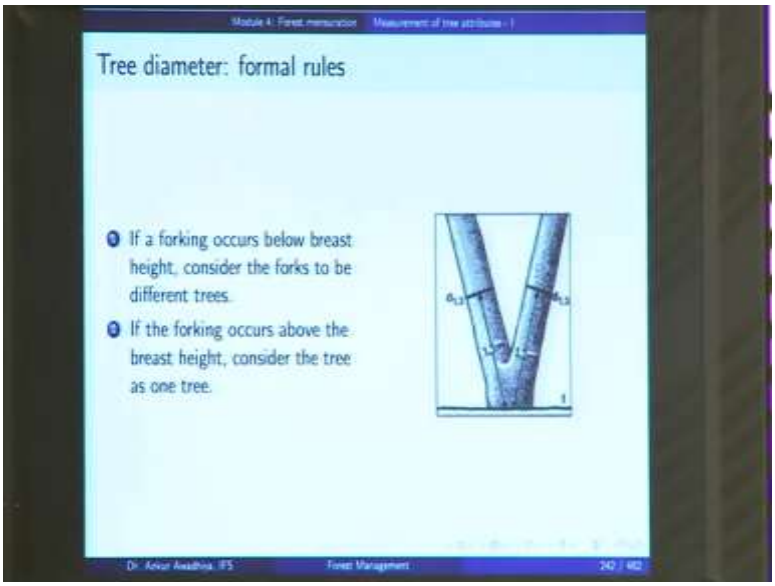

If you have a tree that has a forking, that is below the breast level; in that case, you considered it to be two trees; such as and if it is occurring above the breast height, then you consider it to be one tree.

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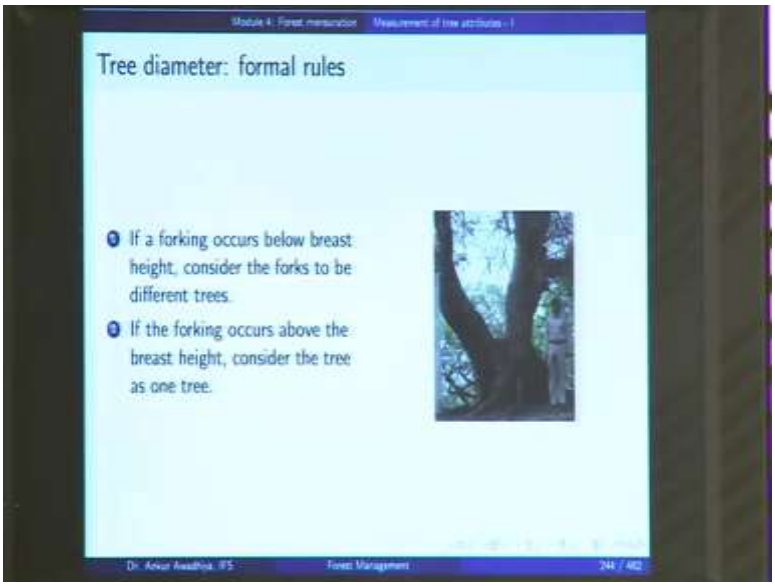

So, this is one tree, and this is two trees. Now, we saw that diameter can be measured using calipers.

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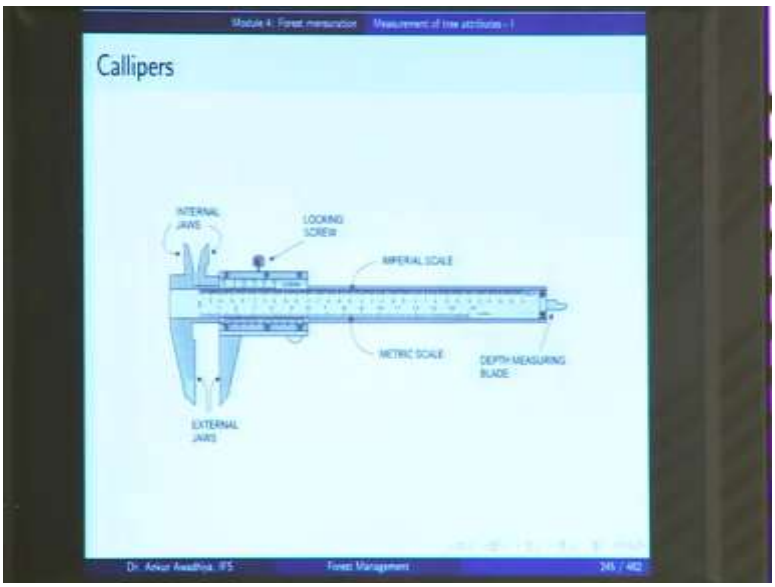

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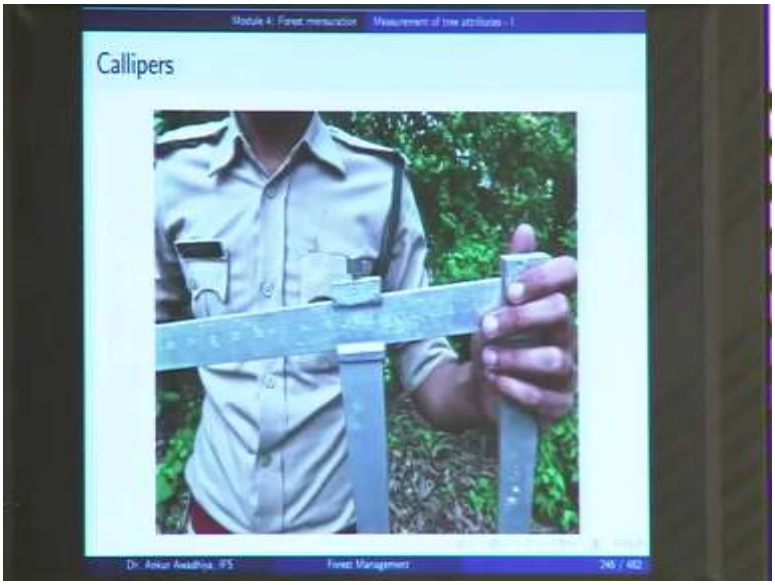

We looked at how a caliper is used, and we looked at the pros and cons of the caliper and tapes.

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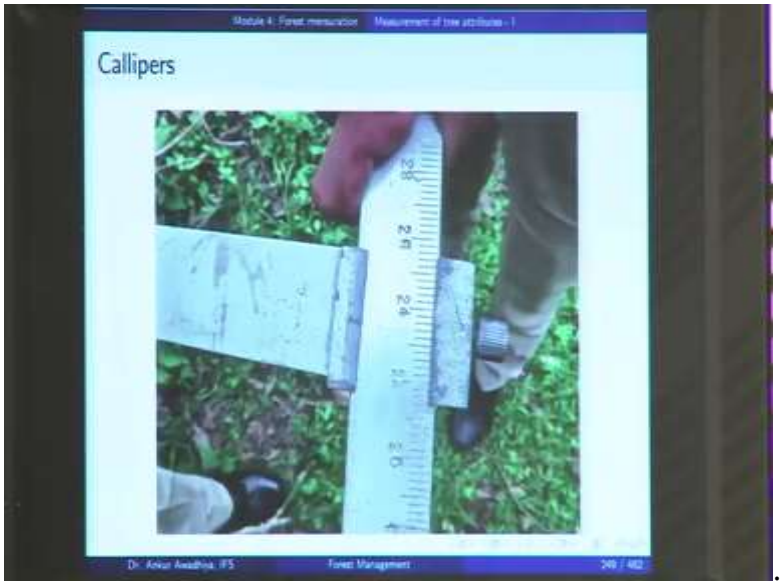

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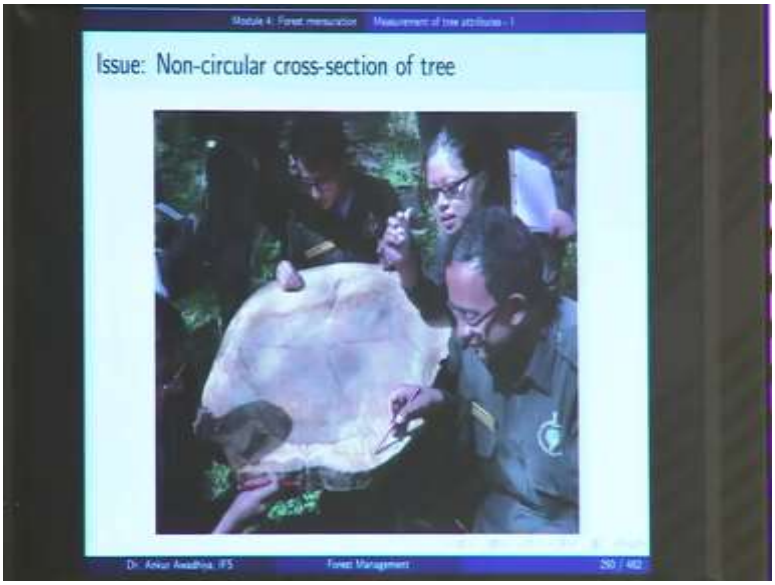

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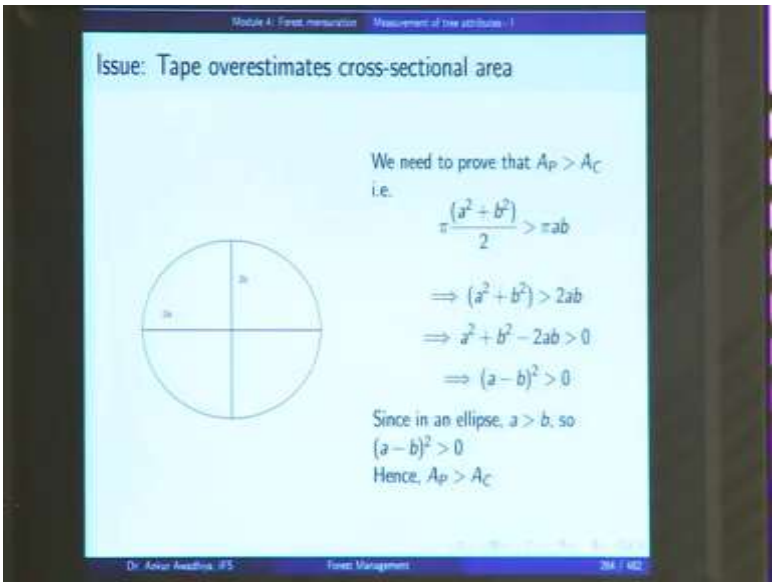

Now, a tape always overestimates the cross-sectional area.

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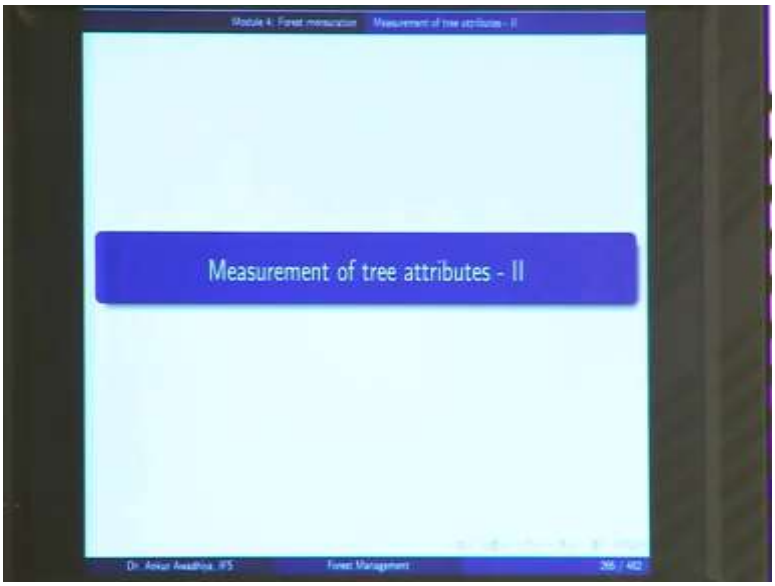

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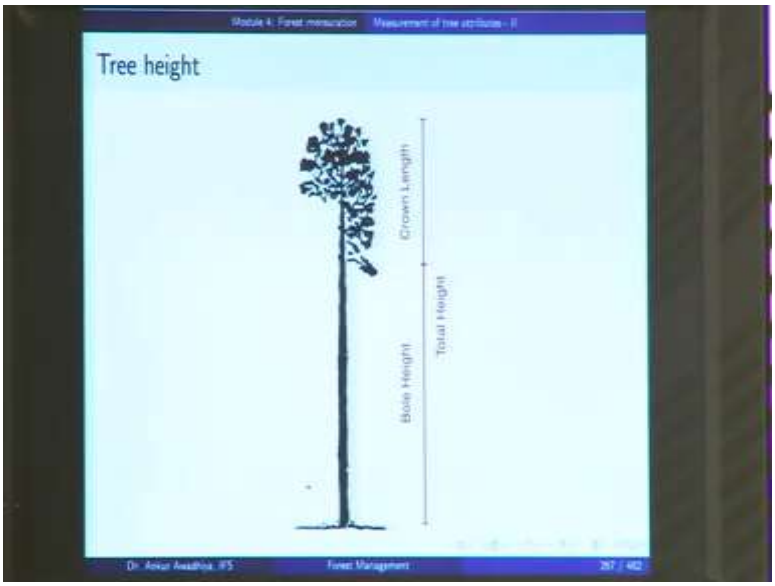

Now, we also looked at measurement of the tree height. So, in the case of tree height, we said that total height is equal to bole height plus the ground length. You can have a direct measurement in which you are measuring the height directly by using instruments or by climbing on the tree, or you can make use of indirect measurements, such as the method of similar triangle and the method of trigonometry.

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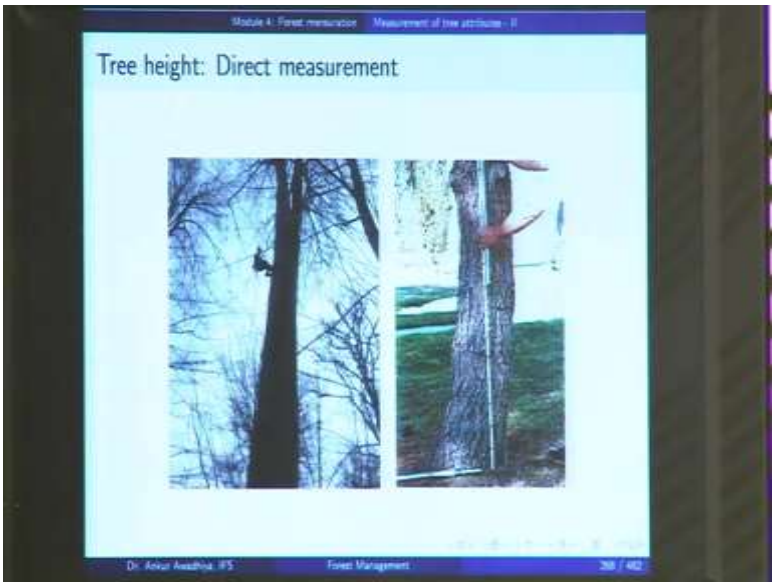

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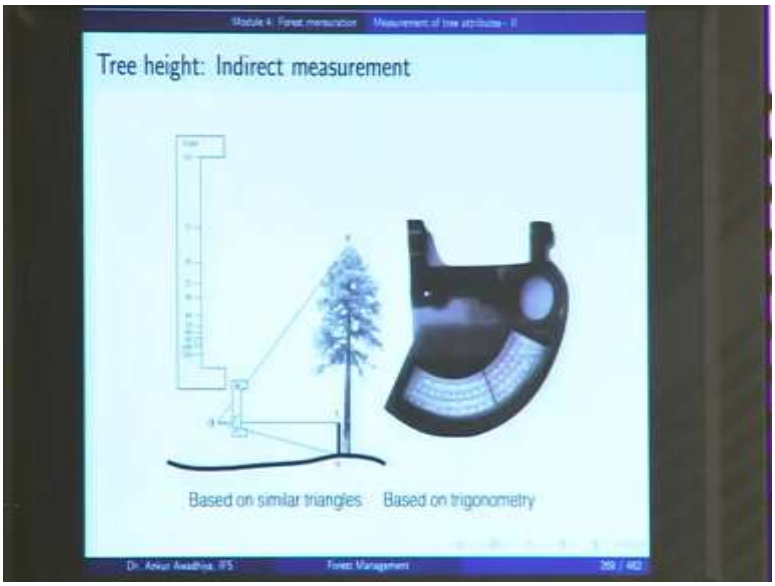

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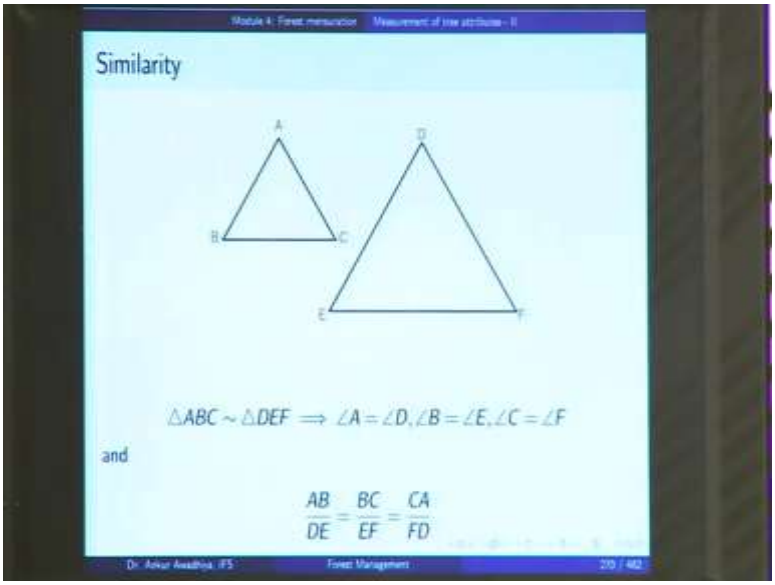

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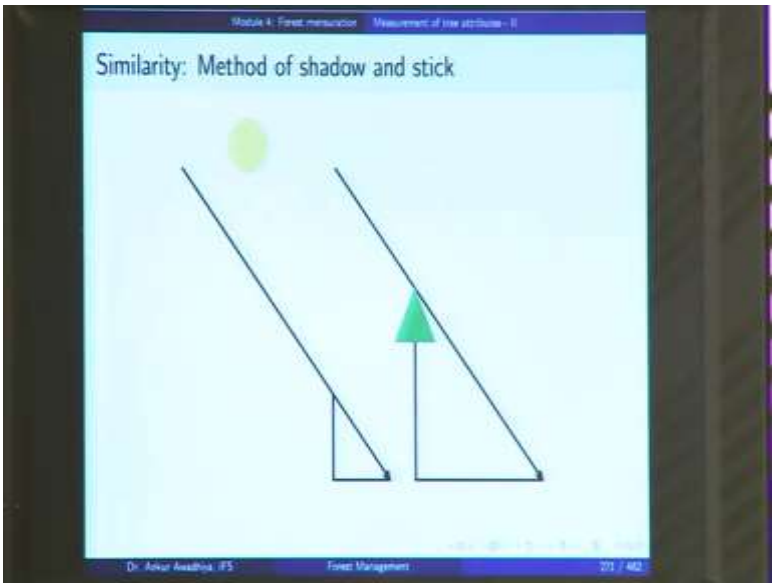

In the case of similar triangle, we looked at the shadow and stick method, and also the Christen's hypsometer.

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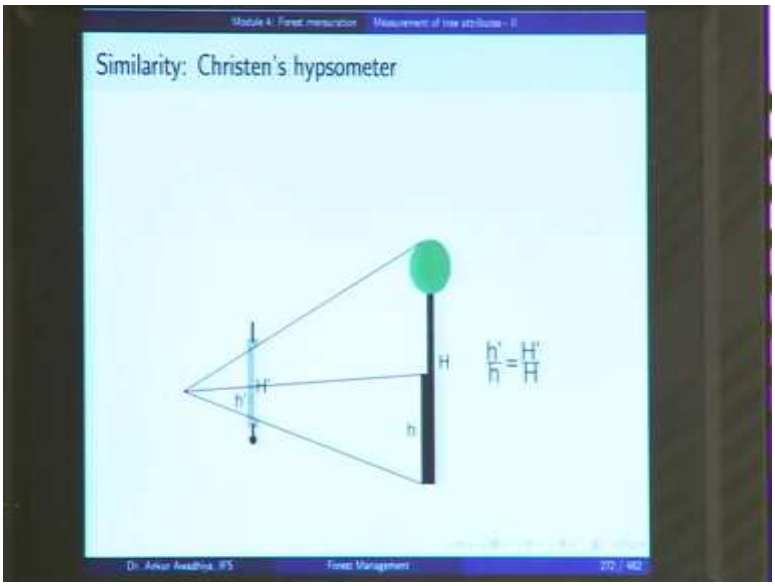

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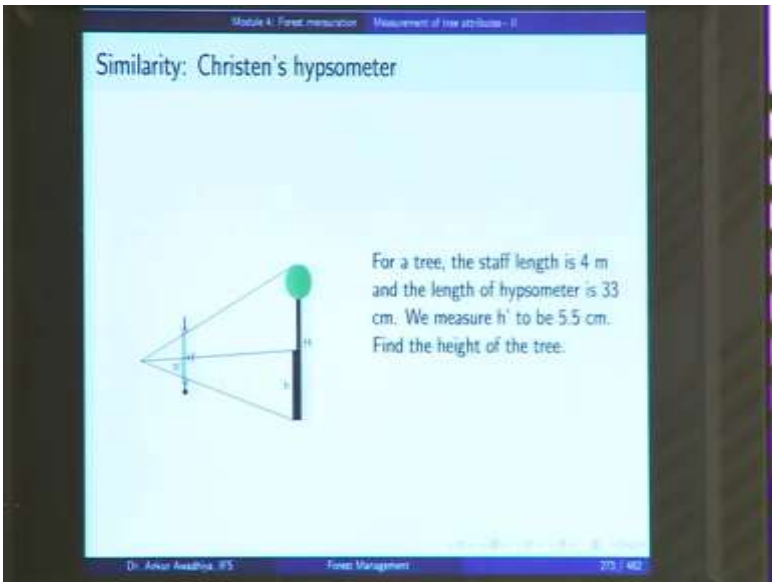

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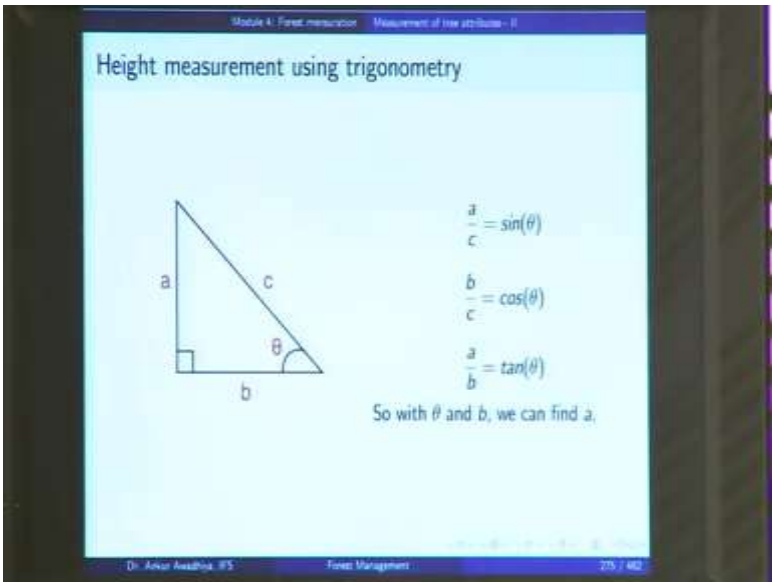

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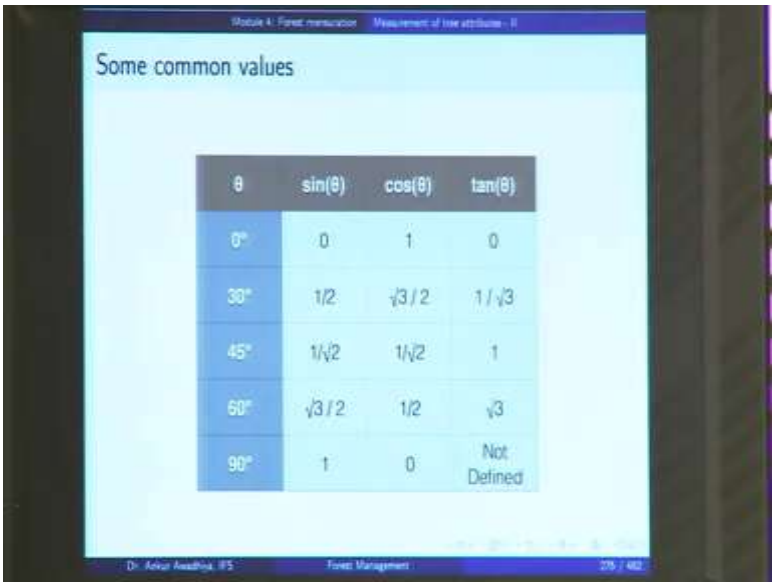

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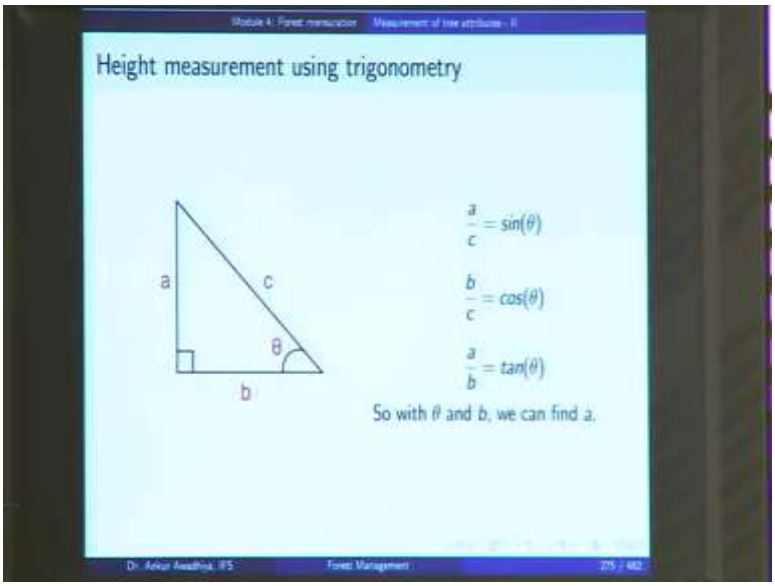

And, in the case of trigonometry, we make use of these relations; we make use of these values of sin, cos, and tan theta for different angles. And, we can make use of this instrument called Blume Leiss to directly get an idea of the height of the tree.

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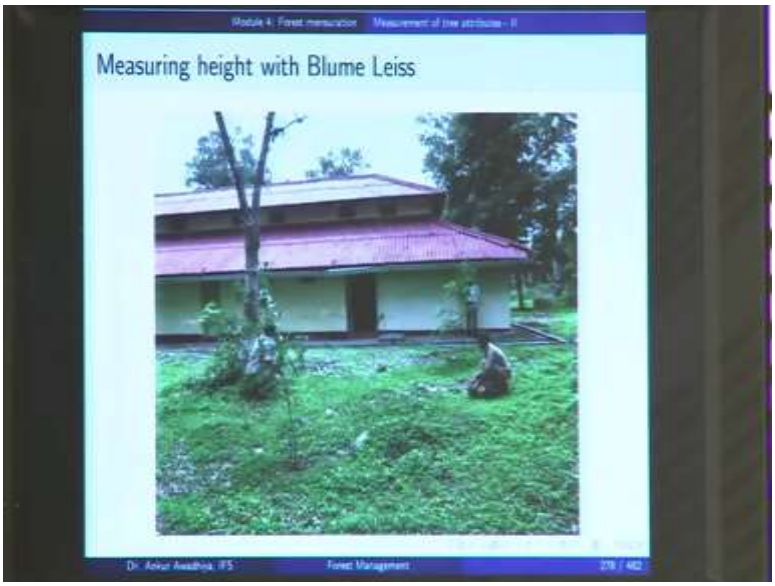

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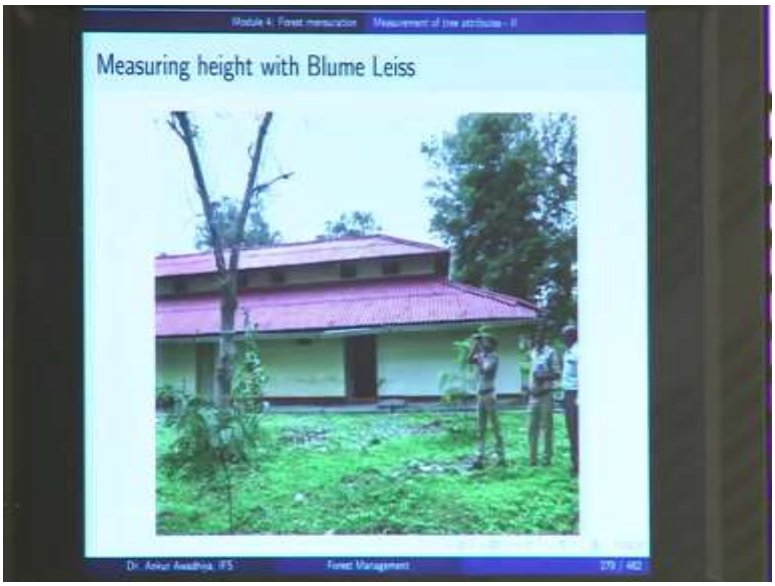

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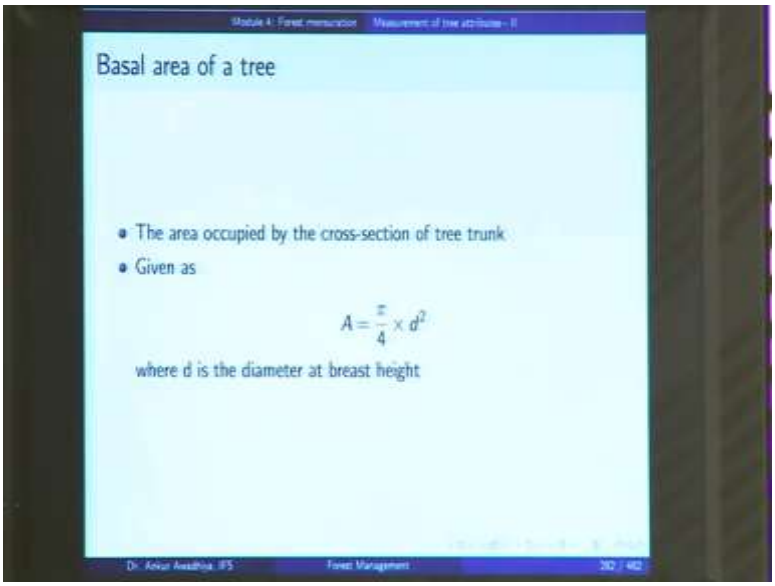

Then, we defined the basal area of the tree as the area occupied by the cross section of the tree trunk, typically at the breast height.

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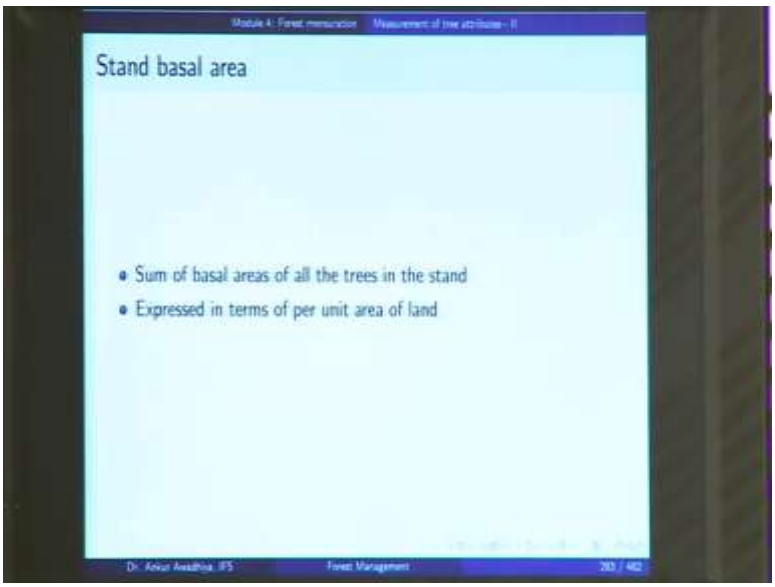

So, area is pi by 4 d square, and in the case of a stand basal area, you sum up the basal areas of all the trees in the stand, and it is typically expressed in terms of per unit area of land.

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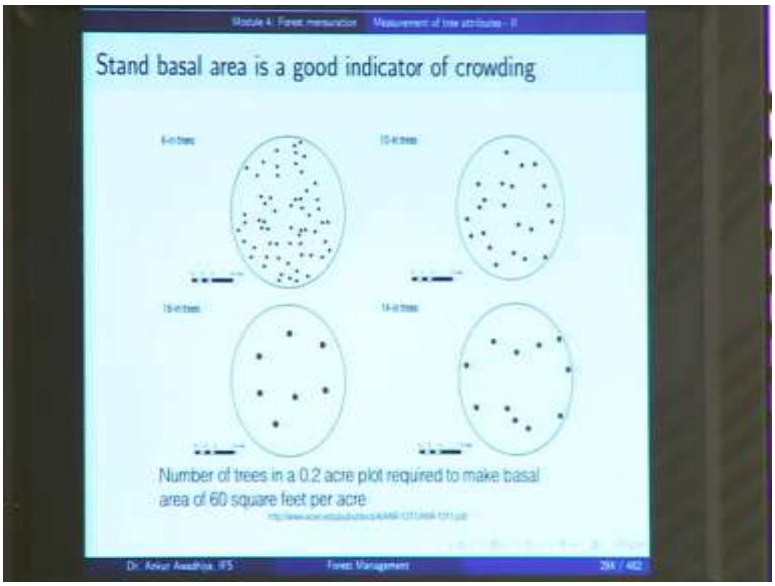

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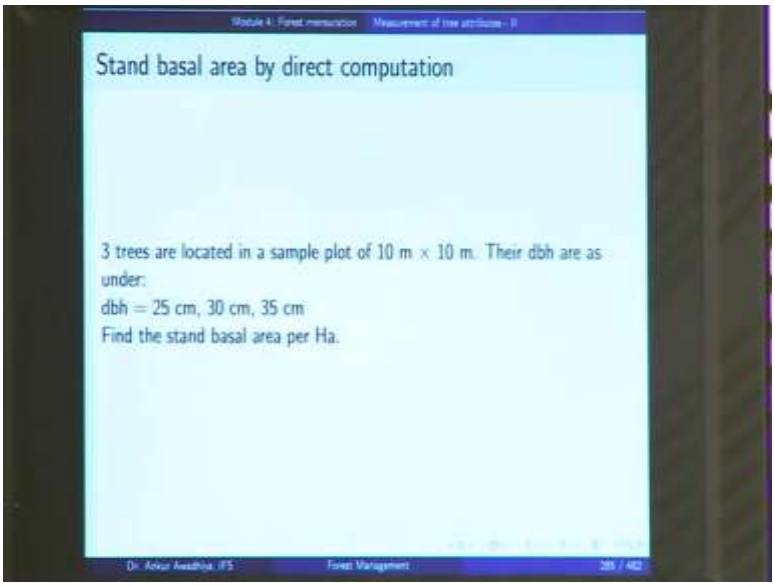

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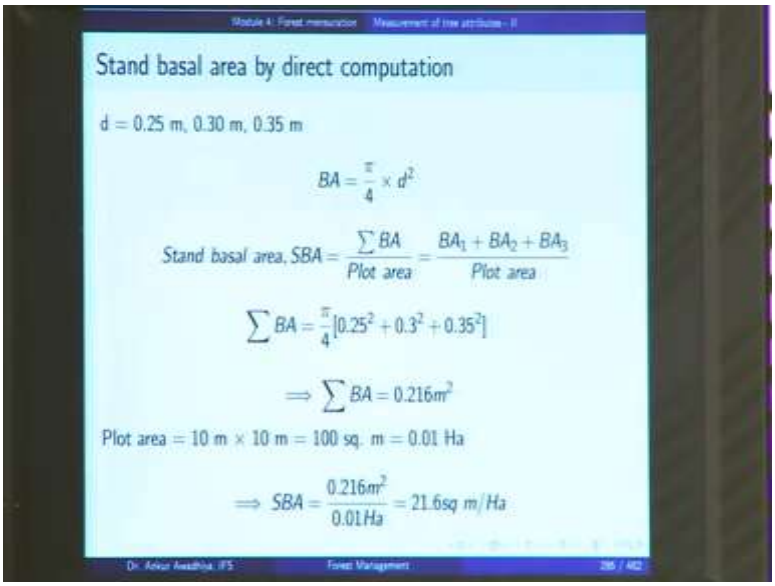

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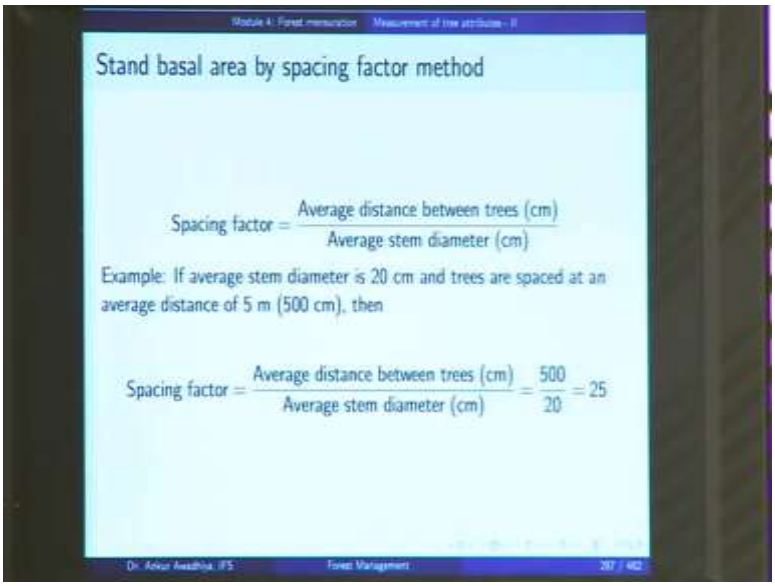

Now, stand basal area is a good indicator of crowding and we saw how to compute it; by direct computation and also by the spacing factor method. Now, spacing factor is defined as the average distance between the trees divided by the average stem diameter, and if we plot the basal area versus the spacing factor, we get this curve.

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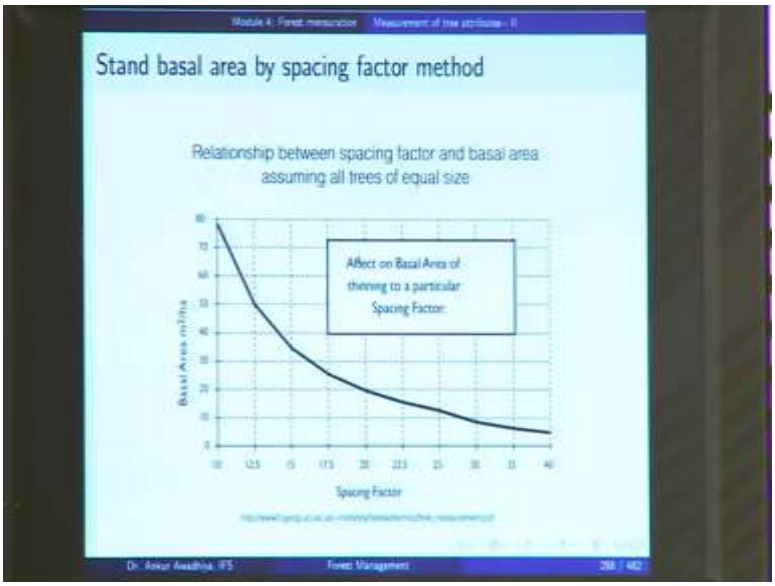

And so, if you know this spacing factor, you can very easily figure out the basal area of this stand. So, that is all for today.

Thank you for your attention [FL].