Soil and Water Conservation Engineering
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Lecture – 50
Design of Shelterbelts

Hello friends, in the last class; we have we have seen the design of wind breaks and in the, this class will be looking at the Design of Shelterbelts. So, this is the third lecture of this module of wind erosion control measure. So, prior to that we have seen we have studied the wind erosion definition of wind erosion, different measures to control wind erosion, what are the different factor that effect that can trigger the process of wind erosion and different ways the that can be used to reduce the wind erosion.

So, in the in this in, so, sequence of that we can see that in the last class we have seen the how to reduce the wind velocity by designing a proper wind break depending on our criteria, design requirement. So, in then in this class, we will be understanding the design of shelterbelts ok.

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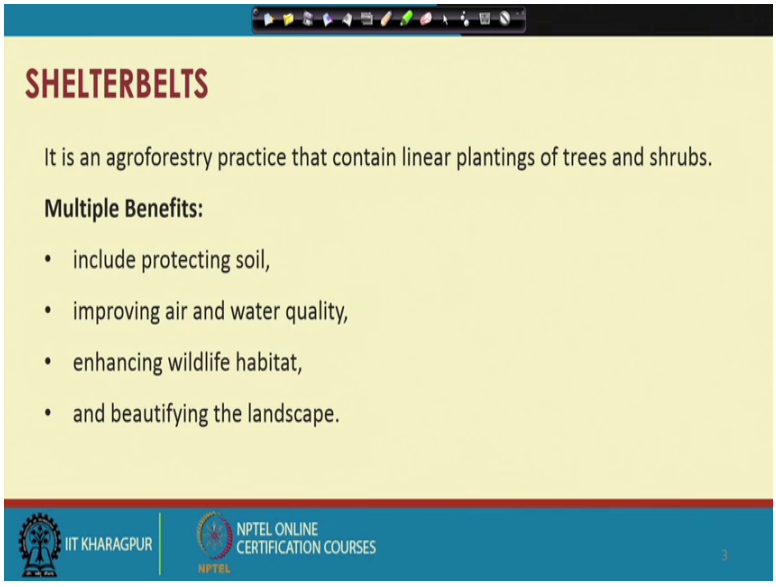

So, shelterbelts are, is actually agroforestry practice that contain a linear planting of trees and shrubs with an objective with a multi multiple objective. So, our objective with a shelterbelt is to achieve obliviously to reduce the wind speed that is the first criteria that

into protect soil. Then to improve the water quality, water and air quality over that region because this shelterbelts are actually we are designing for the bigger area.

So, lengths are bigger. So, so we have we have talking about large scale here compare to the, for protection for firm state ok. Improving air and water quality, enhancing wildlife habitat or improving the biodiversity or that region and obviously, beautifying the landscape. So, these are the different objectives but main objective is to reduce the wind speed and protect the soil.

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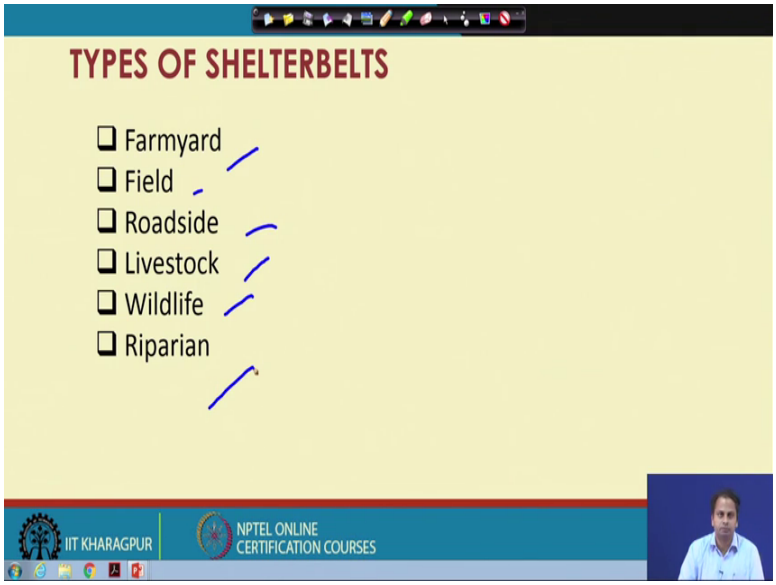

So, there are different types of shelterbelts and these shelterbelts are can be name after different names the depending on their objectives. So, like farmyard, so, like farm farmyard, field shelterbelts, roadside shelterbelts, livestock, wildlife and riparian shelterbelts; so, all of them have different objectives and depending on their objective there designed are there designed parameter changes.

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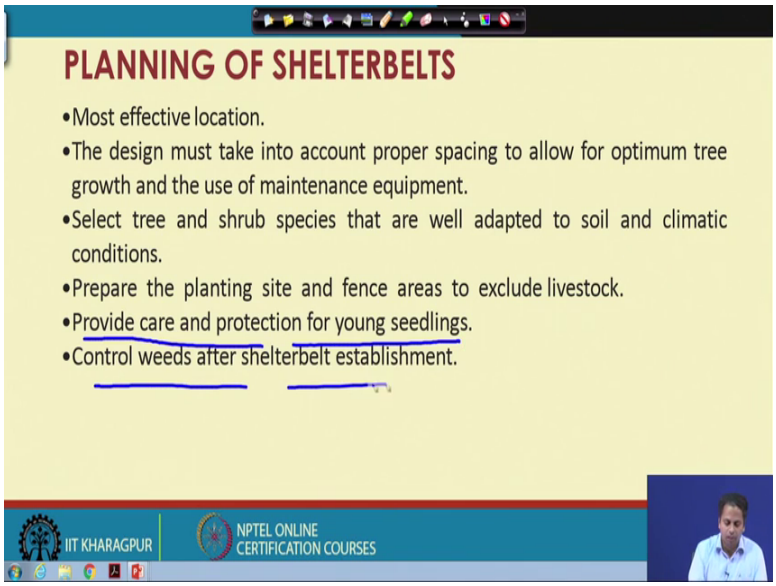

Now, before planning of shelterbelts we need to understand, we need to see the following points actually we need to understand different things before planning any shelterbelts. So, we need to select most effective location which will be effective for planting a shelterbelt ok. So, the design must take into account of proper spacing to allow optimum tree growth and the use of maintenance equipment ok. So, sometimes so, our all though our objective is to reduce the wind speed and protect the, our structure.

But you need to consider other factors also. You need to provide sufficient space as well for optimum tree growth as well as to perform some kind of maintenance activity. So, we need some access length as well ok. So, the design must take into account of these parameters like a proper spacing to allow optimum tree growth and the use of maintenance equipment.

Then select the select tree species or shrub species or combination of that that are very well adapted to the current climate condition of that region ok. So, we it is not like we can plant any tree or any (Refer Time: 04:10) or any shrub, but though only those trees or shrubs which are which can provide a better protection to us or which are most adapted to the, that current climate or that region.

So, that kind of species and or combination of species of trees and shrub should be selected ok. Now, after that prepare a planting site and fence areas to exclude the livestock ok. So, when you are preparing the shelterbelts, so, while preparing a planting

site fence it because for sometime actually you should you should have some protection from the wild animals or livestock ok.

So, when they while they acquire some kind of some level of height or some growth till that time you need some kind of protection. Then provide you need to provide some care and protection to arrange young seedlings; means it means, till the time it develops or it matures, you need to provide protection to the to the designed or to a planted shelterbelts and you need to control weeds over that region to have better growth in the shelterbelts ok.

So, the controls of weeds after shelterbelt establishment that should be in your planning step ok.

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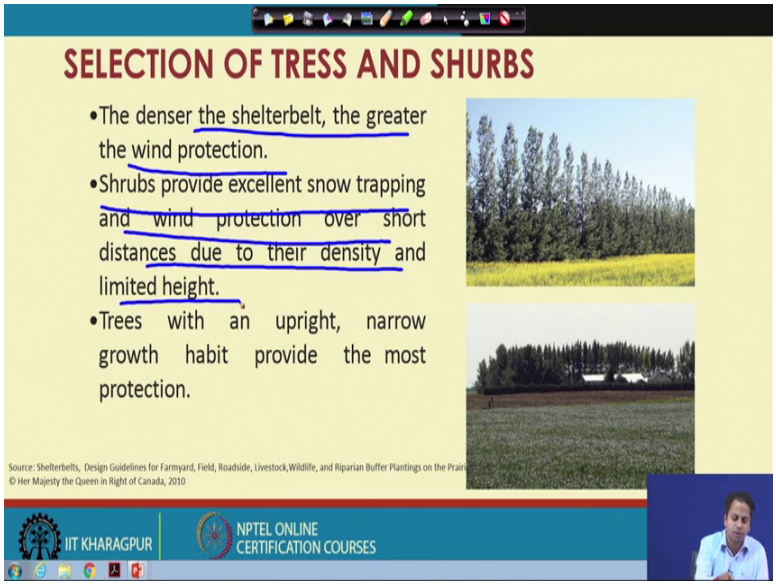

Now, then the selection of trees and shrubs ok; so, this is the one of the most important part of shelterbelt selection because by selecting a particular species, you are not only selecting a particular species, but you are selecting a combination which has some kind of height, density and which can protect we can which can give your protection to a some particular distance ok.

So, all these factors are depend on proper selection of trees and shrubs ok. So, the denser the shelterbelt is the greater the wind protection you will get, but again that dependence

on your design requirement or design need ok. The shrubs provide excellent snow trapping and wind protection over short distance due to the density and limited height.

So, suppose if you are interested in addition to the wind protection you also want protection from snow also, so, you can also think of planting some smaller shrubs which can provide an excellent protection protecting cover against the snow cover snow ok. The shrubs provide excellent snow trapping and wind protection over a short distance due to their ability, due to their density and limited height ok.

So, the combination of different trees and shrubs should be selected based on what is required or what is designed are designed requirements are there ok. Then trees that are actually upright and with which have narrow growth habitat, they provide most effective protection. So, while selecting the tree as species, you need to understand you need to be very careful about selecting a proper tree species which will be effective for your area and which can serve your purpose ok.

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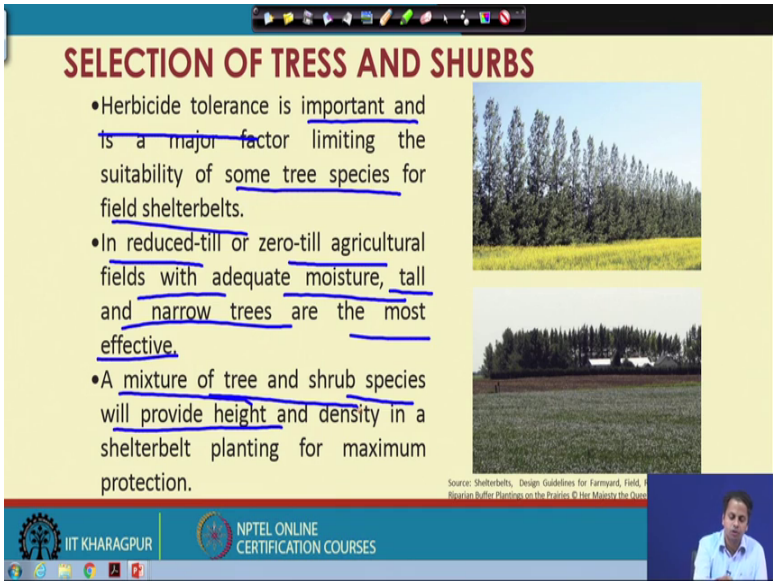

Similarly, to that while selecting the trees, the species should be herbicide herbicide tolerant the. So, herbicide tolerance is important and is a major factor limiting the suitability of some of the tree species for field shelter purposes ok. So, there are different factors as I said. You need to consider before selecting a proper species proper species ok.

So, such for example, in reduced till or zero till agricultural fields with adequate moisture, you can adopt tall and narrow trees that are more effective in that scenario. And also the mixture of trees and shrub species that will provide height and density is a mixture of you can also think of planting mixture of trees and shrubs species to get to achieve maximum height to achieve good enough height and density to get maximum amount of protection length ok. So, these are the different selection criteria which can be used which can be thought of before selecting any particular species for shelterbelt ok.

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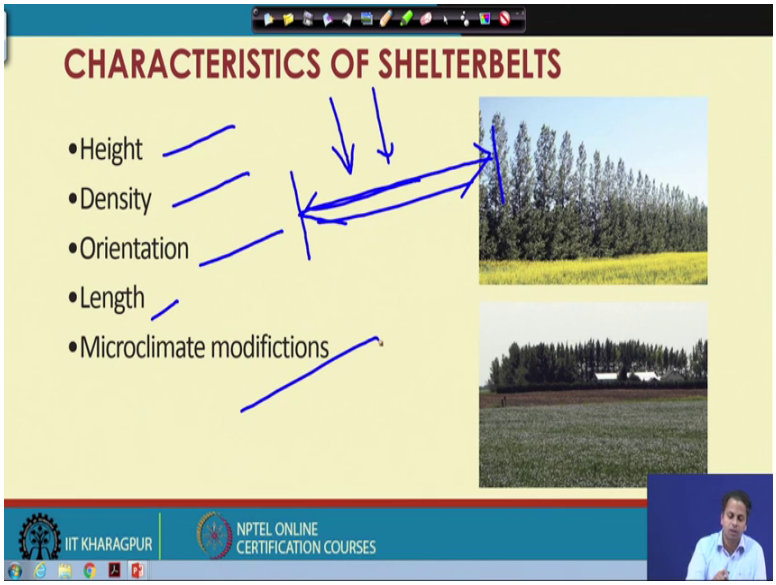

Now, these characteristics of shelterbelts are depend on various parameters. So, like height of the shelterbelt, the density of the shelterbelt. So, densities actually dependent on what kind of tree specifies you are selecting whether conifer, deciduous or shrubs are combination of that. Orientation of that shelterbelts in relation to the prevailing wind direction that is also important criteria. Then length of the shelterbelt which is which we you want to a design ok; then modification and microclimate condition. So, all this things are when the characteristics of shelterbelt.

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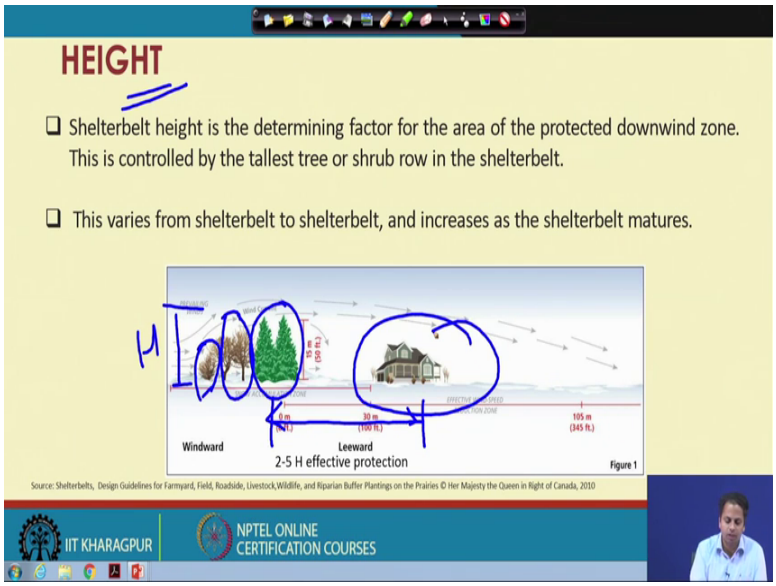

So, first let us see height. So, so, shelterbelt height is actually determining factor for a area of the protected downwind zone and it is controlled by the tallest tree or shrub row in the shelterbelt. So, as I said wind is actually most important sorry height is the most important parameter here which decides the length of downwind protection ok.

So, let us say this is the shelterbelts so, which combination of some kind of shrubs some kind of deciduous or some kind of medium density trees and high density trees conifer trees. So, we can see some we can see the protection from this can be seen can be effectively seen at a distance of let us say 2 to 5 times H, H is height of this shelterbelt ok.

So this suppose you are you want to protect your this structure farm structure, so, to protect this farm structure; so, the distance should be distance of this shelterbelt should be at least a within or the or the location of your firm structure should be at a distance of 2 to 5 H from the shelterbelt ok.

So, the height of the shelterbelts varies from shelterbelt and it increases as the shelterbelt matures. So, so all this thing you need to be understand before designing. So, all this thing needs to be taken care of while designing the any shelterbelt ok.

So, the here we have seen so, this shelterbelts actually is used for to protect from the wind current as well as it is trapping the snow ok. So, it is protecting this area from snow and as well as wind ok.

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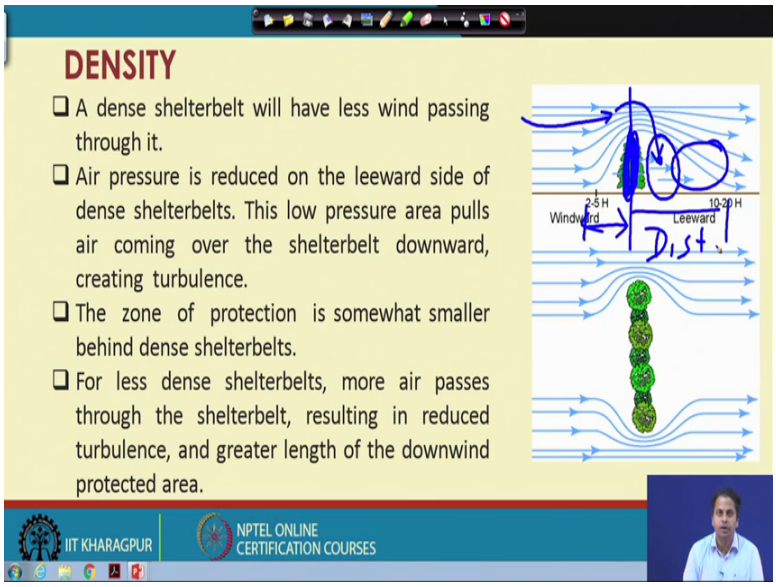

Now, next important parameter is the density ok. So, a dense shelterbelt will have less wind passing through it. So, the air pressure is reduced on the leeward side ok. So, the air pressure will be reduce on the leeward side that will make ok. So, the air pressure will be reduce on leeward side of the dense shelterbelt. This low pressure areas will pull air coming over the shelterbelt downward and will create a downward will create a turbulence over that region.

So, suppose this is your shelterbelt, this is on one section if we see. So, you can see the effectiveness of this reduction in wind speed is can be visible at a at a length of 2 to 5 H here and on the windward side and here we can see 10 to 20 H side, but you can see here as the air rushes through it thus the low pressure which is there will pull this air here and in the absence of very high density sorry in the absence of porous barrier here, so there will be lot of turbulence here. So, the effective distance effective distance of protection will be reduced ok.

So, what we said? A dense shelterbelt will have less wind passing through it and it will reduce the pressure on the leeward side and which will cost the, which will reduce the length of protection ok.

So, the zone of protection is somewhat similar behind this. So, zone of. So, we can see become because of this zone of protection is somewhat smaller behind the den shelterbelts. So, if the shelterbelts is very dense so, zone of protection will be relatively smaller as compare to the porous shelterbelt ok.

So, for less than shelterbelt, the density of shelterbelt is less or porous; more air can pass through it and resulting into reduce turbulence and greater length of downwind protected area ok. So, this is the effect of density on the on the shelterbelt on reduction on reduction of wind speed.

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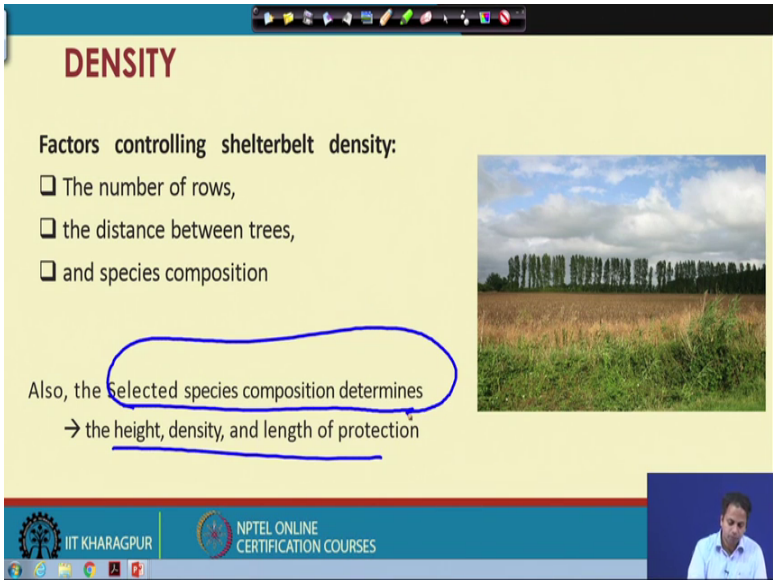

And other things like density factors controlling a shelterbelt densities. There are different factors that all together controls the density of shelterbelts. So, for example, number of rows which are being used, the distance between trees and this species composition. So, what combinations we are using as a for a shelterbelt ok? So, obliviously the number of rows, how many number of rows we have used, the spacing between them, the distance between the tree that is the spacing and different combination of species that like shrubs residues trees or medium den medium density trees or high density trees. Also the selected species composition will determined the height, density or overall structure of your shelterbelt.

So, depending on the species you select for this shelterbelt, the height of this structure high density and the length of protection will be determined.

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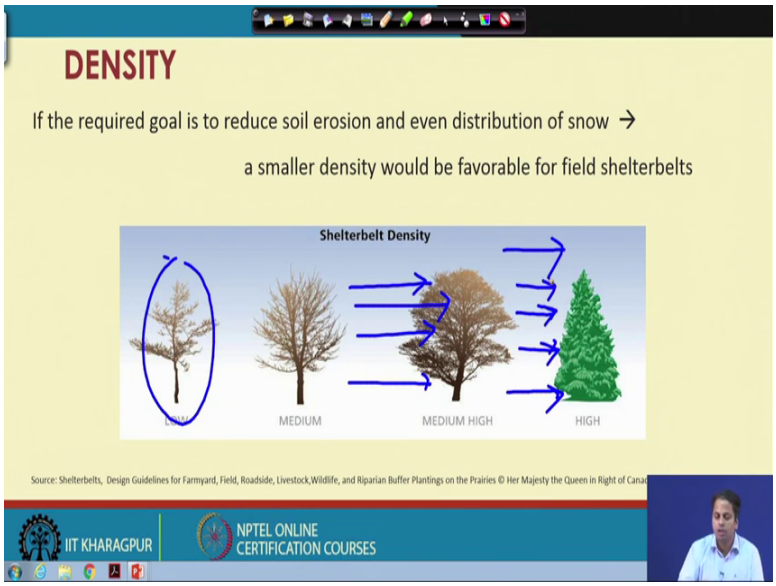

So, this example show; so, this is another image which explain the density. In case so, there are so, is our goal is to reduce the soil erosion and evenly distribute the snow. So, in that case a smaller density would be favorable for the field shelterbelts. As I said there are different shelterbelts. So, in case of field shelterbelts, we have our objective is to reduce soil erosion and even distribution of snow. In that case we need low to medium; we need low to medium density shelterbelts.

So, these are the different density of different range different kinds of tree width different density. So, this is actually low density of shelterbelt tree species, this is medium high and high. So, you can see here when you are choosing a very low very low density very low density tree species as a shelterbelt then it allows moreover to pass through it; so, it dependence on your requirement.

So, so the although the effect. So, the effect of downwind reduction will be more here, but, but the suppose if your requirement is to trap snow also and to reduce the and also to reduce the effect of temperature wind temperature then in that case this will not be the effective ok.

So, in case of medium high, it can allow some part of air to pass through it, so, with some relatively higher density compare to the shelterbelts. So, it can serve your purpose, but it should be planted in combination with some different combination of trees with

different densities and similar this is a conifer which will be most effective to traps to trap snow and to protect from the temperature effect of wind ok.

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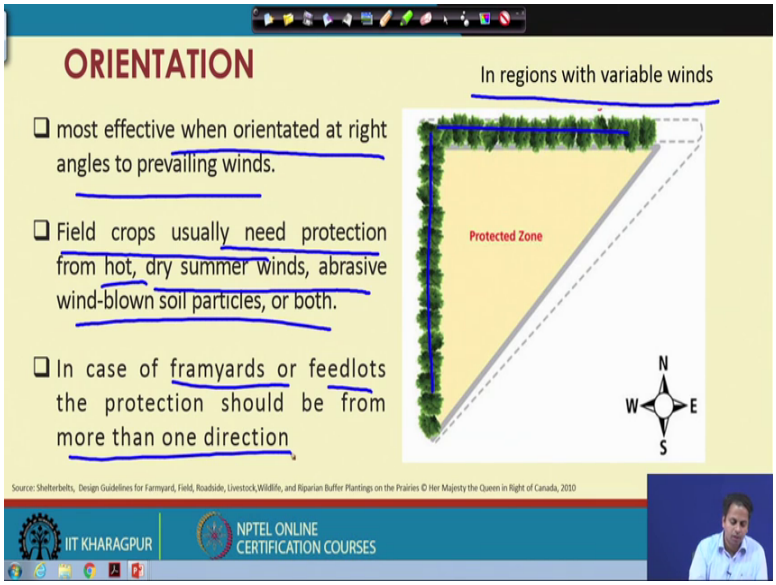

Now, orientation as we discussed; so, though once you finalize you your location, so, you should know the prevailing wind direction. So, once you know the prevailing wind direction you can go for multiple leg shelterbelts. So, in a region which is having variable winds; variable in terms of magnitude as well as direction.

So, in that case you can say multiple leg shelterbelts. So, most effective the effectiveness of shelterbelts are most or you can say shelterbelts are most effective when the, they are orientated at right angles to the prevailing wind ok. So, field's crops such as field's crops usually need protection from hot and dry summer winds abrasive windblown and soil particle. Whereas, farmyards and feedlots they need protection from more than one direction.

So, this like a like based on your requirement ok. So, and the variation of wind in different direction over a year you can you can select the orientation of your field shelterbelt ok. So, as I said in case of farmyards or feedlots the protection is required from more than one direction. So, in that case you need to think of multiple leg shelterbelts ok.

Whereas, in case of field crops if you know the prevailing wind is only in one direction and it is mostly from one direction and you have whole purpose is to reduce the effect of wind effect of soil erosion and reduce the wind speed, then you can go for from most dominant orientation. But again if the wind speeds are changing, then you have to think of different leg of multi multiple leg of shelterbelts.

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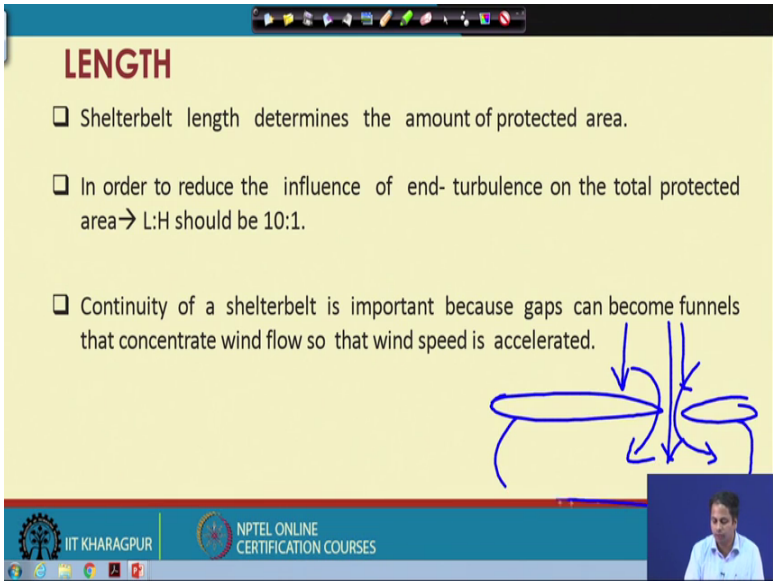

Then the next parameter is a length ok. The shelterbelt the shelterbelt length determines the amount of determines the amount of protected area ok. So, for this shelterbelt, so, this will be the let us say amount of protected area.

So, length of shelterbelt determines the amount of protected area downwind of the wind barrier ok. So, in order to reduce the influence of end turbulence, so, as I was said the L by H ratio in the previous class also, L by H ratio should be 10 is to 1. So, also the there is the shelterbelts should be continues and there should not be any gap ok.

Because gap can cause can become funnels and that concentrate wind flow. So, that wind speed is accelerated over the end ok, over the end or where wherever the gap is present. So, suppose this is our shelterbelt if you are planning and there is some gap and prevailing wind direction is in this direction ok, so, the air the wind speed will be moreover this region ok.

So, the effectiveness of your shelterbelt or the effective protected area will get reduced ok. So, gap should be avoided, but in case if you want some lengths; so, you can, so in shelterbelts we are actually planning multiple rows. So, you can stagger actually ok.

So, you can give access suppose prevailing wind direction is like this is you can stagger the different rows and provide the access.

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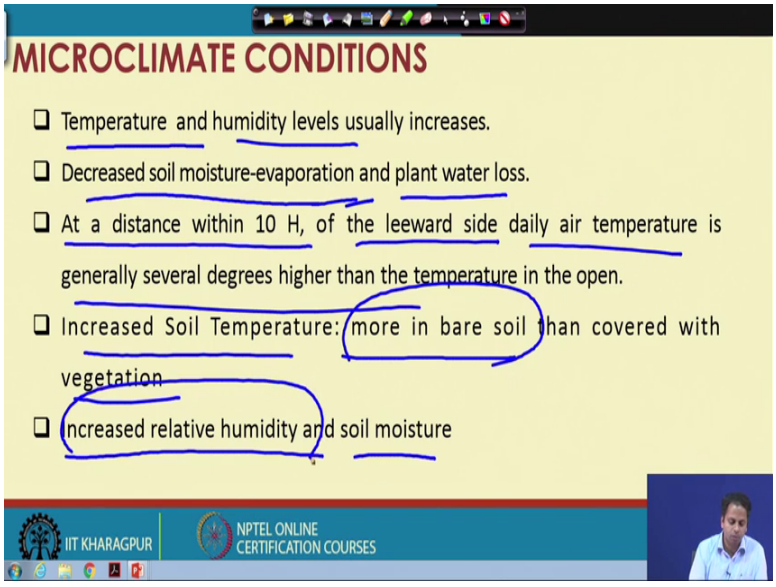

Then modification in micro climate conditions; so, because of this shelterbelts, the temperature different metrological or different micro climate variables will get effected. So, most important will be air temperature and humidity will raise ok. There will be reduction in soil moisture soil moisture evaporation and plant water loss ok. So, evaporation will be reduce and there will be increase in soil moisture, but the loss because of a evaporation will be reduce. At a distance of 10 H from this shelterbelt that is on leeward side of the belt, you can see daily air temperatures are warmer then the open field condition ok, also there will be increase in soil temperature.

So, if you compare 2 cases like bare soil; compare to the bare soil, the soil which are covered with vegetation they have they will have low soil temperature. So, most of more soil temperature will be observed over the bare soil ok. Then increase in relative humidity and soil moisture ok.

So, sometime this increased in relative humidity it should not be as I said the selection of species; the selection of species such that some sometimes the relative humidity is too high. Suppose, if relative humidity is too high then there are chances of attacks from the pesticide pest and disease ok.

So, these are the thing these are the conditions these are the microclimate variable that are effected that are that are modified because of the placement of shelterbelt.

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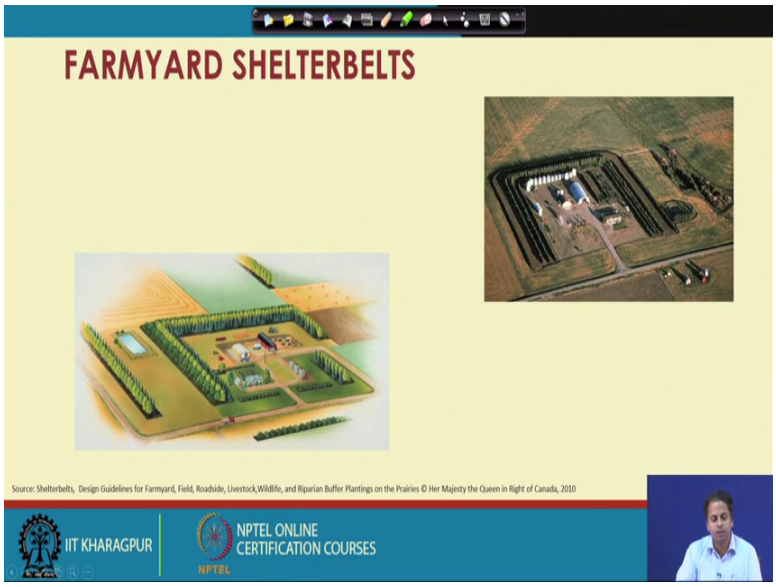

Now, will see the different types of shelterbelts; so, first this is the farm farmyard shelterbelt which is generally used to protect the farm structure may be temperature structure or permanent structure or combination of different things to mostly protect the farms farmyard from structure. We use these farmyard shelterbelts ok. .

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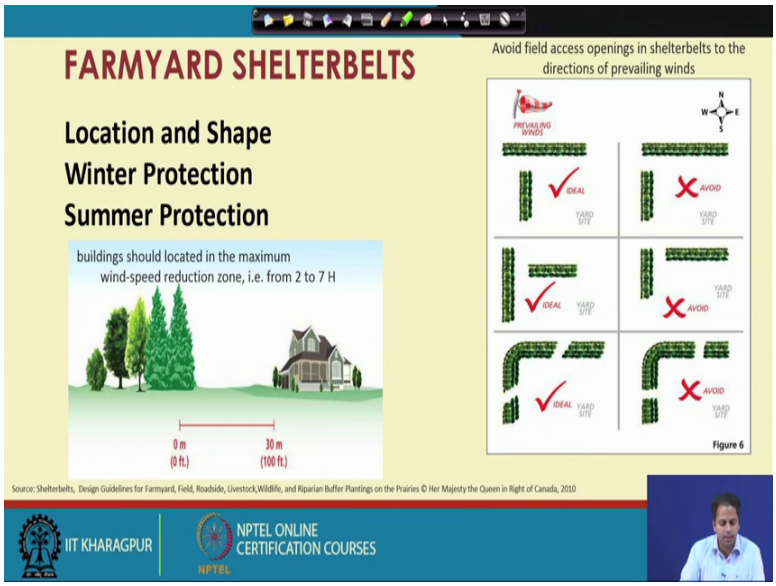

So, to design that the farm structure should be located at least should be located within the distance of 2 to 7 times H of the H here is the height of shelterbelts. So, building should be a structure should be located within a maximum speed reduction zone that is 2 to 7 H ok, 2 to 7 H ok.

So, these are the different things which we need to consider while designing farmyard shelterbelts. So, location and shape of the shelterbelts at what location we are planning then why we need a protection where whether we need protection for winter conditions like protection form wind temperature or do we need protection from summer like dry and dustbins ok. So, depending on that we have to design the farms farmyard shelterbelts ok.

Similarly, avoid access opening in the shelterbelts into direction of prevailing wind. So, this is the wrong way here to provide access here ok. So, if the prevailing wind direction is like this sorry. So, this is the wrong way to provide to provide access to the to the shelterbelts ok.

So, the correct way is to have a, some kind of to have some kind of buffer or stagger the row actually. So, that effect of this opening can be reduce ok. So, there is some angle is there. So, that kind of measures can be adopted.

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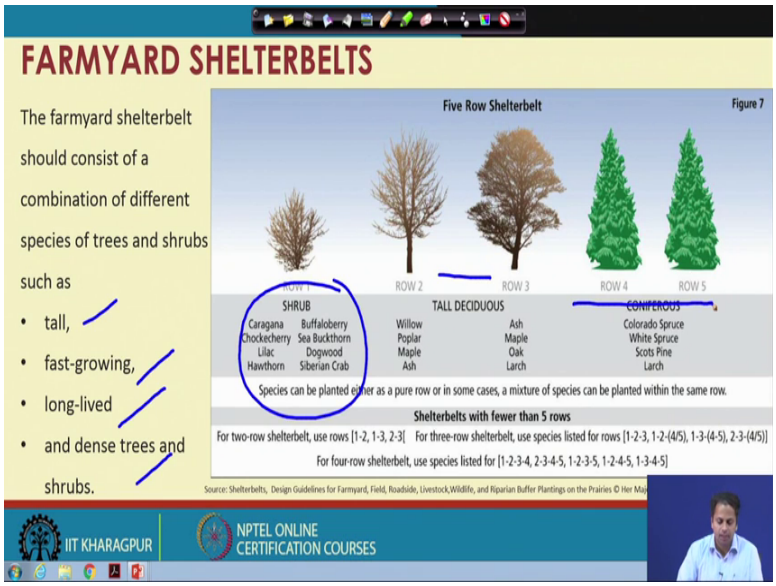

Now, the farmyard shelterbelts should consist of combination of different species and trees of shrub which have different properties. Such as they should be tall, they should be fast growing, they should be long lived and they should provide sufficient density they should at sufficient density ok. So, these are the different this example shows the typical 5 row shelterbelt which is the combination of multiple rows which is the combination of multiple rows ok.

So, the first row which is of very low density very low height ok. So, here the row 1 is mostly shrubs ok. So, row 2 is also relatively lesser density then the coniferous trees. So, this is row 2 and row 3. So, these 2 are the deciduous trees and then row 4 and row 5, 2 rows of coniferous are high density shelterbelts ok.

So, if you have the some design, if you have the area constraints, in that case also you can see select different combination of these shelterbelt different rows of shelterbelts. So, shelterbelts fewer than 5 rows can also be think of; so, the combination of rows 1 or 2, 1 or 2 or 1 or 3 or 2 or 3. So, for 3 row shelterbelts also you can think of combination of row number 1, 2, 3 or different combination ok.

So, different these are different combination that should be selected based on your design requirement and the constraints area constraint.

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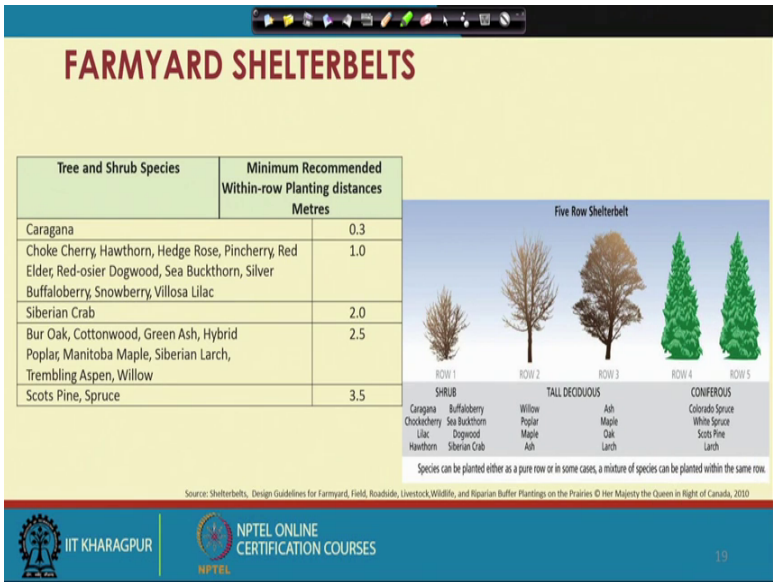

Similar this is a actually the spacing requirement for different combination actually. So, for shrubs mostly the spacing should be around 0.3, 0.3 to 1 meters. For deciduous, the spacing should be around 2 to 2.5, whereas, for highly dense coniferous tree there were spacing can be 3.5 meter.

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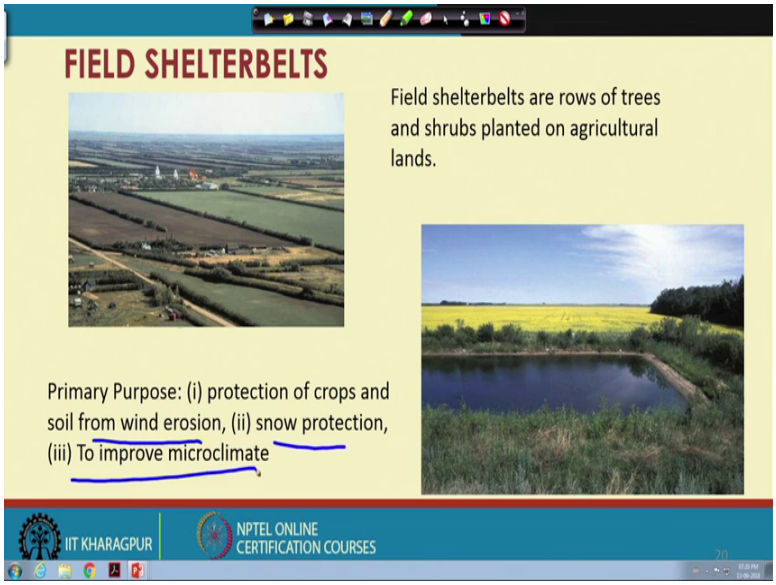

Now, next is the field shelterbelts ok. So, in field shelterbelts are combination of different rows and trees. Field shelterbelts are rows of trees and shrubs that are planted on agriculture land with an objective to protect the crops from soil and wind erosion to

protect the soil to protect the crop and soil from wind erosion and also to provide protection against this snow and to improve the microclimate condition.

So, field, so, these field shelterbelts are nothing but the combination of some trees and rows with an object to protect crop or agricultural land. So, this protection can be against either against the wind erosion or snow or with an objective to improve the microclimate.

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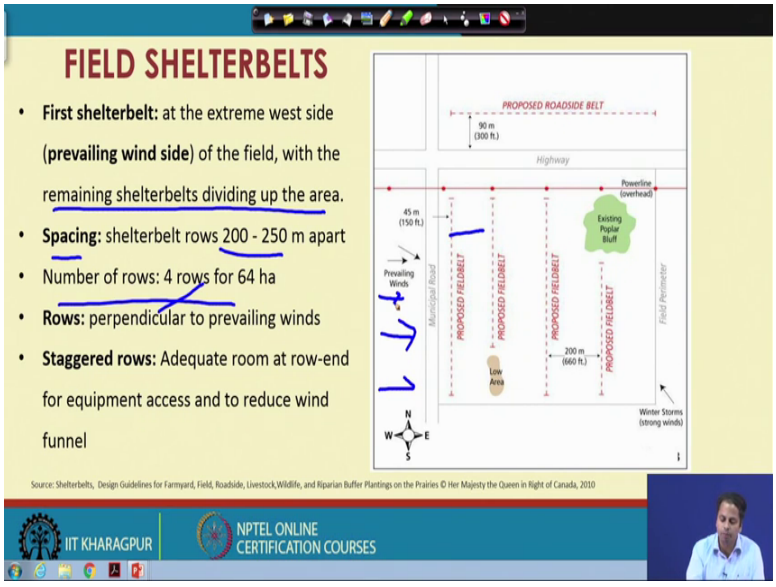

So, this is this is one example of design of field shelterbelt ok. So, the first shelterbelt suppose this is your main row and the first shelterbelt should be on the extreme side of the, of the field. So, suppose the prevailing winds are here actually. So, it should be at least around 45 meter from the road.

So, it should be place it should placed at the extreme wind side of extreme wind side of the field. So, this is your field this is of let us say 64 hectare ok. So, the first shelterbelt first row of this shelterbelt is placed at a distance of 45 meter which is let us say extreme west side of this field and remaining rows can be can be place depend depending on the area available ok. So, the remaining shelterbelts divided can be placed dividing based on the area available ok.

Now, spacing; so, the spacing between these 2 shelterbelts can be kept as 200 to 250 meters and number of rows let us say suppose here the field size was 64 hectare, so, for this 64 hectare, you can think of 4 rows ok. So, and these row should be the

perpendicular to the prevailing wind. So, that is the one thing and so, in incase if you want to provide some excess line or to move your farm equipments for one place to another place. So, what you can do?

You can you can you can put some staggered row. So, this placement can be some kind of staggered manner ok. So, that will get some adequate room at the row and for equipment access and reduce the effect of wind funnel. So, this was designed for shelterbelts of field shelterbelt.

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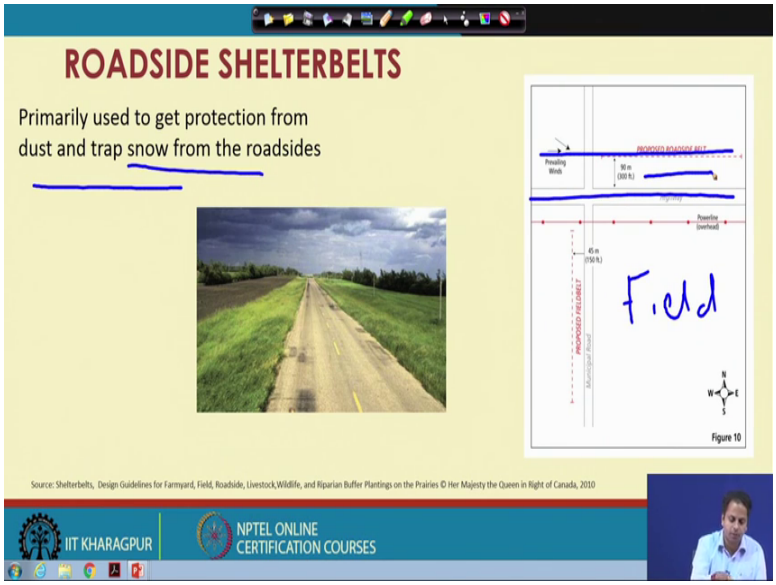

So, next is roads roadside shelterbelts. So, I am explaining this in briefly. So, purpose of roadside shelterbelts is to protect to protect the field from dust and to trap snow from the roadsides ok. So, suppose this is this was your field ok. So, and this is the highway. So, the proposed roadside belt should be at least 30 meter away max ideally it should be around 90 meter, but ideally at least it should be 30 meter away from the high way ok.

So, and there are different measures actually different designed styles, but since our objective is not to design for road sides shelterbelts, I am just explaining briefly here.

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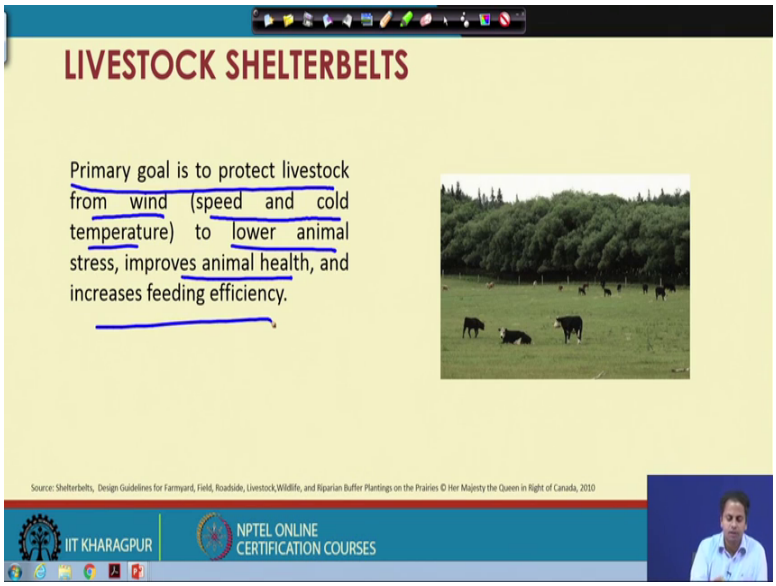

Similarly, livestock shelterbelts: so, the primary here also the primary goal of this kind of shelterbelt is to protect livestock from wind both, the speed as well as temperature and lower animal stress improve animal health and increase feeding efficiency ok.

So, the purpose of this livestock shelterbelt is to protect the animal ok. So, in this case actually we will mostly use the high density very high density of shelterbelts, tress with very high density ok, so to reduce the temperature effect of wind.

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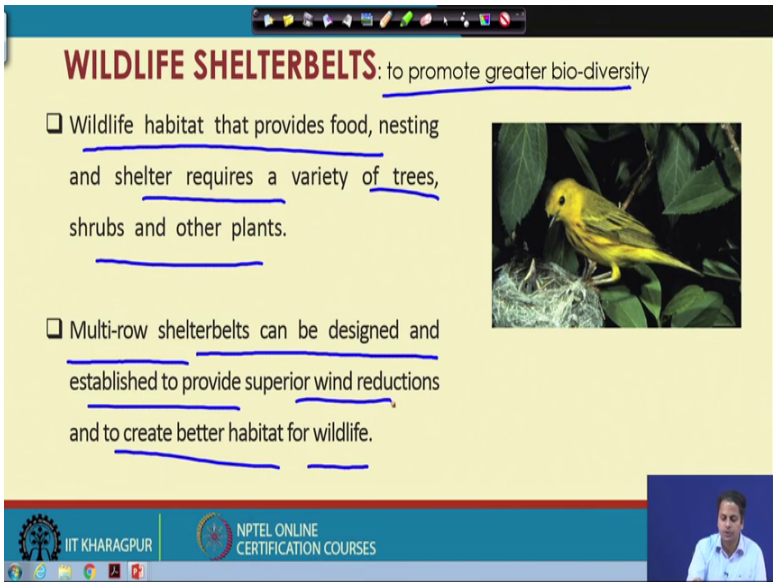

Now, similarly the next is the wildlife shelterbelts. So, it is on the purpose of wildlife shelterbelt is to promote greater bio diversity. So, wildlife habitat that provides food, nesting and shelterbelts required varieties variety of combination of trees and shrubs and other plants ok.

So, our purpose here is to protect the wildlife habitat here. So, in that case we can think of multiple row shelterbelts. Multiple row shelterbelts can be design an establish to provide superior wind reduction and to create a better habitat for wildlife. So, so, this is objective here is to promote the bio diversity.

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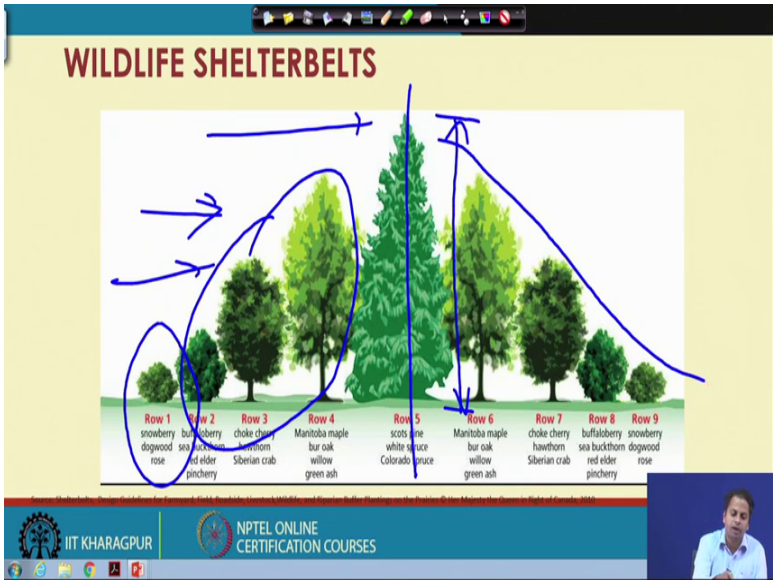

So, this is one example of wildlife shelterbelts. Here we are using different combination of tree species. So, on the windward side, the starting from the shrubs with the lower height and lower density; lower density trees and shrubs. At the middle, the coniferous tree with vary coniferous tree with very high density and again towards the leeward side you can follow the similar pattern ok.

So, this is the overall is one example of wildlife shelterbelt. So, it is a combination of multiple trees and trees and shrub to make a better wildlife habitat for improving the wildlife habitat ok.

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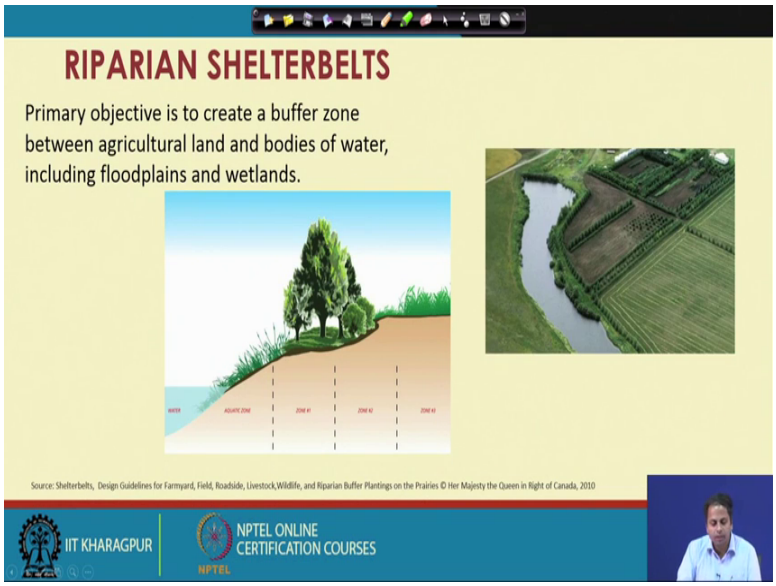

Now, next is the riparian shelterbelts. So, the purpose of riparian shelterbelt is to create a buffer zone ok. So, the purpose of this a riparian shelterbelts is to create a buffer zone between the agriculture land and bodies and water bodies including floodplain and wetlands. So, these are most effective soil and water conservation measure actually which can be use as a large scale along the along the along the side of the river actually ok.

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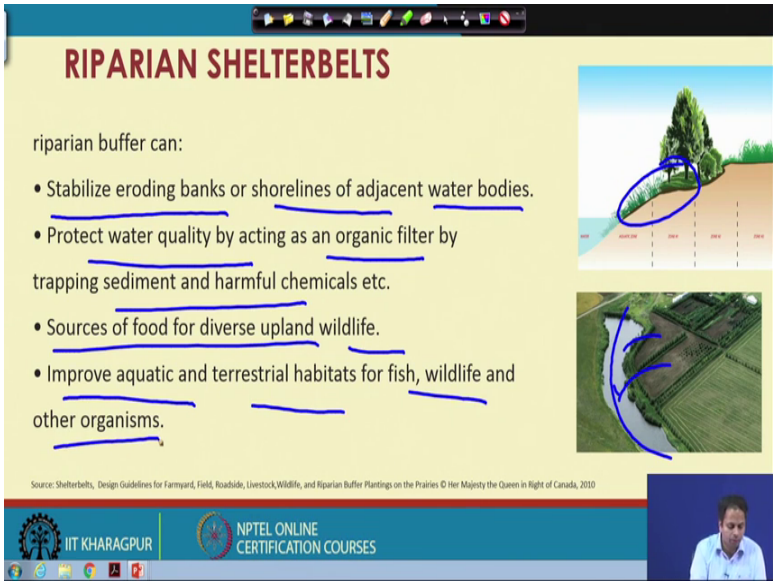

So, the repair as the, what is the benefit of this riparian shelterbelt? So, riparian buffer or riparian shelterbelt they can provide or they can stabilize the bank which is under erosion, they can stabilize the eroding bank or shorelines of adjacent water bodies. They can protect the water quality by acting a organic filter; they can protect the water body by acting a organic filter by trapping sediments and harmful chemicals going to the going directly to the directly to the water body ok.

It can be a source to sources of food for divers of upland wildlife and it can also improve the aquatic and terrestrial habitats for fish, wildlife and organism ok. So, the if so, these are the different these are the different benefits of riparian buffer. First; so, we can get a protection from the erosion then we can trap the excessive harmful sediments going to the water body and it can improve the aquatic life and terrestrial habitats over that region and also it can provides source to the wildlife habitat which are applying to the to the this to the riparian shelterbelts ok.

So, so, in this class actually we have seen different we have we have seen the shelterbelts, definition of shelterbelts, what are the different types, different factors that effects the shelterbelts, what are the different parameter parameters that effect the effect effectiveness of shelterbelt or they can provide which can be governed which can have a governing role in providing the effective protection area; that is density, height, then combination of different trees and species and length.

And we also seen the different types of shelterbelts with different objectives ok; so, like of farmyard shelterbelts, field shelterbelt, livestock shelterbelt, roadside shelterbelt and riparian or wildlife shelterbelts. So, with that I will stop here in this class for this class. So, in the next class we will be discussing more about the about the sands sand transpose and how to control it ok.

Thank you.