Forests and Their Management
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Module - 06
Forest Protection
Lecture – 16
Kinds of Threats

[FL] Today we begin a new module and this module is Forest Protection.

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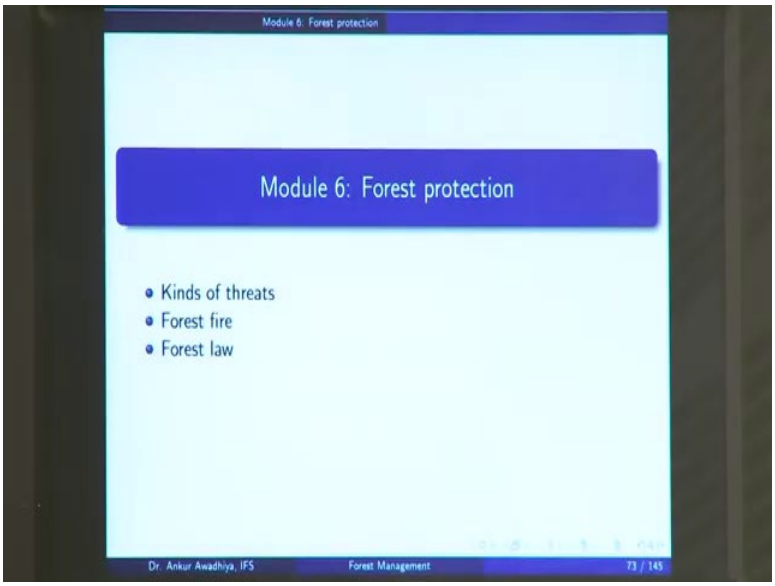

This module will have three lectures - the kinds of threats that are being faced by the forest, forest fire, which is one major threat that we look in more detail, and forest law.

So, let us begin by looking at the kinds of threats. So, there are several threats that are constantly being faced by the forest. These threats can be natural threats or they can be man-made threats.

Now, here is a list of the mostly natural threats that are commonly found in the case of forests.

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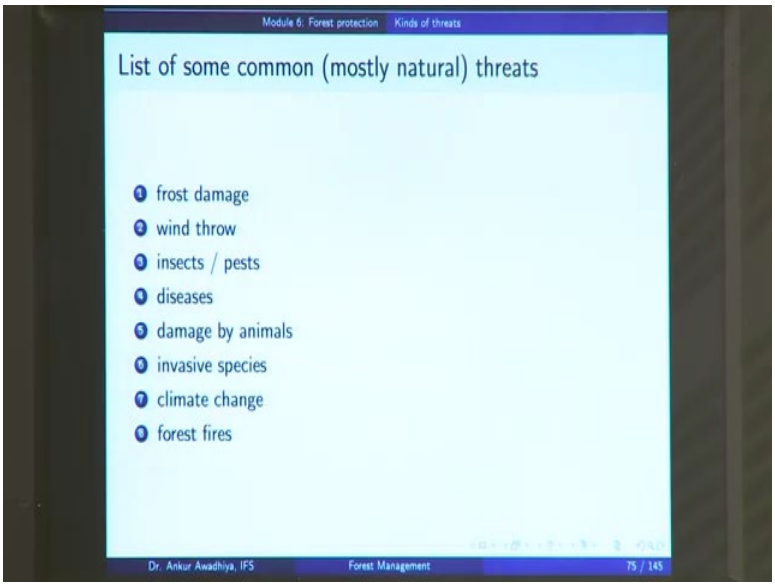

So, you can have "frost damage." Now what is frost damage? In those areas, where the temperatures go very low especially during the night times, there is a chance that the temperature becomes so low, that the water starts to freeze, and in that case, we will have a situation of frost. So, when you have a frost, the dew that is forming on the leaves and on the trees, it gets frozen; and, when it gets frozen, they will also be a damage to the leaves.

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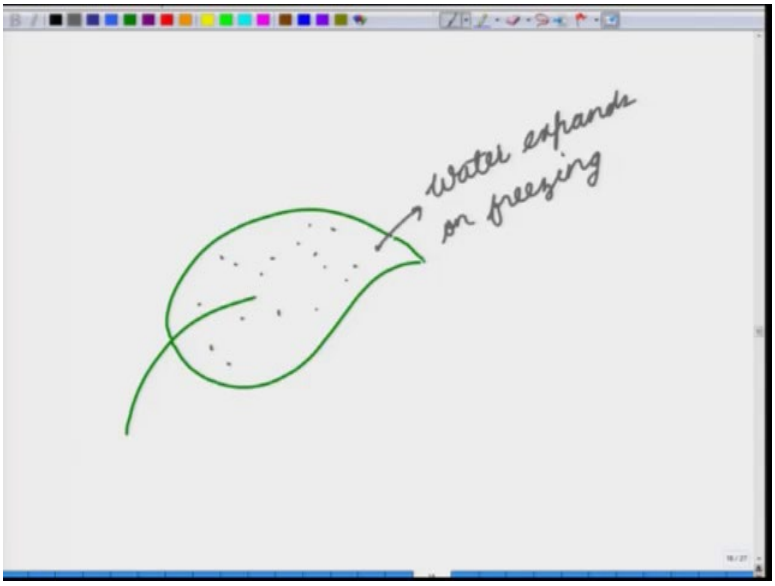

Because, what is happening here is that, you have leaf and when the temperature is going low, then there is there is a ice that is developing on the surface; but at the same time the water that is inside the cells also starts to freeze.

And, when that happens, because the water expands on freezing; so, you will have a situation that inside a cell; the water that is there that has now started to freeze. It is expanding in volume, and in that case, there will be a tremendous amount of pressure that is being exerted on the cell membranes and the cell walls. Once that happens, you can have a situation where the cells rupture. And, if there is a rupture of cells, the cells die, then your plant will also suffer, the damages.

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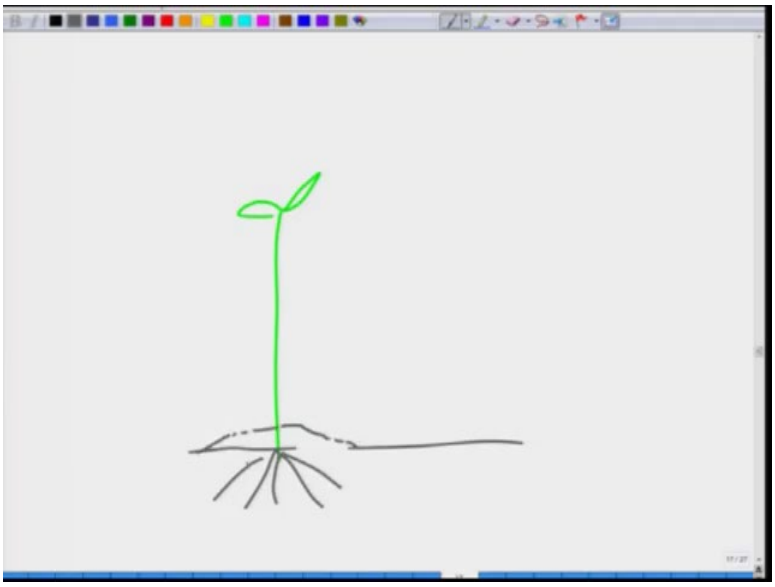

In other situations, you can have a plant that is growing in the soil and you have the roots here. Now, when you have a frost like situation, the water that is there in the soil that is also freezing. Once that happens, the water expands here and the soil bulges. And, when it bulges, it is also exerting a pressure on the plants from downside up. So, in that case, the plants might even get uprooted. So, in this case, there is a plant and there is pressure that is being exerted on the plant from the bottom, and the plant might topple down. So, these kinds of damages can happen when you have a situation of frost.

Then you have "wind throw." Now what is the wind throw? If you have a very fast-moving wind, then it exerts pressure on the trees; and if the pressure is large enough, then you can have a situation of uprooting of trees, or even the breaking of the stems or

the boles of the trees. Now, wind, in these circumstances, can exert a huge negative impact on the forest.

Next, you have “insects and pests.”

Now, insects and pests, if they increase in number, then you can have a possibility that a number of trees in your forest are getting infested at the same time. And, once that happens, there might be a reduction in growth; a reduction in seed production; or, even a large-scale mortality, because of the insects or the pest.

And, a similar thing happens with the “diseases” as well. The – these - diseases could be bacterial diseases, fungal diseases, viral diseases and so on. And here also, the plants will show reduced growth, reduced production of seeds, and also mortality. Then, you have “damage by the animals,” especially animals like monkeys. So, we do see situations where a troop of monkeys comes to a tree; and, in the process of eating the fruits, it also causes damage to the trees.

Then you have the problem of “invasive species.” Now, invasive species are those species that when enter into your forests; start to invade. So, what is the meaning of invasion? So, you have a plant, and this plant is able to out compete the name the natural vegetation; and in certain circumstances, it produces a large number of seeds and it grows so profusely that the other plants are all are unable to thrive in that situation.

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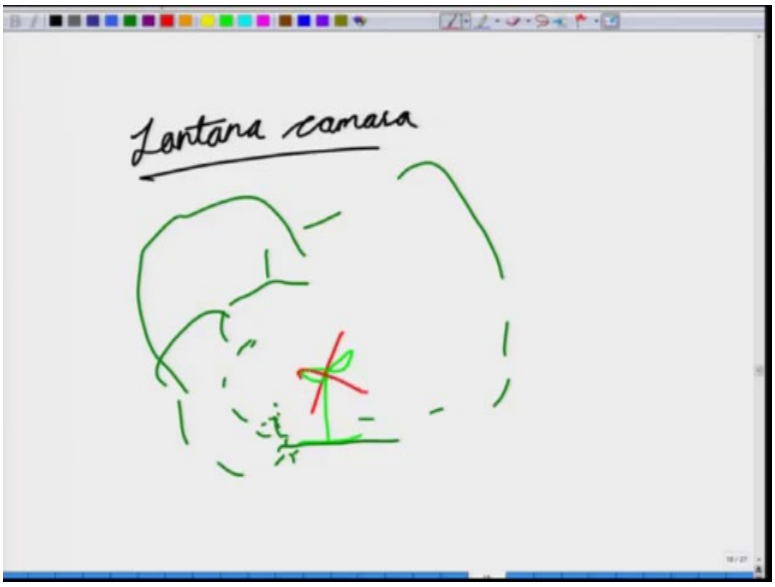

Now, a good example of an invasive plant is the plant called '*Lantana camara*.' Now, this plant it has very small sized seeds; and, the berries where the seeds are inside, these berries are sweet in taste, and so these are eaten by birds in large numbers. And, the seeds are so hardy that, these seeds are able to pass through the digestive system of the birds, and then with the bird droppings, these seeds are able to spread.

Now, these plants are toxic for a number of animals. So, their leaves have aromatic compounds; the stem has aromatic compounds; and so, a number of herbivores are unable to eat the leaves and the stem of these plants. Now, consider a forest, in which you have say mango saplings; now, the mango saplings are edible and the animals will be able to eat the mango saplings. So, the amount of damage that will be there to the mango saplings will be huge, whereas, if you have a saplings of Lantana camara, there is no animal that is eating it.

So, these plants are very highly protected against damage from the animals. At the same time. the birds. that are eating the seeds. are spreading these seeds to large areas. As against the mango tree whose seeds are not only bulky, they are produced in much smaller numbers as compared to *Lantana camara* and they are not spread too far of areas by a number of animals. So, in this case we can see that the *Lantana camara* plant is having an advantage or competitive advantage over the mango saplings.

And, another way in which it impacts is that, if you have this mango sapling and you have a *Lantana camara* that is coming up in this area; so, the *Lantana camara* will show a much faster rate of growth as compared to the mango sapling. And so, what happens is that, in a very short period of time it increases in size and it becomes a large size bush.

Now, when you have this bush, then the sunlight is unable to enter into the, is unable to enter to the forest floor, and so, the mango sapling is now unable to get sunlight and it will die off. Now, similarly it is known that these plants of *Lantana camara* they also secrete certain chemicals that are able to stop or halt the growth of the surrounding plants.

Now, with all these competitive advantages; if you have a forest and this *Lantana camara* is able to enter into your forest, it will spread like wildfire; it will spread very fast. And, it will not only dominate, start to dominate the ecosystem, but also it will start

with is that a negative influence on all the native species. So, such kinds of plants which are known as invasive or alien species are also a threat to our forests.

Now, another source of natural threat is “climate change.”

So, when we are when we have a situation of climate change, there are extreme weather situations that come up. So, in the in a scenario of climate change; suppose you have a year in which there is a very heavy rainfall, the soil gets waterlogged, and in that situation, a number of plants die off. Or, you can have a situation where there is a draught and because of the lack of water, plants die off; or, you can have a situation where it is so - where the water is so less and the temperatures are so high, that there is a huge or a large scale forest fire that is happening. Now, in these scenarios, the climate change will lead to a large scale destruction of the forests. So, this is also another threat.

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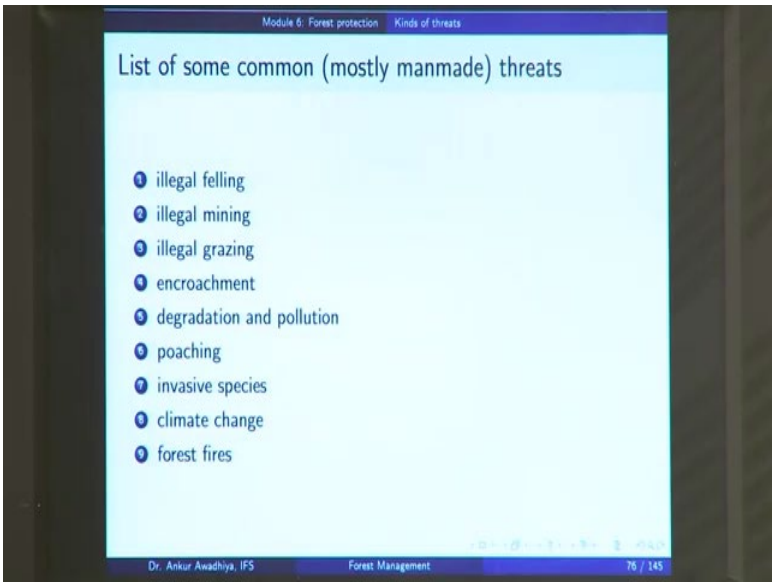

Then, we have the threat of “forest fires,” especially when we are talking about the areas that are suffering, that are having volcanoes, or that are having dry bamboo twigs that are rubbing against each other, and so on. So, you can have these natural sources of threats that the forests are facing. But to a large extent these days, the threats that the forests face are coming from the human beings.

So, we have a requirement for a number of resources, and because of an excess of requirement, there is “illegal felling” of trees. So, we have had situations where people

go into a forest, especially in night times. They enter inside, cut a tree, fell a tree, take it out, convert it into timber, make plants out of it and in the night time itself this tree would be smuggled out of the area, probably even out of the district.

So, illegal felling is happening on a large scale. It is not only for timber; it is also there for firewood. And, especially if you have a brick kiln somewhere, then you will find large scale felling of green trees to supply the brick kiln. Then, we have "illegal mining," especially mining for sand. So, sand is a minor mineral and it can very easily be removed from the forest areas. Because, you can just take a vehicle inside, put the sand and take it out. Now, once that happens illegally, then it is also altering the ecosystem; it is affecting the plants that grow there; it is affecting the water dynamics of the area; it is affecting the habitats of several species.

So, this is also another threat to the forests, and this is a manmade threat. You have "illegal grazing" inside a forest. So, in the case of a forest, you have a plants of different age groups, you have a mature trees; you have old trees; but, you also have the young crops. Now, in the case of the young plants, there will be some plants that will be eaten away by the animals; and, because of that the plants are there in control, so you do not have a situation, in which you have a very dense overgrowth of plants in the forest areas. But, what happens is that, if people from the surrounding villages they start bringing in cattle's; so, now you have a small forest. and it is unable to cope with the large size cattle population. So, once that happens, you will have a situation where most of the young plants that are coming up; most of the regeneration that is coming up, is being destroyed by the cattle. And, if that happens, then you will have a forest without a young crop, without a regeneration; and in a short time, you will have the old trees that are dying off, but there is nothing to replace them. And, if that happens, then this forest will be converted into a bare land.

So, illegal grazing. Now, we do permit certain amount of grazing inside the forest; but in certain areas where we are doing the regeneration operations, we close these areas for grazing. So, when you have a young crop you will say that, these areas are open for grazing and these areas are closed for grazing; but then people also tend to enter into these closed areas and allow their cattle to graze. So, this is also another big threat to the forest areas.

Then, you have the “problem of encroachment.”

Now, in encroachment. people enter into a forest area, cut the trees; typically, they also burn these trees. And so, the forest has now been cleared; and once it has been cleared, it will the land will be put for agricultural use or for the construction of some buildings. And, encroachment is a big problem, especially in those forests that are near the village areas; because people are known to extend their fields by cutting the trees. And once you cut these trees, you start cultivation in that area; and, if you are able to carry out this cultivation for a few years, then there will be hardly any trees that they were the forests in this area before. So, encroachment is a huge threat.

Then, you have the problems of “forest degradation and pollution in forest areas.” Now, degradation is a situation where the habitat quality has come down. And, it has come down to such an extent that, now, the forest is unable to support that many number of species or that many individuals of certain or more species. And, in that case, we say that the forest has become degraded. And, we are seeing large scale degradation of forest, because of either the felling of trees, or because of grazing, or also because due to pollution.

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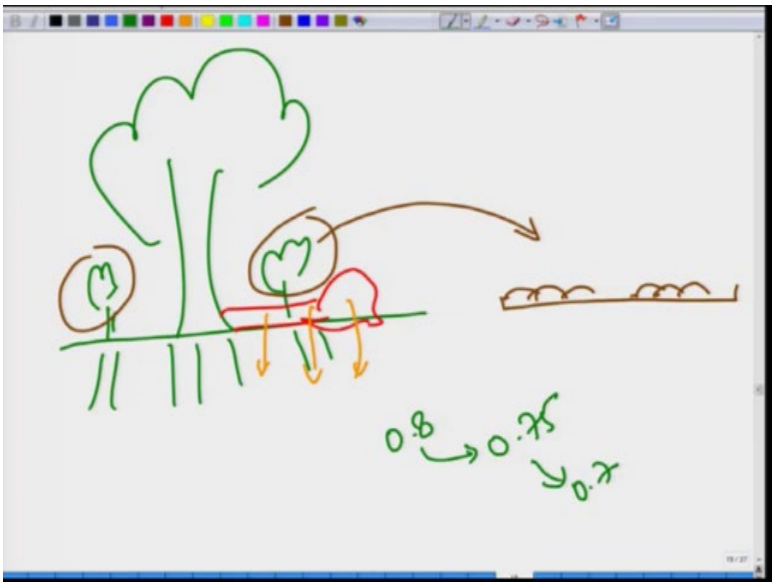

Now, what is happening, in this case, is that, in a natural forest what happens is that, you have these young crops and all of these plants are taking their resources from the soil, and the minerals are then being taken up by the plants, they are getting deposited in the

biomass. And, when the trees shed their leaves or when the branches fall down or when the trees die off; in that case, this biomass is, so it comes down to the ground and then it is acted upon by the decomposers, which in turn release these minerals back into the ground.

So, once you have these minerals back to the ground, then the next generation or the regeneration is able to come up. But what happens in the case of illegal grazing, is that you will have people who will make their cattle eat on these young crops and then they take their cattle away; then they put their cattle onto their fields and they make and they permit the cattle to deposit their dung in the field areas.

So, now you there is a situation where the minerals that were there in the bodies of the plants, they were eaten up by the animals; and the dung is deposited not in the forest areas, but in the fields. So, slowly and steadily you are reducing the amount of nutrients that are there in the forest soils and depositing them in your own fields. Now, when this situation happens, the soil is now unable to support a large number of plants. And, what we and in such a situation, there will be a degradation of the forest.

So, typically earlier you have a forest that was having a canopy density of 0.8, and slowly and steadily it will come down to 0.5, and it will come down to 0.7, and so on. So, even though this land legally is a forest land, but the cover slowly and steadily goes down. Also, there have been situations in which certain industries release their pollutants either into the rivers or they dump them in the forest. And once that happens, then do because of the toxic impacts of certain waste products; animals die, plants die, and you see a degradation in the habitat. So, degradation and pollution are also major threats to forests, which are mostly manmade.

“Poaching” is a big threat to the forests, because, in the process of poaching, certain animals get removed from the system.

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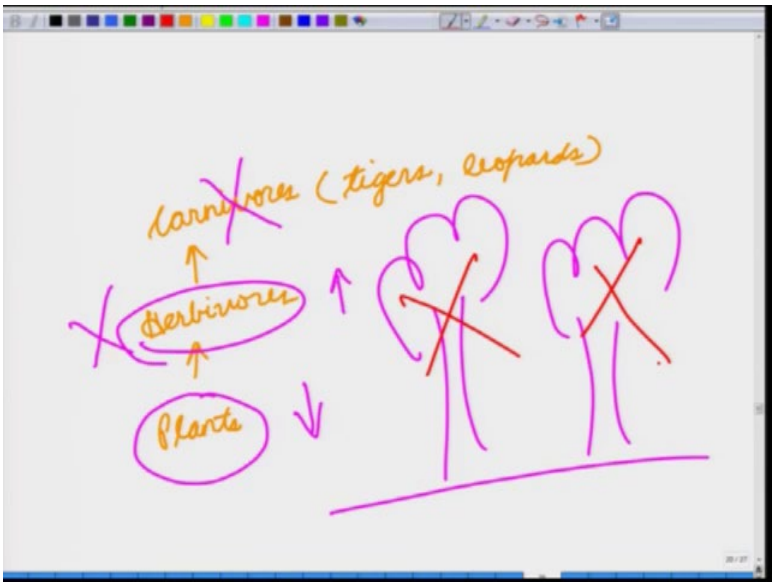

Now, let us consider a forest, in which you have plants. These plants are eaten up by herbivores and these herbivores are eaten up by carnivores; examples are tigers or leopards. Now, if there is a poaching of tigers and leopards in this area; so, what is happening is that the carnivores are being removed from the system; they are being eliminated.

Now, once you remove the carnivores, the herbivore population will start to increase; because now there is nothing to control them. Now once the herbivore population increase, they will start there will be more number of herbivores, and so, they will be eating a larger quantity of the plants. So, once herbivore population increases, the plant population goes down. And, this has a big impact on the regeneration of the area. So, you have removed the tigers; you have removed the leopards; because of which the herbivore population increases; because of which the plant population is and especially the young regeneration is getting eliminated.

So, once that happens, you will have a situation where in your forest you will be having the tall mature trees, or and most of the regeneration is now gone, because it has been eaten up by the herbivores. And after a while, because there is no more regeneration or there is a dearth of food, the herbivore population will also collapse. But in that time period, because you did not have any regeneration for a number of years; now the trees

that are remaining in the system, they are also very mature trees; there they are getting older and older with time, and once they become very old, the trees also die.

So, earlier where you are having a large size a very lush forest, because you remove the top carnivores like tigers and leopards; you are having now a situation that there are no there are no plants; because of it the herbivore population has collapsed; because of and also the trees that have become very old; they have also died off. So, slowly and steadily you are converting a lush forests into a barren land, just because you remove the predators the top carnivores that were there in the system. So, poaching is a big threat to our forest. If you want to manage a forest; if you want to maintain a forest in a good condition, it is utmost necessary to keep certain top carnivores in those forests. So, poaching is a big threat.

Then, we also have these three things that we saw in the previous slide; invasive species, climate change and forest fires. Now, we are seeing them in both the slides, because you have invasive species, forest fires and climate change that are happening because of natural reasons and also because of man-made reasons. So, for example, in the case of invasive species, certain species are brought from other ecosystems; from other countries to be grown in gardens. For instance, *Lantana camara* that we just saw itself is an invasive species that was brought from Africa to be grown in garden areas, because the flowers look beautiful.

Now, when humans are bringing in invasive species, they did not bring this species, so that it would be able to exert a negative influence on the forest. They just brought it an obviously thinking that the flowers look good; let us have them in the gardens. But then once, but then in the African situations, you had a number of plants like these and they were competing against each other and so, the population was controlled. But once you brought these plants to India, then these were able to dominate and became an invasive species.

So, invasive species can be brought into an area by human beings, and especially with the advent of modern modes of transportation. People are moving from one area to another area in large numbers, and because of that more and more number of invasive species are able to reach into different areas, especially in the form of seeds and spores. So, invasive species also is a man-made threat in certain situations. Climate change -

these days a large portion of the climate change is happening because of man-made causes because we are releasing huge amounts of carbon dioxide into the atmosphere, especially by the combustion of fossil fuels. And, that is leading to global warming and climate change.

So, climate change is to a large extent a man-made threat as well. Then, forest fires. as we will see in the next lecture, forest fires have both natural and manmade causes. And, these days as much as 95 percent of the forest fires in our country are happening because of man-made reasons. So, there can be accidental reasons; there can be deliberate reasons; but humans are setting fires or are causing for fires in the forest areas.

So, these are the common manmade threats.

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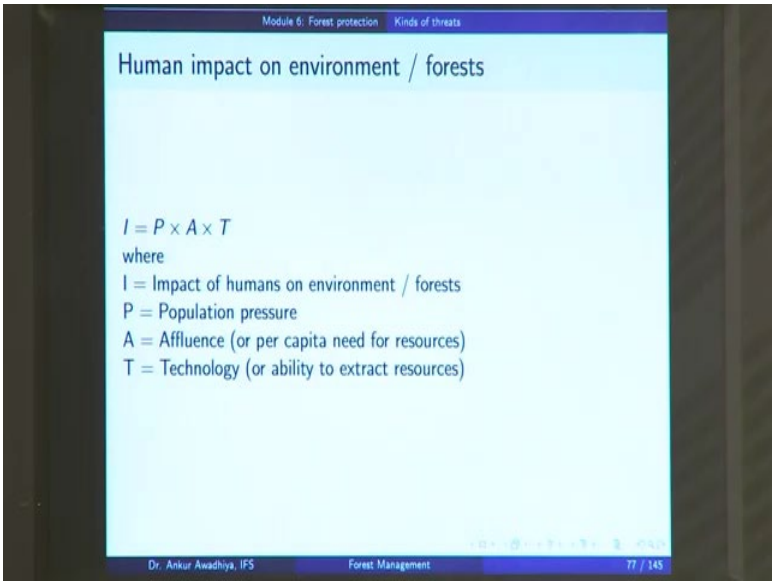

Now, we have seen before the impacts of human beings on environment and forests.

So, I is equal to P into A into T

where I is the impact of human beings, P is the population pressure, A is the affluence or the per capita need for resources, and T is the technology or the ability to extract these resources.

Now with the advent of modern civilization, we are having a situation where we require more and more resources per capita. If you look at the definition of GDP, the one

commonly used measure of GDP is the amount of electricity per capita that is being used in a country.

So basically, we are trying to increase the amount of electricity that is to be used per person. So, we are we have now created a society in which affluence or a greater use of resources is not looked down upon, it is promoted; is it is being actively promoted, and once that happens, the impact increases.

The technology has also been growing with time. And so, earlier when on one hand, we people had to go into the forest and cut trees using axes or with saws; but these days, we are having modern machines.

So, you can get into a forest with the large size harvester, which will automatically cut the trees, put them into a truck, and it is very easy to take these resources out of the forest. So, the impacts are increasing. Our population size has been growing for the past many years. So, now, we have a situation where in this formula, P is large, A is large and T is large; so, we are having a large impacts on the forest. And, the impact is so large that it is now threatening the forest; it is a big threat.

Now, because of these large scale impacts on the forest, we are see seeing a situation where we are losing out species.

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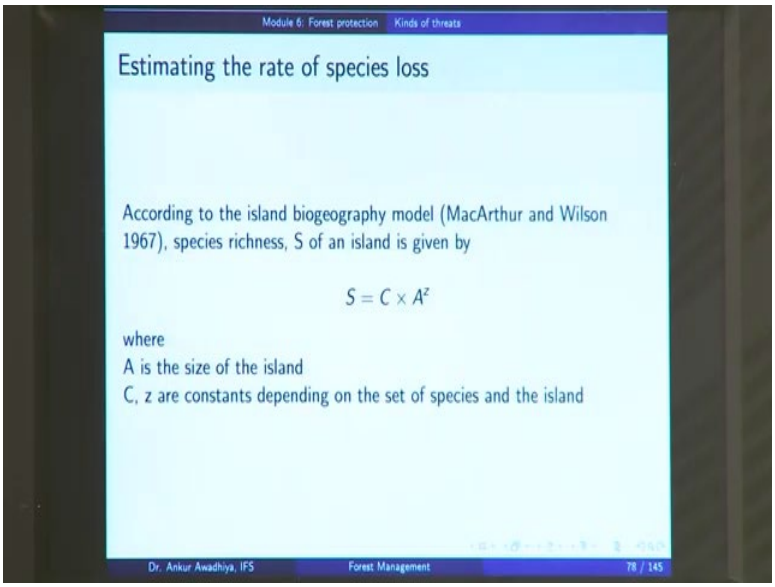

And, we can estimate the rate at which we are losing species in this way. So, according to the island biogeography model, the species richness of an island is given by

S is equal to C into A to the power z;

where A is the size of the island, and C and z are constants depending on the set of species and the island.

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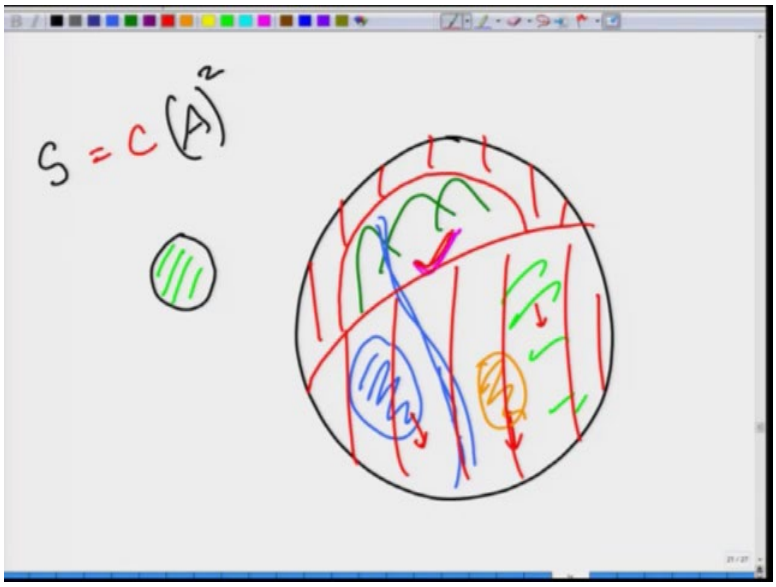

Now, what we are saying here is that, suppose you have two islands; one is a small island and the second is a large size island. Now, considering that the soil type in both the islands is the same; considering that both these islands are surrounded by the sea, which of these would be having more number of species? which of these will be able to support more number of individuals of a species? So, the answer is evidently, the larger sized island, because it has larger areas; it has more types of ecosystems that can be there. So, probably the smaller island is just a plain area.

But, in the case of the larger island, probably you are having certain areas with health; certain areas that are plain areas; certain areas that have a stream that is flowing; certain areas that have say a water body, or say a marshy land. So, because you have a larger area, they can be a greater variety or a of ecosystems that can be there. So, a larger sized island will be supporting more number of species. So, that is obvious.

But then, if we represent it mathematically, we can say that the S or the species richness which is proportional to A. But then, we do not know whether it is directly whether it is proportional to A or it is proportional to some power of A. So, let us say that is it is proportional to some z power of A. So, it is possible that the number of species that the species richness is proportional to the square of the area, or probably it is proportional to the cube of the area, so that is possible. Now, this proportionality can be removed and we can say that S is equal to C into A to the power z, where C is a constant. So, this is the constant of proportionality.

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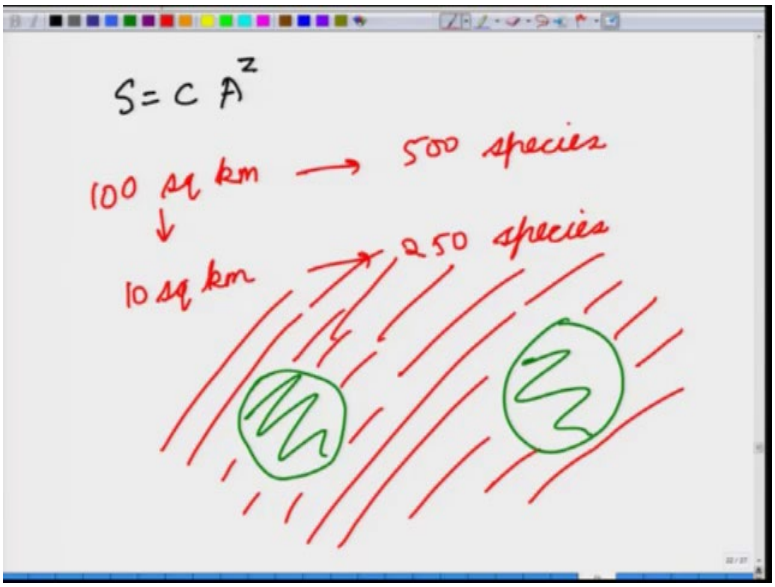

Now, if you begin with this model S is equal to C into A to the power z.

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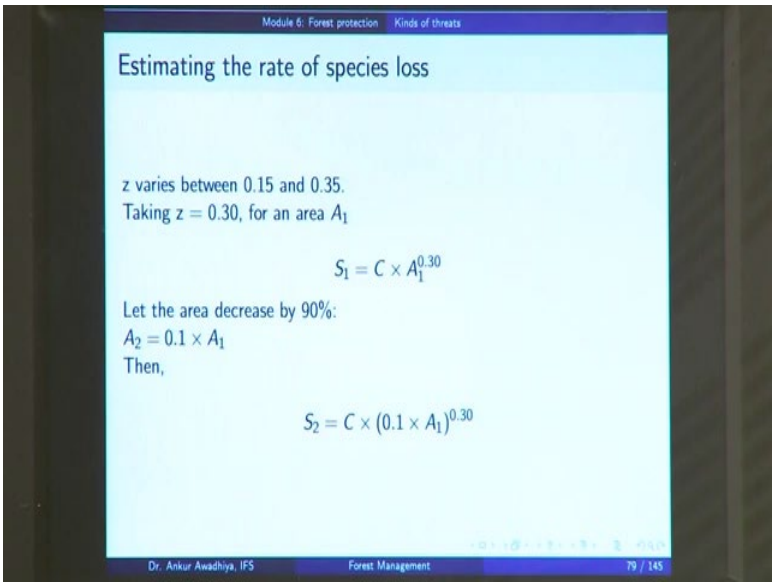

Then, as we said that z is something that we do not know, it could depend - it could be say twice ah, it could be the square of the area, it could be the cube of the area; but then typically what we have found through experiments and through observations, is that, z typically varies between 0.15 and 0.35. So, this is a reading that we are getting from the natural systems.

And, if you take a midpoint; so, let us or let us take the larger point. So, taking z is equal to 0.3, then for an area of A 1, you have S 1 is equal to C into A 1 to the power 0.3.

Now when the forests are getting reduced in this area? So, what we are saying is that, earlier you had this large sized island with a number of different ecosystems; but now what is happening is that, humans have come into this area; they have drained this piece of wetland; they have drained this marshy area; and they have converted these fields into their own agricultural regions.

So, probably these humans have now occupied all of these areas. And, only a small portion is now left; they probably also have occupied the beaches, and so only those areas that are of a rugged topography; because they are having the hills, so these areas are left. So, as much as 90 percent of the area is now removed, you only have 10 percent of the area left. Now if that happens, the area that is left is only 10 percent of the original area. So, in that case, so we are just taking a hypothetical situation to understand how

this is species dynamics works. So, in this case, S 2 will be equal to C into A 2 to the power of z.

Now, A 2 is 0.1 of A 1, and z is 0.3 in this case.

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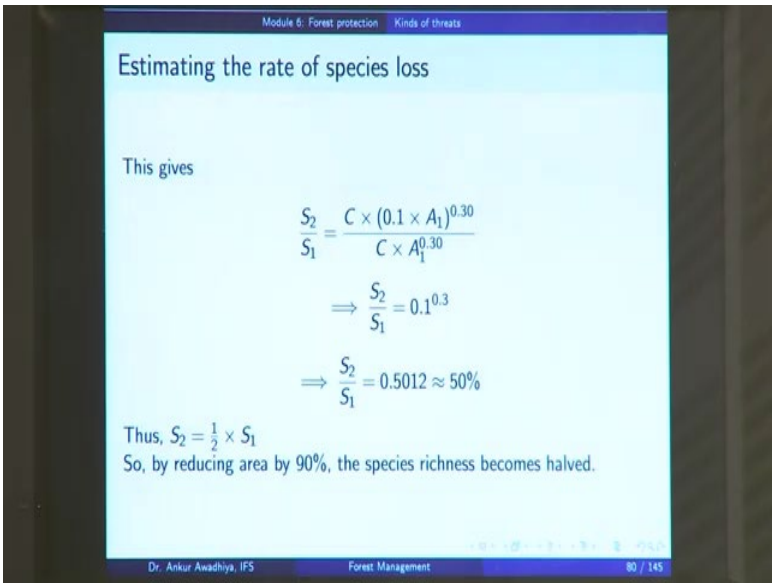

Now, if we look at the ratio S 2 by S 1, we will get, C into A 2 to the power of z divided by C into A 2 the A 1 to the power of z. C and C get cancelled out, A 1 to the power of 0.3 gets cancelled out. So, S 2 by S 1 is 0.1 to the power of 0.3, which is roughly equal to 50 percent.

What it means is that, even if you are able to reduce the area of a forest or of this island by 90 percent, the number of species only goes down by half. So, earlier you were having say 100 square kilo square kilometer and probably you were having 500 species. If this area is reduced to one ten, so you now have only 10 square kilometers; the number of species it does not become 50; it does not become one tenth of the original; but, it comes down to around 250 species, which means that we have ample amount of hope in the system. Even when the area of the forest is decreasing, we still have a substantial number of species.

Now, this island biogeography model is very apt in this situation, because forests are actually in the form of islands these days. So, you will have a patch of forest; you will have another patch of forest; and, these forests are surrounded by human dominated

landscapes. So, you are having cities; you have villages; you have the agricultural fields; you have the industries, and so all this area is now unapproachable by the animals or the species that are living in the forest.

So, these days in place of having islands that are surrounded by water, now we have islands of forests that are surrounded by a human dominated landscape, which is out of bounds for the species that live in the forest. So, it is very much like the island situation. But then, this island biogeography model has now predicted that, if you have reduced the area of these islands by 90 percent, we only have one tenth of the area left; still, it will be able to support a large number of species.

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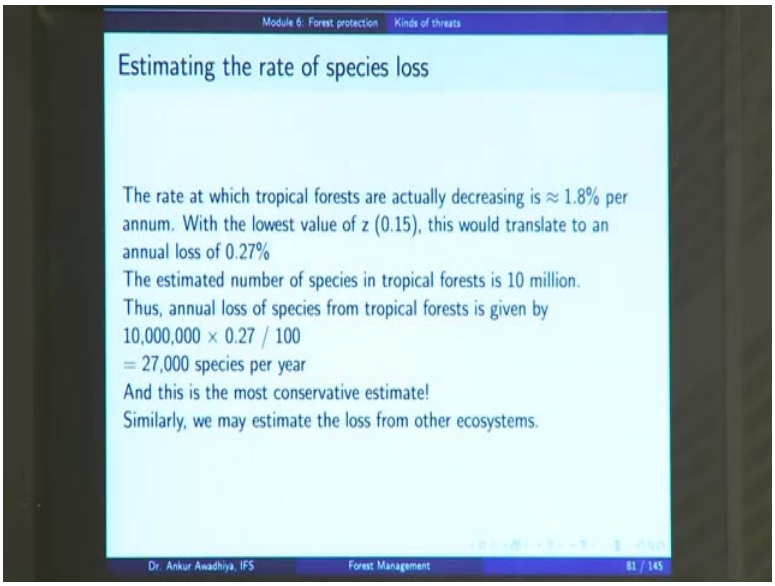

But now, what is happening actually is that the rate at which the tropical forests; so, these are one big islands are actually decreasing is around 1.8 percent per annum.

So, you are not decreasing this size by 90 percent in a year; you are decreasing it by just around 2 percent in a year; 1.8 percent per year. So, that should be a very small decrease. But then, even if you take the lowest value of z; in the previous example, we took a larger value of z of 0.3. But, even if you take the most conservative estimate of the value of z being 0.15, you will have a situation that there is an annual loss of 0.27 percent. Now, this annual loss of 0.27 percent; because you have a roughly 10 million species in the forest, it is now corresponding to 27,000 species in a year.

So, even with a very conservative estimate; with the lowest value of z, we are able to see that there is a loss of 27,000 species in a year, just in the tropical rainforest. And, if you look at the other ecosystems; if we look at the polar ecosystems; we are looking at the desert ecosystems; we have a look at temperate ecosystems; subalpine - alpine ecosystems. In that case, we will find that, this that in all of these areas now the impact of humans is such that, we are reducing the areas that are available for forests and wildlife.

So, 27,000 species in the tropical rainforest; and probably say 10,000 species in temperate rainforest or temperate forests; let us say, 15,000 species in all the other forests combined. So, now, you are looking at figures of like 40000, 50000 species in a year, and we are talking about extinction of these species.

Once the species is extinct, there is no way you can bring it back. Once the dodo got extinct, now whatever we do, we are unable to bring the dodo back. And, here we are not talking about one or two species, we are talking about tens of thousands species.

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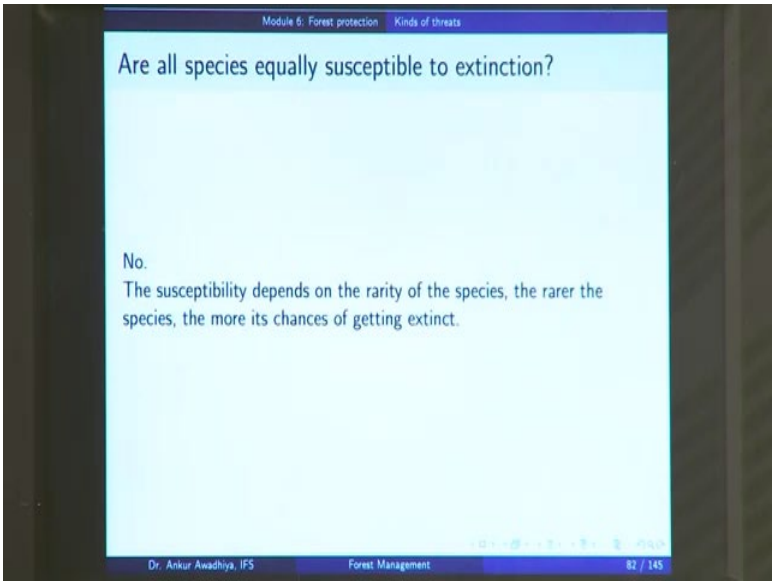

Now; obviously, all the species are not equally susceptible to extinction. But, there are certain factors that govern the probability of extinction of different species. The susceptibility depends on the rarity of these species. The rarer the species, the more is its chances of getting extinct. So, for instance, if you have a species that only has 10 individuals left.

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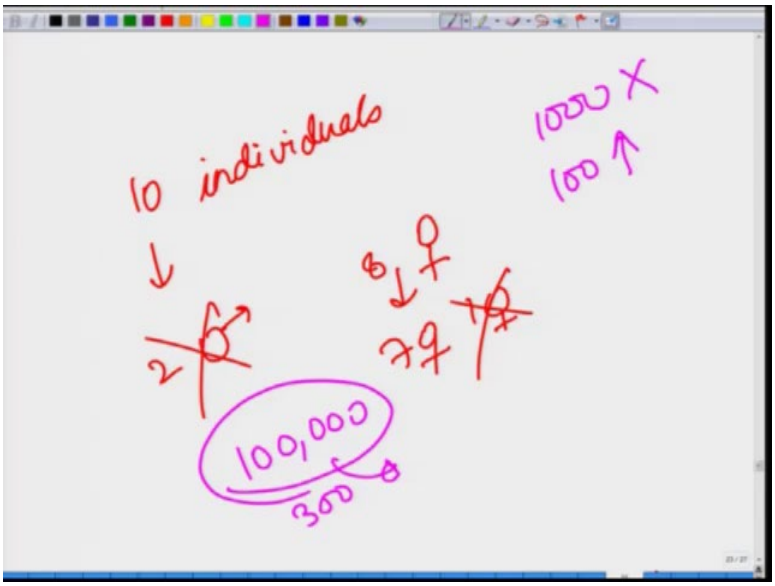

And, in a very good scenario; suppose 2 of these are males and 8 of these are females. Now, in this population, so this is a very rare species, only 10 individuals left. And in this situation, suppose 3 individuals die. So, 2 males are dead; and out of 8 females, 7 females remain, and 1 female dies off. But then what will happen to this species? This species will be unable to survive without the presence of males. So, now, this is species it is just a dead species that is walking, because you only have females that are left here.

So, if a species is rare, then it has a greater chance of becoming completely extinct. So, that is the sad state of affairs.

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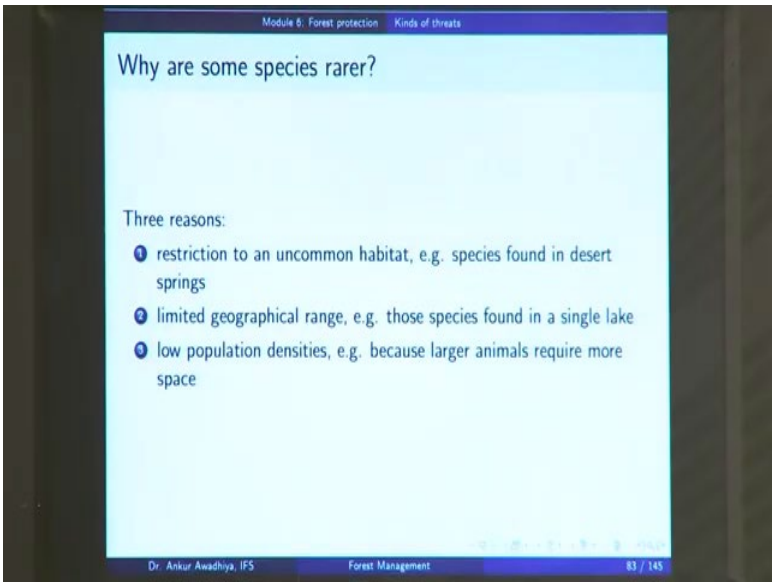

But then why are some species rare?

There can be several reasons. There could be as a species that is restricted to an uncommon habitat, such as a species found in the desert springs. So, this is a species that is only found in the desert springs. So, we have deserts and we have very small areas that are desert springs. So, if it does not have suitable habitats around, it will not be able to increase in its population size; so, it is a rare species. Or, you can have a species that has a limited geographical range, such as those species that are found in a single lake.

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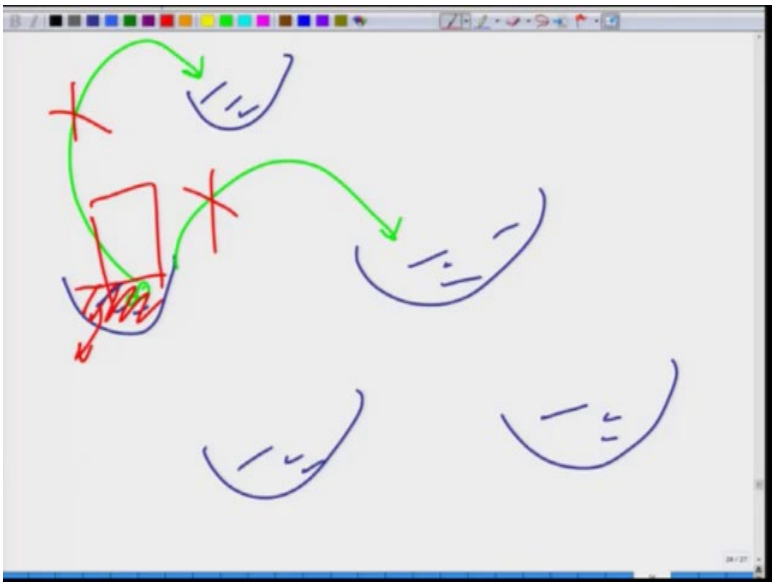

So, here we are saying that, you have lakes and probably the this species could have survived in a number of lakes, but then probably this species is a fish. Now, if you take this fish out into the other lakes, it will be able to survive; but then, it does not have a way to move out of this lake. So, it is confined to just a single lake. Now, if you drain this lake, probably to construct a building in this area. So, suppose a developer comes and says that this area this is a wasteland. We do not require the lake; let us drain it out. Let us fill it up with land and we will construct a building on top of it.

Now, once that happens, this is species has become extinct, because this is species was only found in this lake. Once the lake is gone, the species is gone. So, one reason for the rarity of species is a limited geographical range, or you can have certain species that have low population densities. For instance, the Pandas. Pandas do not produce a number of children; a number of young ones; and so, the population size itself is less. It is typically seen that in the case of larger species, the individuals produce less number of young ones.

So, for instance, if you look at mice. So, every generation will be having say 10 or 12 mice, the young ones. But, if you look at tigers, they will only produce 2 or 3 or maximum 4 off springs, in one litter. If you look at elephants, then the number goes even less. So, if, so every after, so in most of the cases, you will only have one calf that is getting produced. In the case of the larger sized species, because you are because the

individuals are producing less number of young ones, so there will be a low population density.

And, if a species is such that, it has lesser number of progenies, then because it has lesser numbers, so it has rare species. So, the impacts of human beings on these forests and these species is even greater.

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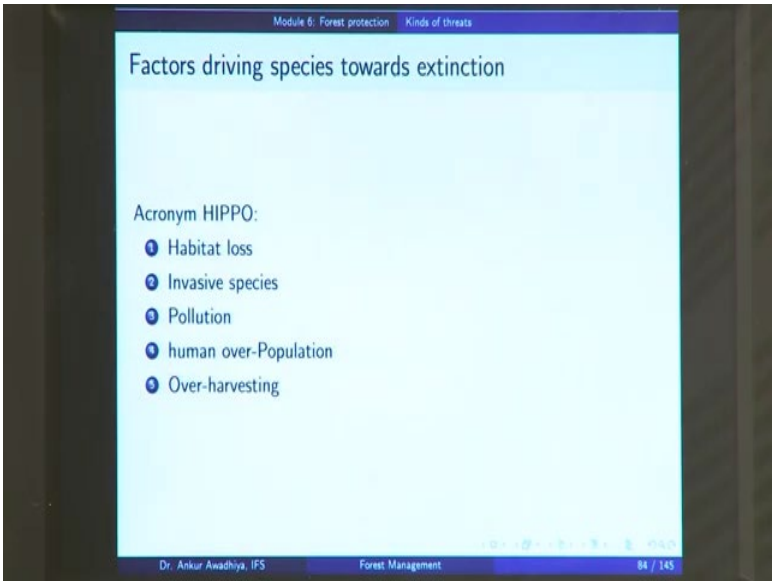

And, the fact is that are driving species towards extinction can be remembered with this mnemonic called HIPPO. So, HIPPO - H is the loss of Habitats, I is Invasive species, P is Pollution, another P is human over Population, and O is for Over harvesting. What is over harvesting?

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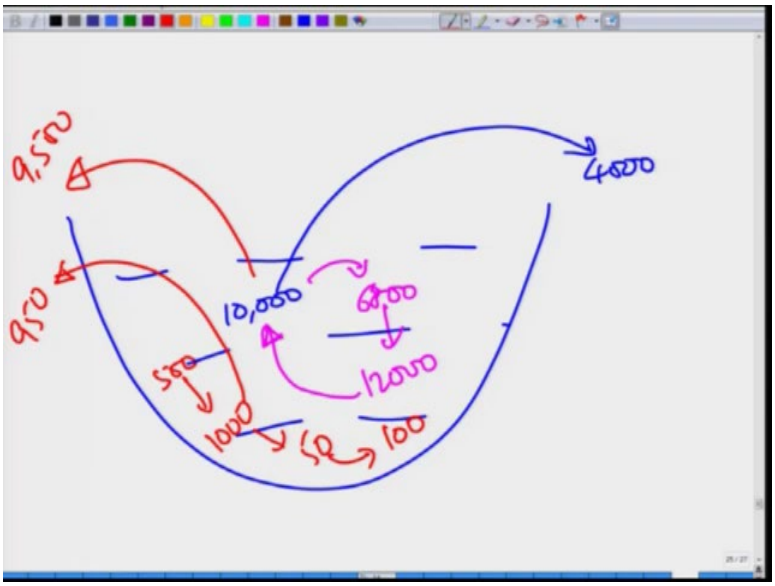

You have this lake and this lake has 1000 or 10000 fish.

Now, if you take out say 4000 fish out of this 10000, then 6000 remain. And, these 6000 are able to breed and will again produce large number of offspring's, and so this lake is able to sustain itself. The fish population is able to sustain itself. So, if you go on taking away 4000 fishes every year; so, next year this 6000 has again increased to 12000; some of the individuals should die off because of natural reasons, so the population has again come down to 10000. Out of this 10000 you are taking away 4000, so 6000 remain and the cycle will continue on a sustainable basis.

But what happens if you do an unsustainable harvest; if you do an over harvest? So, what you are doing in the second scenario is that, in place of taking out 4000 fishes, you are taking out say 9500 fishes. So, in this case, only 500 fishes remain in the system. Now these 500 fishes are again doubling in the population size. So, they are now becoming 1000 fishes. But then out of these 1000 fishes that remain, you next year your catch size is less, but your because your catch size is less, so your profitability has gone low, and so now, you are having even greater interest to take out more and more number of fishes.

So, in the next year, out of these 1000 fishes, you have removed 950 fishes. So, only 50 remain. Now, in the next year, this 50 has again doubled, it has become 100; but then what is happening to the lake? Earlier this lake was having 10000 fishes, but because you over harvested it, now it only has 100 fishes left. And, probably in a few more years, if

you go on with this over harvesting, this lake will become completely devoid of the fishes.

So, HIPPO gives us an idea of the five major reasons that are driving species towards extinction, and that are also driving our forests towards extinction.

Habitat loss, which means that, earlier you were having large areas that were there for the forest, now you are converting these forest lands into agricultural fields. And in the case of an agricultural field, you are managing in it in such a way that the forestry species do not thrive in those areas. So, there is a loss of the forest area because of habitat loss. There could be invasive species like Lantana. So, Lantana was introduced in our country; and because lantana is an invasive species, it is destroying our forests.

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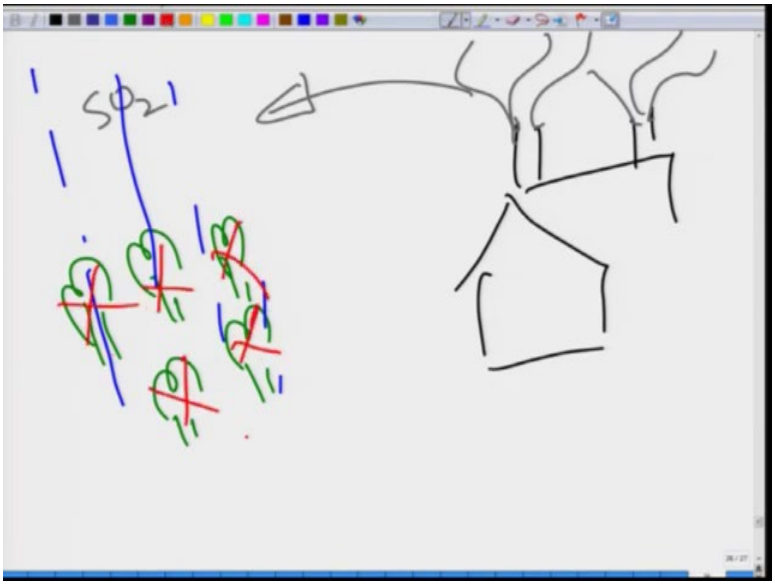

Pollution. So, if there is an industry, so you have a forest in this area. And, in this area, an industry comes up, and this industry is releasing sulfur-rich fumes. Now, because of wind this sulfur or sulfur dioxide is coming into this area; and with the rains, it is coming down on the forest. So, you have a situation of acid rain and because of this acid rain, the trees are dying off. So, pollution is one major factor that is leading to a loss of our forest; it is a big threat to the forest.

Human overpopulation. You have larger sized villages; more number of people with more requirements of resources with better technologies, and so, there is a more pressure on the forest. And so, human overpopulation has become a threat.

Over harvesting. So we will look in the next module that, in the case of forests, you can do a sustainable harvest; you can do a silvicultural management, in such a way that, you are able to extract resources or extract timber out of the forest in a sustainable way for many number of years. But then, if there is an over harvesting of timber; if people get into a forest and cut down most of the trees, they get very greedy. They want to extract most of the timber out in one go. If that happens, the forest will cease to exist.

So, because of over harvesting, there will be such a huge threat to the forest that the forest is now gone. So, these factors of HIPPO, which are factors that drive species towards extinction, are also the factors that are putting a threat to our forests.

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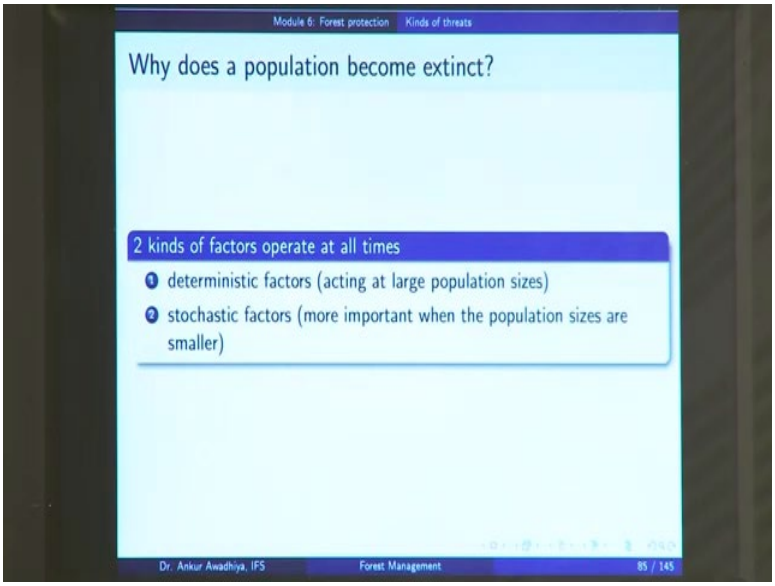

Now, in the case of any species, you have two kinds of factors that can lead it towards extinction. There are ‘deterministic factors’ and there are ‘stochastic factors.’ Now, deterministic factors are those factors that act at large population sizes, and the stochastic factors are those factors that are more predominant when the population sizes are small.

So, for instance, we looked at the scenario of this species which had all which already had a very small population size; you just had 10 individuals, out of these 10 individuals

2 were males. And, out of these 10, 3 got killed, and just because of a chance, it was a chance that 2 out of these 3 were males. So, that has led to the extinction of this species.

Now, this is a factor that is happening on a very small sized population. Because suppose you had a situation where you had 100,000 individuals. Now, in this 100,000 thousand individuals, suppose now; in the previous case, only three individuals died. Let us say in this case, three individuals died. But even then, you would have a situation in which the population continues to survive, even though there is more number of individuals that have been killed. Now, this is because the larger size of this population is providing it with a buffer; it is providing it a support against extinction. So, these are stochastic factors.

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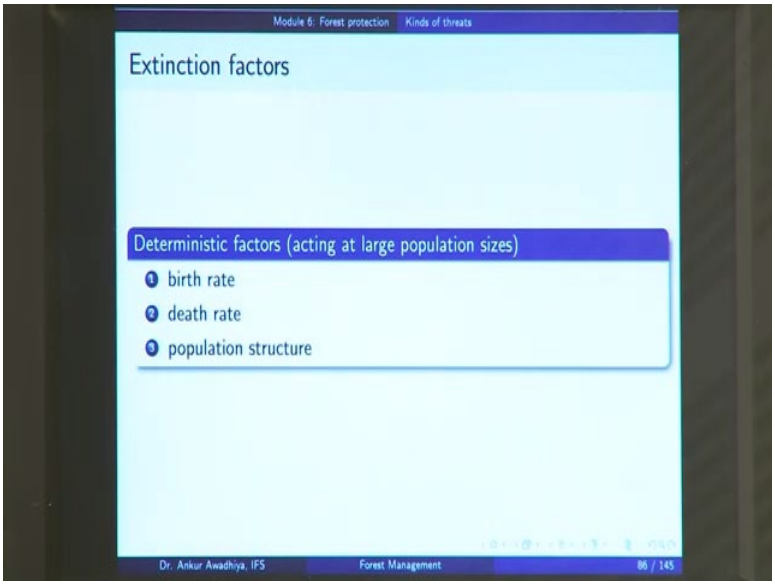

So, let us now have a look at the deterministic and the stochastic factors. Now, deterministic factors acting at large population sizes are - birth rate, death rate and the population structure. Now, every species is giving rise to new ones, and the old and older individuals are dying off. Now, if there is a balance between the birth rate and the death rate; so in that case, the number of individuals that are getting removed because of the old age or because of deaths, are getting replaced by the younger generation. And if that happens, the population is steady in size.

But, if it so happens, that the death rate is greater than the birth rate. So, in that case, suppose 1000 individuals are dying off because of the old age. So, 1000 individuals are

dying off, but only 100 individuals are coming up in the form of young ones. Now if that happens, if there is a mismatch between the death rate and the birth rate; in that case, the population will slowly start to reduce in size and there could be a slow and steady extinction of this particular species.

Now, for instance, if you consider a forest, the death rate these days typically is, because of the extraction of timber. Now if you are extracting your timber in such a way, and you have a large forest; so suppose you have 10000 trees, and you are extracting your timber in such a way that, you are extracting out 5000 timber. But, only 500 young crops are able to establish themselves. Now, if you remember, establishment is the stage at which the young plants have reached to such a stage of maturity that the normal adverse impacts are not able to pose a great threat to them.

So, we now we are saying that the young ones have become established, when they have reached to such a stage of maturity that they will not be affected by the normal adverse influences; such as a small insect has attack or some amount of regular grazing. So, these kinds of normal or some changes in the weather; these small changes will not have much impact on the young crop; because they have become mature. Even in the case of human beings, the babies are much more susceptible to adverse impacts as compared to the mature individuals.

So, in the case of babies, you do not feed them for say one or two days, and they might die. But in the case of adults, they have sufficient amount of fat storage that they will be able to survive for many days. So, in the case of every species, you have to wait, or you have to let the young ones reach to a certain level of maturity when we call, when we say that they have become established.

Now, in the case of plants; in the case of a forest, if you are doing an extraction at a rate which is greater than the rate at which the regeneration is happening, or the young ones are getting established; so, in that case, if the death rate is greater than the birth rate or the rate of establishment, then slowly and steadily the number density in your forests will reduce. And, slowly and steadily your forests will cease to exist. So, this is a deterministic factor, because you are looking at large scaled rates birth rates and the death rates.

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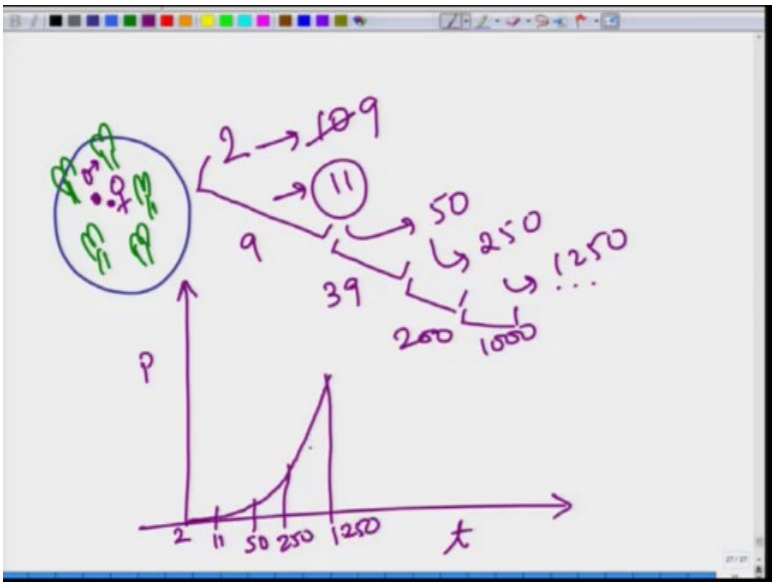

Also, another factor which is a deterministic factor is the population structure. So, let us consider an island, and on this island, you have ample resources. So, suppose you have ample food supply in the form of plants, and you are adding two individuals - a male rat and a female rat. Now what will happen and there are no predators on this island.

So, these rats are getting a sufficient supply of food materials; there is nothing to kill them off. So, they will have the food and they will breed, and the next generation also is having an abundance of resources. So, say if they are producing a litter of 10, then all then say 9 out of these 10 are able to survive; because there is abundance of food available; there are no predators; there is not there are no diseases on the system.

Now, in the next generation, so we started with 2, and with the first litter it became a 10 out of which 1 died, so 9 remains. So, from the 2, the population has increased to 11; then after a while because of the old age these 2 died, but these 11 are reproducing and so the population say has increased by another 5 times.

So, it has become close to 50. Then, it becomes again 5 times of this, it becomes 250 and so on. So, in this case what we are seeing is that, in the beginning the rate of growth; so, from 2 it became 11, so there was an addition of 9 individuals. But then in the second stage, in place of 11, it is becoming 50; so, we are adding 39 individuals. In the third stage, you are adding 200 individuals. So, if you plot the population size, p versus time - it started with 2, then it became 11, then it became 50, then it has started to rise now.

Suddenly, it has become; so, we started with 2, then it became 11, then it became 50, then it has become 200. Now, in the next stage, you will have 1250 individuals. So, the increase is 1000.

So, this is 250 and here it is 1250. So, what we are saying is that, the population which was earlier increasing at a small rate, because we had very few individuals to begin with; now, has breezed in exponential phase. But then, what will happen is that, you will now start to have a situation where the resources are now getting limiting; because you have so many rats on this island that, now everybody is not able to get sufficient amount of food; they are now competing against each other for resources. Now, once that happens because of the overcrowding, the rate of increase of the population will now start to reduce.

Why? Because now, these rats are not well fed; their young ones are not well fed. So, probably a few are dying out of starvation.

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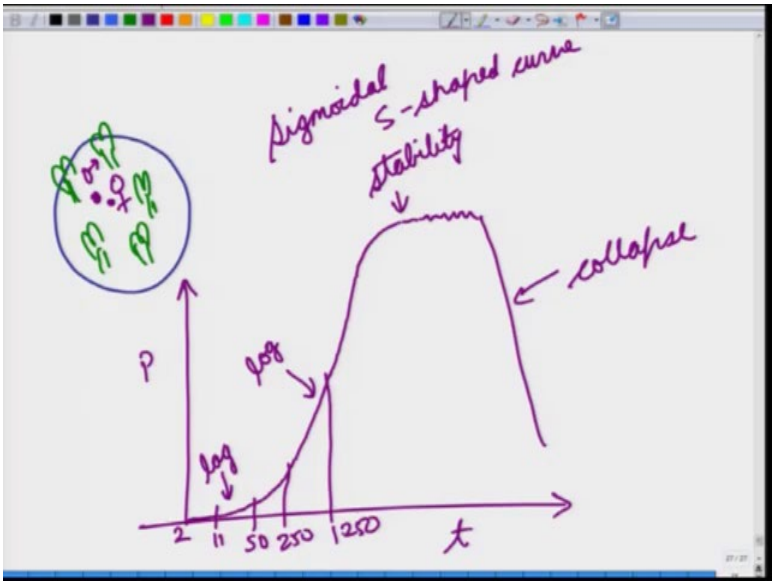

So, in this case, the population has now started to reduce in its rate of growth. Now, it the population is still growing, but the rate has now reduced. Now, if you have a situation where the population is at this stage; now, there will be some variations in the population sizes, so it will go up and down. But now, you have a situation where there is an overcrowding, where you have a large number of individuals that are old in age; because the young ones are not able to compete against them, so the young ones are preferentially

dying and the population is showing some fluctuations, but it is a very large population size.

Now, if you have a single disease that comes up in the system, what happens? Because there is an overcrowding, every individual is in touch with everybody else, the disease spreads like anything and the population collapses. So, this sort of a curve is known as a sigmoidal curve or an S shaped curve. So, in the beginning we have a lag phase, the population is increasing slowly; then, we have a log phase; then, we have a phase of stability, and then we have a stage of collapse.

Now, you have a very similar situation, in the case of forest as well. So, if you have a forest and there is regeneration that is happening, but you also have large size trees that are sort of competing with their own young ones. Now, if you have a large size tree, it has an extensive root system; it is able to get water and minerals from a very large area, whereas your young seedling is having a very small root system; it is unable to compete. Your mature plant is having access to sunlight, because it is starving plant; but your seedlings are living in the shade and they are unable to compete.

Now, if this sort of a situation occurs where your older generation is sort of out competing the young generation, and slowly and steadily, you will have a forest with a number of old individuals. There are hardly any young individuals that are able to cope up.

Now, if there is any disease in such a forest, the older individuals will die off, the younger individuals will get completely exposed, and you will have a situation in which the forest collapses. And, this is why you the population structure is a deterministic factor, and you need to maintain your forest in the log phase, where most of the trees are mature trees, that are able to cope up; that are able to compete; and that are able to resist the adverse influences.

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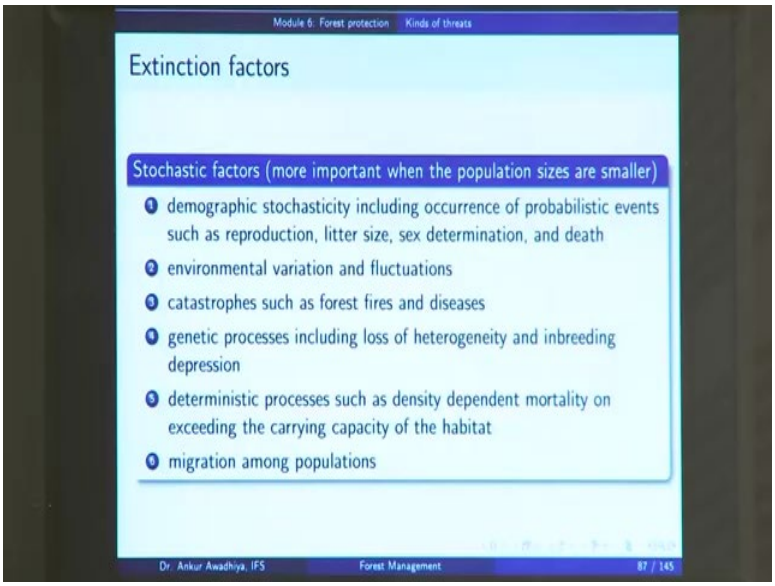

Now, along with also have stochastic factors that are important when the population sizes are smaller, such as demographics stochasticity. In which case, you are talking about the probabilistic events, such as sex determination of the young ones.

So, you could have a very small sized population, but all the individuals that come up in the young generation are probably all of them are males. So, even though you are having then the next generation, because all of them are males, so the population will collapse.

You can have environmental variation and fluctuations. You have a single year in which there was a huge draught and the population collapsed, because you had very less number of individuals to begin with. So, suppose you have a species with 10 plants remaining, and in the draught 9 out of these 10 plants died. So, the population has become extinct.

You can have catastrophes such as forest fires and diseases, genetic processes such as loss of heterogeneity and inbreeding depression. So, in the case of a very small population, you are having breeding amongst brothers and sisters, you are having breeding amongst fathers and daughters; so, in this case, the recessive disorders that are there in their genome will be able to show themselves. So, these are also stochastic factors, which will be important only when the population sizes are very small. Or, deterministic processes, such as density dependent mortality, on exceeding the carrying capacity of the habitat.

What we are saying here is that you have a very small population; but this small population is in a very small area, and if it is in a small area, the density of the population in that small area is very high. Now, because of large size density, there will be certain mortality that is happening. And, this mortality just because the population sizes is small, so you have a large densities; but the sizes is small, so this mortality will be able to wipe off the population. So, this is another stochastic factor or migration amongst populations.

So, you had a forest in which you had suppose 3 tigers and these tigers migrated out of your area, and so now you have a forest without a tiger. So, this is another stochastic variable that will only impact when the population size of tiger was very small; it was only 3 individuals. If you had suppose 50 individuals, 10 out of them migrated out. It does not matter, because you still have 40 individual left in the forest.

But in the case of smaller populations, migration also becomes a very important stochastic factor.

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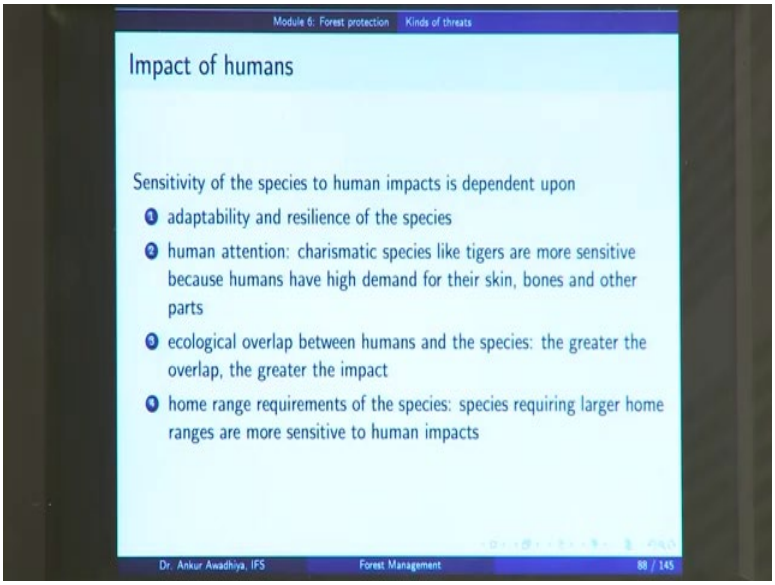

And, we are seeing more and more impact of humans on these populations, especially on the smaller populations. And the sensitivity of the species to the human impacts; it is dependent on a number of factors, and so, a number of species are getting extinct every day. So, the sensitivity of species to have an impact; it is dependent on the adaptability and resilience of the species. There are certain species that are not adaptable. You have certain birds that are ground dwelling birds; they live in grassland areas, and they are not

able to adapt to the impacts of human beings. So, humans go into those areas, kill these birds for meat, and these birds have nowhere to go, because they just live on the ground; they live over in the grasses; they are unable to fly, and reach to the tops of the trees.

If you have a species like this, the impact of human beings is much greater. The species is much more sensitive to the impacts of human beings. Human attention, tigers are threatened not because they are not adaptable, but because they look beautiful and so humans have a huge demand for their skin. So, if a species is a charismatic species, then it might be much more sensitive to the impacts of human beings.

Or, if there is an ecological overlap between humans and the species, the greater the overlap, the greater the impact. There is a species that lives in grasslands, and humans want to use convert grasslands into agricultural fields. So, just because both of them want to have the grassland, so the impact of human beings on such a species will be much greater than a species, that say lives in the desert areas.

And, the home range requirements of the species. The species that require larger home ranges are more sensitive to the impacts of humans, because they require larger sizes of areas. And so, if humans say encroach upon half of that area, then because the requirement is more, then they will not be able to get those large chunks of forest, and the species will die off.

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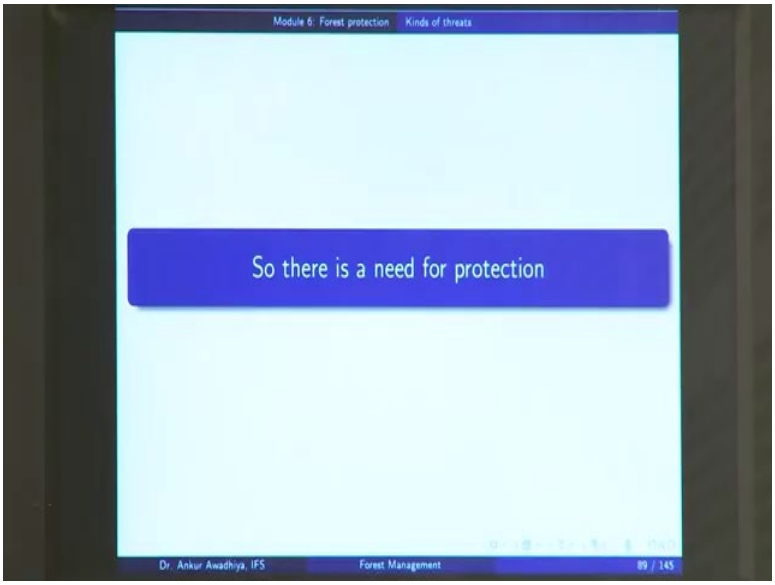

And because of all these different impacts that the humans are having, there is now a greater and greater need for protection of the forest. So, we are interested in the protection of forests, because our impacts on the forests have become so large, that if we stop doing the protection, then probably we will be losing out our forests and our species. That is all for today.

Thank you for your attention [FL] [FL].