Wildlife Ecology
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Lecture - 32
Biological control

[FL]. We carry on our discussion on applied ecology and today, we will have a look at the Biological control of pests.

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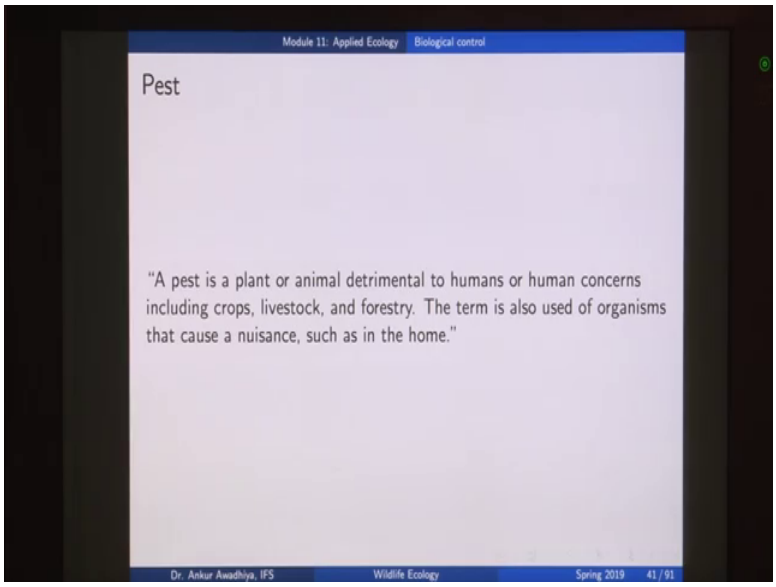

So, we begin with the definition of a pest. "A pest is a plant or animal detrimental to humans or human concerns including crops, livestock and forestry. The term is also used of organisms that cause a nuisance, such as in the home." So, essentially a pest is any organism that is concerning us, that is disturbing us, that is giving us some sorts of harms or losses or is in a general term, it is a nuisance for us and especially, those organisms that are causing damage to crops, livestock and our forestry applications, they are the major pest.

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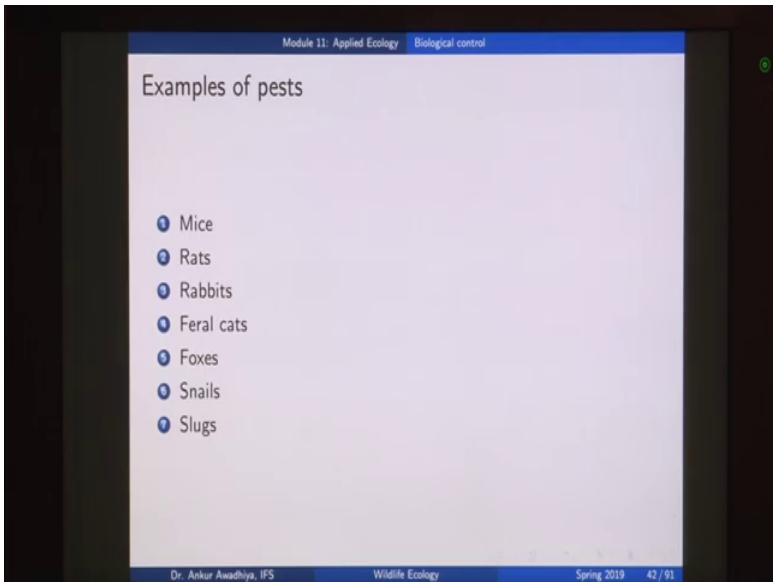

So, some examples of pests include mice and rats. So, mice and rats are the number one causes of the losses of our food grains, even in the fields and also when they are stored in the warehouses. Then we have rats; mice and rats are also very important for the passage of a number of pathogens. Then, we have rabbits. Now rabbits are harmful pests especially in the agricultural system because they can eat up a number of crop products. Then, we have feral cats; so feral cats and feral dogs are also pests in a number of areas, where the specially people are rearing things like poultry.

So, if you go to a poultry farm and if there are cats around, the cats might eat up the chicken that is being reared there. So, feral cats are a big issue and there are also big issues when we talk about the environmental concerns. Because in a number of islands throughout the world, when the cat were introduced they started eating up the native birds that were found in those islands and quite a number of birds became extinct because of the feral cats. Then, we have foxes, snails and slugs which are also pests especially in the agricultural areas and when people are rearing small animals such as your poultry or things like rabbits.

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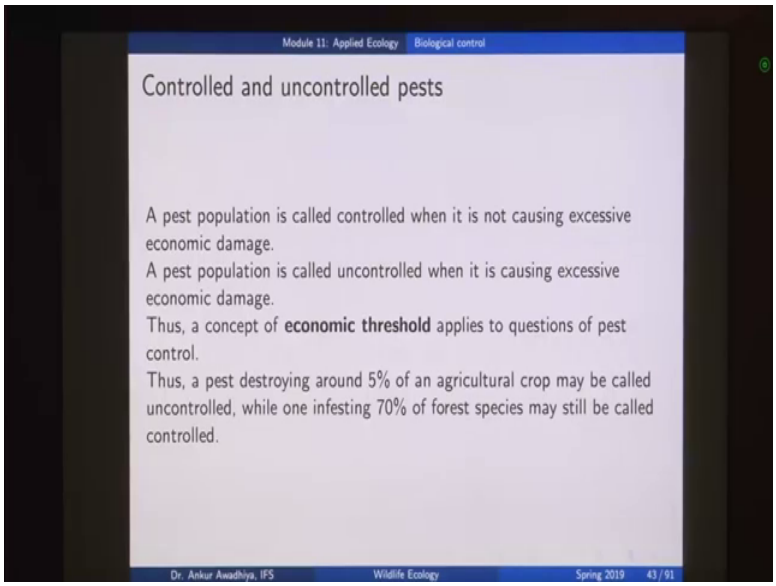

Now, pests are divided into controlled pests and uncontrolled pests. A pest population is called controlled when it is not causing an excessive economic damage. Now, here the term to note is an excessive economic damage. Even if there is a pest that is causing an excessive environmental damage, but then that environmental damage has not yet been counted in terms of economics. So, people might say that it is not an uncontrolled pest. And a pest population is called uncontrolled, when it is causing excessive economic damage. Thus, a concept of economic threshold applies to the questions of pest control.

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So, essentially if we look at the pest populations. So, let us see that this is the pest population and here we have the time. Now if the pest population is and are economic threshold is let us say this much. Now, in this case if the pest population is hovering above the economic threshold, we will say that the pest population is uncontrolled. And when the population goes down and then, starts hovering at a level that is below the level of the economic threshold.

We will see that the pest population is a controlled population. Now, when we are using this term control, it does not mean that the pests have been eliminated completely; it does not mean that you have achieved a 100 percent extermination or removal of the pest from that particular region. But it is just that the levels of damage that they are doing economically are those that we can tolerate.

Now, this brings us some paradoxical situations such as if you have a pest that is destroying around 5 percent of an agricultural cost, you will start calling it an uncontrolled pest. When we are talking about especially the fruit trees, if you have an apple occurred and there is a pest that has infected say 10 percent of the fruits and you will start saying that yes, this pest is an uncontrolled pest; we need to do something about it because the 10 percent economic loss is a very big loss for a farmer.

Whereas, if you have a similar pest that is infesting seed 70 percent or even 90 percent of some particular forest species and probably it is leading to a very heavy damage to all the leaves. You will still call it a controlled pest as long as the damage that it is causing economically is not very high. Now, if you have pest and especially when you have these uncontrolled pest, you need to have some ways of solving the issue.

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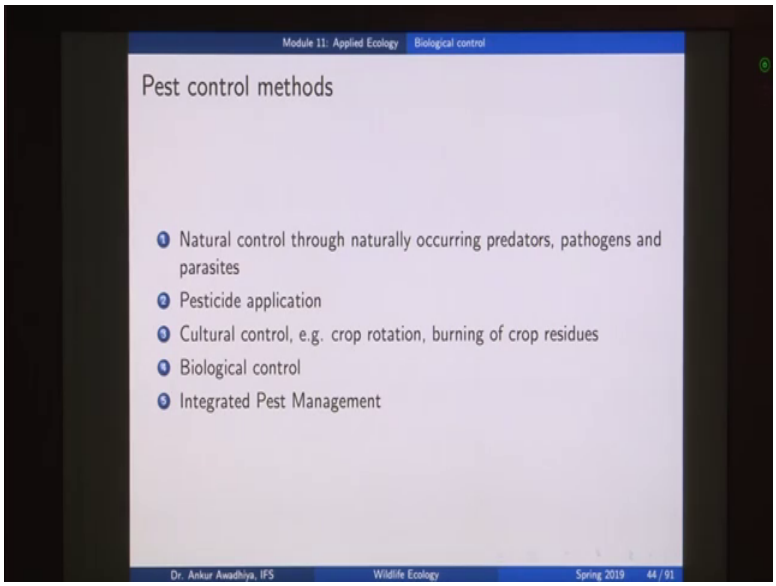

So, we have a number of pest control methods that have been used for a very long time. Now, the easiest method is the natural control. In the case of a natural control, you do not do anything. So, how does a natural control work? Well, a national control generally works because any pest that you have in the system.

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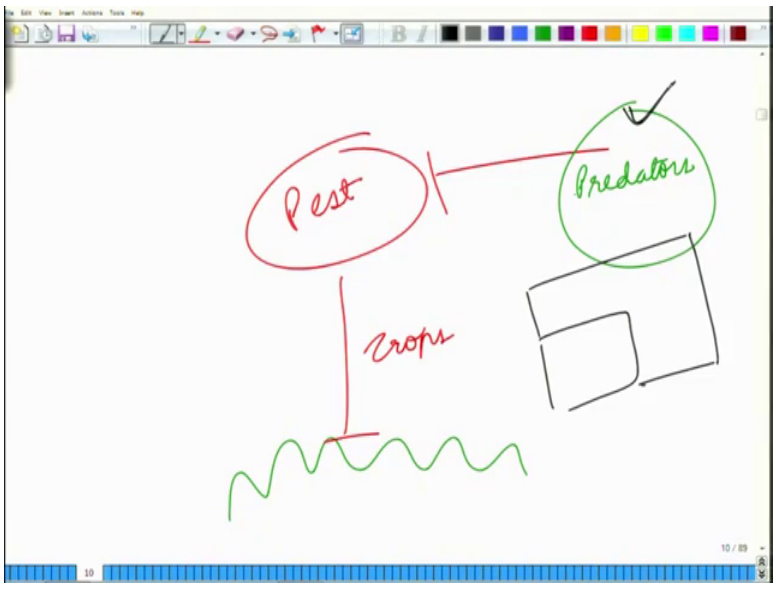

So, let us say that you have this particular pest which is say affecting the crops. So, it is inhibiting the crops or it is damaging the crops, but then we will also have some other organisms that will be harmful to the pest. So, let us say that you have a predator for

these pests. So, for instance if there is a particular insect that is affecting your crops because it is eating away the leaves of the crops.

It also has a predator, probably an insectivore's bird. Now, when we did not have any other method of pest control, the natural methods work for us because if you have a last size farm, you do not have a very large population. The population is your own population or the human population is limited. In that case, suppose you require this much amount of field to produce crops, you may start producing this much amount of crops; so that even if there are losses, they will be taken care off.

And especially in such situations, if the population of the pest increases, if the number of insects increases, then the number of predators will also increase in a short while and they would start impacting the pest. So, when you have a large number of insects, you will also have a large number of insectivorous birds. They will probably start flying from other areas into your area because in your area, they are having a plentiful supply of insects. And once that happens, they will start heating up the insects and so your problem will start to solve by itself. So, this type of a method is known as a natural control; through naturally occurring predatives, pathogens or parasites.

The second one is pesticide application and we have seen pesticide application in one of the earlier lectures and pesticide application is also very much responsible for a lot of environmental damages. So, we will come to it in a short while. Then, there are some methods which are known as cultural controls such as crop rotation or burning of crop residues. Now how does this work?

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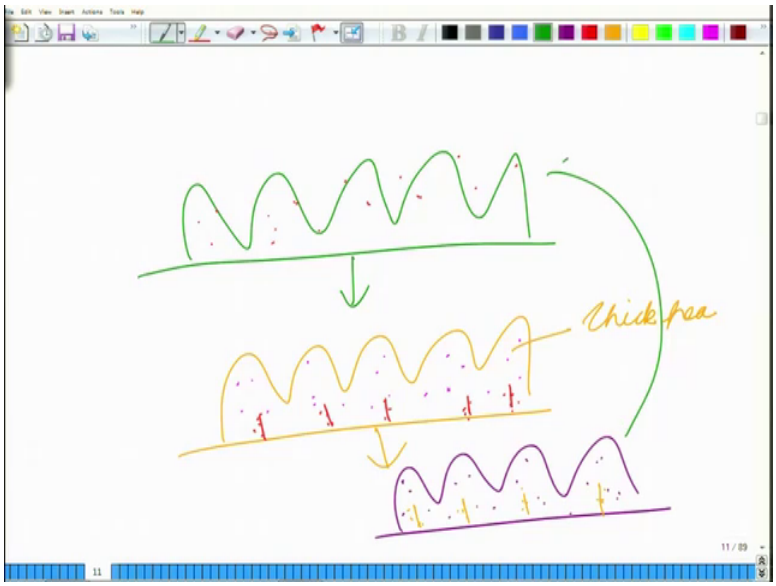

Suppose, you have a field and you have a particular crop and then, this crop is also having a number of pest with it. Now, at the end of the season, your crop will be ready and you will be cutting and removing your crop. Now, what happens to all of these pests? Probably they will also spend some time somewhere else probably they will also spend their time. So, when you have a tall. So, let us say that this is your wheat. Now, when you are cutting the wheat and let us say this is the ground level, you typically cut the wheat at say this level.

So, when you are removing this wheat, you will be removing some of the pest that are associated here, but then also some of the pest will remain here. So, you have removed this top portion, the bottom portion remains. You have removed this top portion and then, when you use this field again and next time also if you are growing wheat only. So, what will happen is, you will have some small wheat plants that are coming up here and you also have the pests here and it is very easy for the pest now to start infecting your new plants. Now, to reduce this possibility one way that farmers have used for quite a while is to burn up the stocks.

So, once you have removed your wheat, you put the whole thing on fire and in the fire all the pests are killed. So, that is one way that is known as the burning of the crop residues. Otherwise another way is that there are a number of pests that have a very specialized

requirements. So, let us say that you have a particular insect that only impacts the members of the grass family.

So, it will be impacting your rice, it will be impacting wheat; but probably it does not impact something that does not belong to the rice family. Let us say if you grow something that belongs to the leguminous, family your pest will not have access to food because it does not eat the plants of the leguminous family and after a while in the shortage of food it will start dying.

So, how will you make use of such a process? So, you again have this field that is all full of wheat and it is all full of pests and in this case after you have harvested your crop, you next put in another crop. Now, let us say that this is another crop. Let us say that this is your chickpea. Now, your stubbles are still here. So, the stubbles of your wheat are still here, they still have these pests, but then these pests are not able to infect the chickpea crop. So, after a while in the absence of food, they will start dying off. So, once these pests are dead and in the meantime you will start having some other pests and that are infecting the chickpea crop.

So, after a while you will grow something else. So, probably in the next season you will neither go for wheat nor do you go for rice, let us not do you go for your chickpea. Probably you go for something like a soya bean. So, in by this time all the pests that were there of the weed are now gone, you have some chickpea pests, but probably they are not able to infect your soya bean.

After a short time, you will start having the pest of soya bean in this area because now you have abundant supply of food for them and after this season, you again shift to your previous crop. Now, this is a method of crop rotation. So, by crop rotation and by burning of crop residues, you can have a control pests and these methods are known as cultural controls because you are just using some good farm practices to keep a control over the pests.

Now, the other two methods are biological control and integrated pest management that we will come to in a short while. But so far what we have seen is that the natural control does not work these days very well because our requirements have grown up, our greed has gone up and we cannot spare any amount of our food grains for the other organisms;

we want everything for ourselves. So, these days the mainstay of agriculture is the pesticide application.

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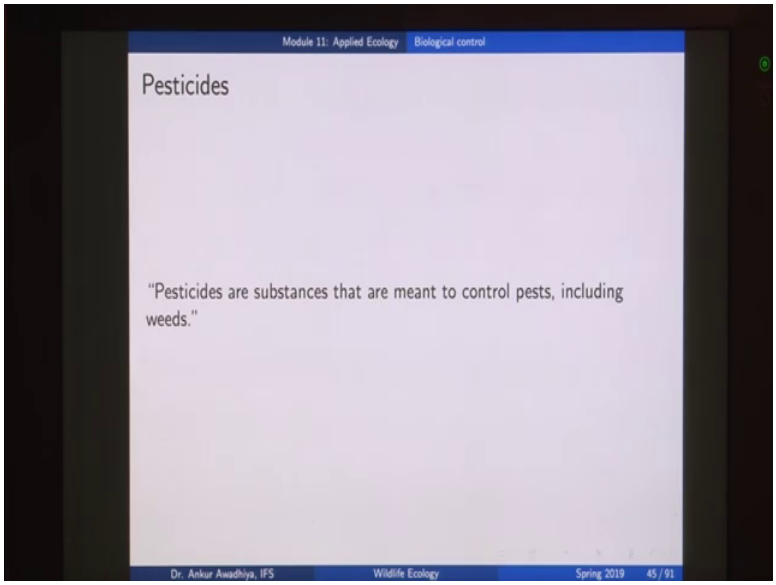

Now, we have seen earlier that "Pesticides are substances that are meant to control the pests, including weeds." Most often, they are very extremely toxic substances; they are poisonous substances. So, when you have your crop, where you have a pest infestation.

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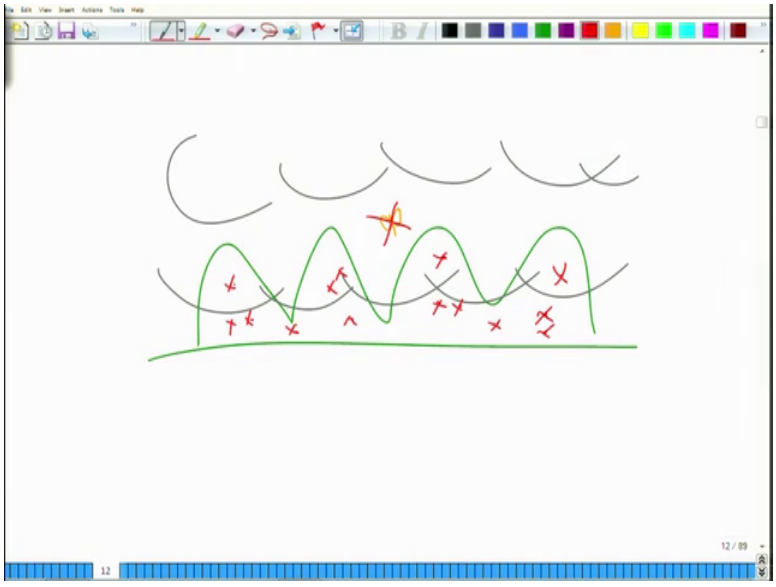

So, let us say that this is again your wheat crop and this wheat crop is having these pests. So, you will apply your pesticide over the whole of the area and once that happens, the

plants will survive; but all the pests will be killed. So, once that happens you have a situation where you have controlled your pest population. So, pesticides are another good way of or the other mainstay of our current agricultural practices.

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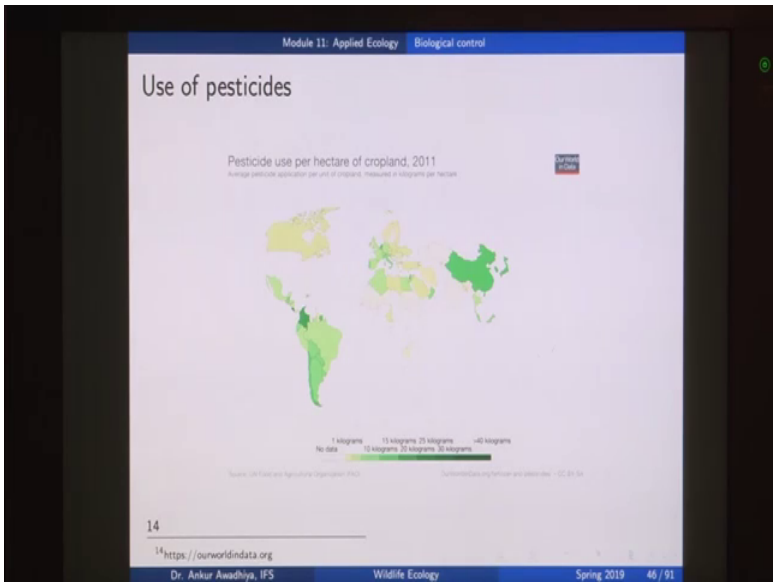

And a number of countries are using these and they are also using it in very high concentrations and we have seen this in the chart before.

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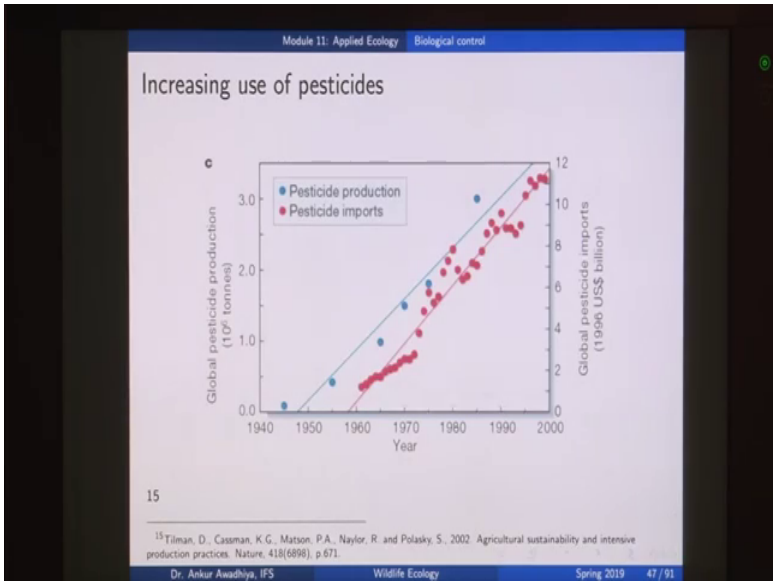

And we also saw that the pesticides are increasing in their usage for quite a time. So, if you look at from 1940's till present the amount of pesticide production, it has been

increasing. And so far so good, if you had a pesticide that only killed the pests, it would have been a wonderful solution.

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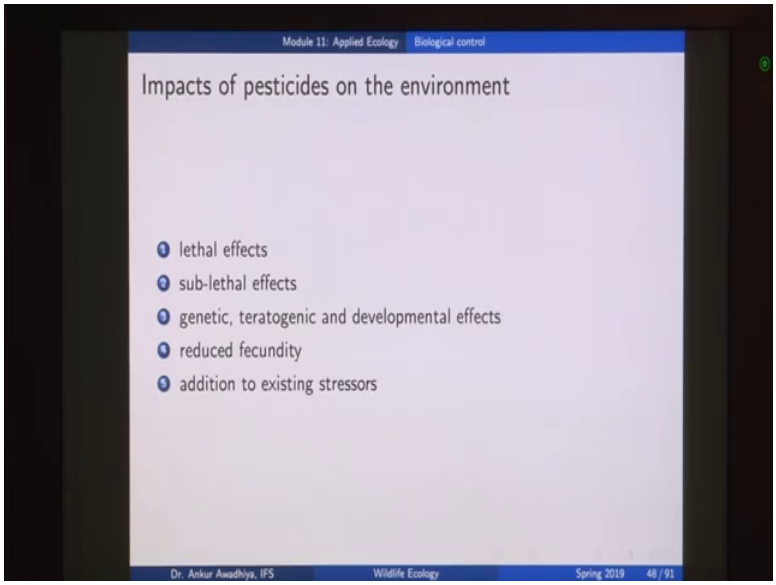

But the problem comes because the pesticides also have other negative impacts on the environment and some of these we have seen before. So, there are lethal effects. Now, lethal effect is something that can kill an organism and in this case the lethal effect is not just confined to the pest. But it is also affecting a number of other organisms. So, for instance in this particular example, suppose you had things like butterflies and when you are applying your pesticide; the butterflies will also be killed. Similarly a number of other pollinators also get killed because of the pesticides.

Apart from the lethal effects, you also have a number of sub-lethal effects in which case a number of organisms will start becoming extremely lethargic, they will have a reduced fecundity which means that they will not have a large growth of population. They will not be able to produce their off springs properly and when we have these sub lethal effects, they would add to the existing stressors.

So, for instance you have a population of some organisms that was in some way coping with the impacts of say a particular disease. But then, if you put these pesticides also on the same population. So, this population will now be suffering from two impacts at the same time; one is the sub lethal impact of a disease, the second one is a sub lethal impact

of the pesticides and together a number of sub lethal impacts if you give it together, they might result in and a large amount of lethality in these animals.

Then, in a number of cases we also observed genetic changes, teratogenic changes and developmental changes. Now, genetic changes, it means that you have some mutations because of some pesticides. Teratogenic changes means that in a number of organisms though the birth of the off spring. It is impacted in a way that the off spring when it is inside the foetus or when it is inside the womb, it is in the form of a foetus, it is not able to grow properly. So, terato refers to a monster and gen refers to producer.

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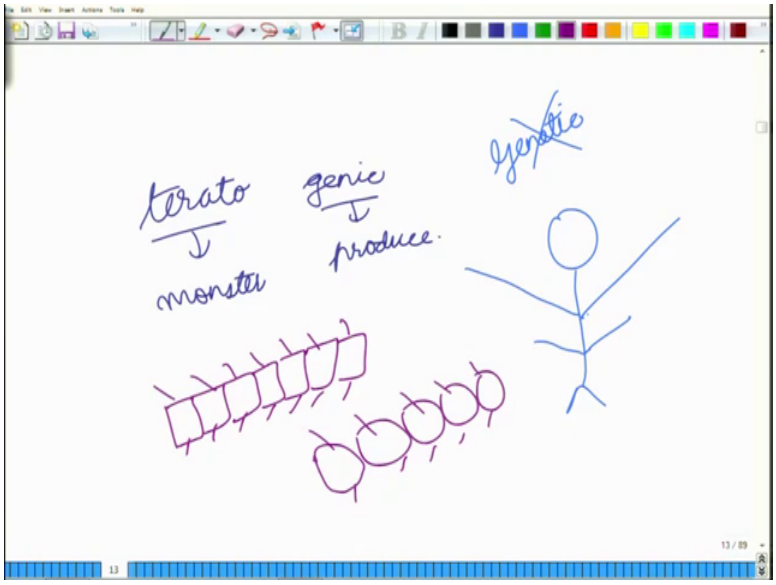

So, when we look at the world routes terato genic. So, terato is a monster and gen is to produce. So, a teratogenic chemical is a chemical that produces a monster. So, for instance if you think about human beings. So, are you a human being has 2 hands, it has 2 legs. Now if there is a teratogenic chemical probably the hands will not be formed properly. So, you will have very small hands or probably you will have a situation where you have very long hands or probably you will have multiple hands.

Now, if you have any of any such condition, we will say that there are some teratogenic chemicals that are there in the environment or there are some teratogenic chemicals to which the foetus is getting exposed to because these changes are not genetic changes. So, these are not genetic changes, but they are actually altering some of the developmental mechanisms through which the body is getting formed.

Now in one of the earlier lectures, we had seen that I throughout the biosphere, most of the things are formed in the form of small blocks. So, we looked at a centipede. Now in the case of a centipede, you have a repetition of all of these segments and every segment has the legs. Now, in this case suppose the formation of the segment itself is hampered or say it has changed. So, in that case it is possible that in place of having these segments, you will have a centipede that will have say rounded segments.

Now, with these rounded segments, it will not be able to move properly. It will probably die in a very short time, but then such kinds of changes if they are produced not because of genetic changes, but because of some chemicals in the when it is developing, we call it a teratogenic change. And we also have a number of developmental effects which also come up when the off spring has been produced and is now developing.

So, we have had a look at a number of such impacts before as well. So, there are impacts of a number of chemicals and pesticides are no exceptions.

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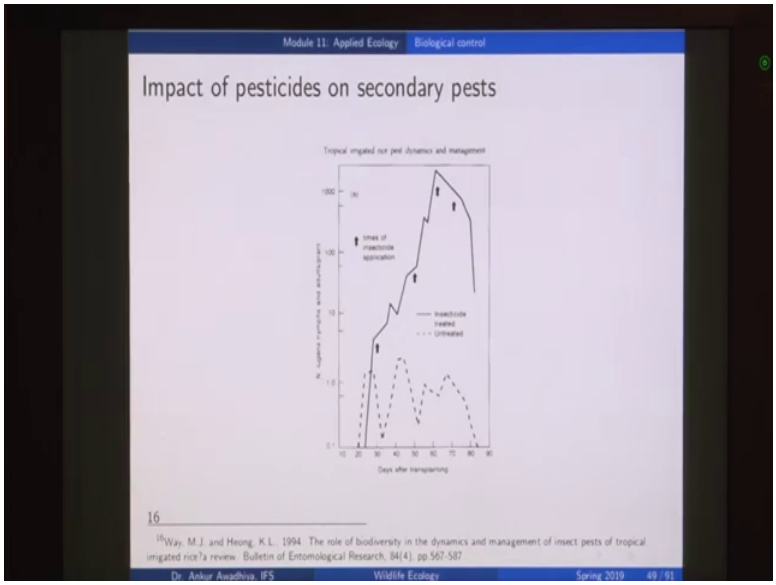

But then, another big factor is that the pesticides also have another set of impacts. So, for instance here we are looking at rice grains and we are looking at the number of pests that we have in this particular rice. Now here what we are talking about are the secondary pest..

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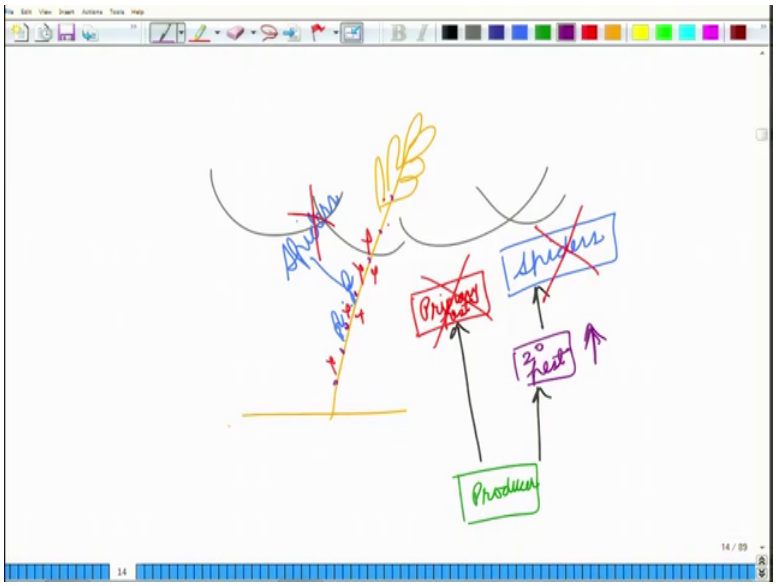

Now you had a pesticide; so you have this rice that is growing and this rice was impacted by this particular pest and you sprayed your pesticide over your crop so that all your pests die off. But then, what happens is in the absence of these pests, you will probably start getting another pest because in ecology we earlier talked about niche differentiation or niche partitioning.

Now, in this case there are two species of pest that will make use of the same rice grain and when you have the red coloured pest that was earlier there, it was able to out compete the purple coloured pest. So, in that case you will not see any of your rice with a very substantial population of the purple coloured pest. But then during when you spray it with your pesticides and you kill off the red coloured pests, so in this case now there is nothing to stop the purple coloured pest to grow in this area.

So, typically we will observe that in and in this case the y axis is showing you the N lugens nymphs and the adults per plant and this is a logarithmic scale. So, it is 0.1, 1, 10, 100 and 1000. Now, in the normal case you will see just around 1 nymph or 1 adult per plant, if you are not spraying the pesticides. But then when you spray the pesticide, it may even rise to as high is something that is greater than 1000 adults or 1000 nymphs per plant. So, that is the impact of pesticides on a secondary pest. So, when you are removing the primary pest, then probably you will have some secondary pest and it is

possible that your secondary pest may then lead to a much greater harm the new primary pest was causing.

The other thing especially in the case of this particular secondary pest is that when you are killing off your primary pest, you also kill off those predators. So, in this particular area you will also have some predators. So, let us say that these are the spiders. Now, when you have these spiders, these spiders feed on these purple coloured secondary pest and they keep their population in check.

Now, it is possible that when you are spraying your pesticide then along with your primary pest, you also kill off these spiders which were again predators. Now, we have seen earlier in ecology that if we talk about the food chains. So, here you have the producer which in this case is rice and then, you have your let us represent it like this. So, you have your primary pest and you have your secondary pest and both of these will be feeding on the rice.

Now, in this case the secondary pest also has its own predator in the form of spiders. So, the spiders were feeding on the secondary pest. Now, you when you spray your plants with the insecticide, you are hoping that you are will get rid of the primary pest and so, your crop will be saved. But in this case you are also killing off these predators because of which your secondary pest are now able to increase their numbers because there is nothing to stop them.

They have ample amount of food because there is no competition and at the same time they have no predators to predate on them. So, there is nothing to keep their population in check. So, in that case the secondary pest population will increase to such an extent, then that it becomes a much more serious problem than before.

Now because the insecticides or the and the pesticides they are having a number of negative influences and because we cannot make use of just the natural controls. So, then people thought why not make use of biological controls.

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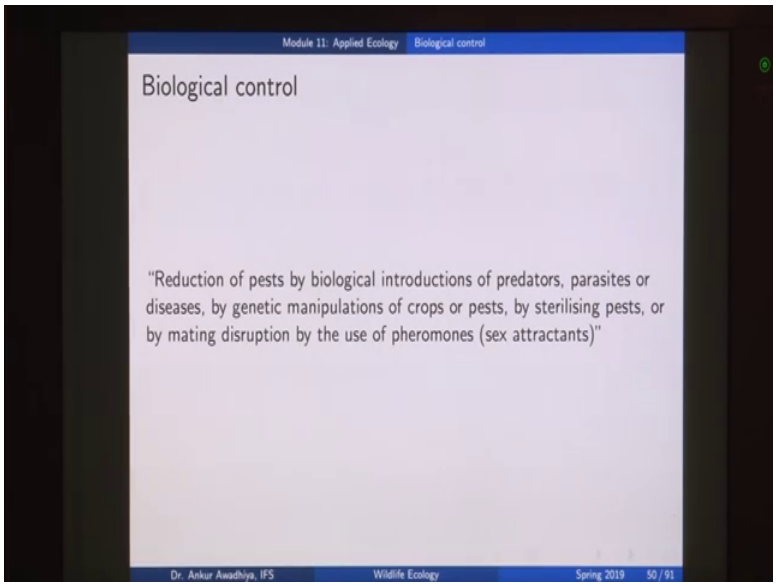

Now, biological control is something that works very similar to a natural control. So, in the case of a natural control you had a field that had rice. There were insects and there are insectivorous birds. Now, if the insect population increases the bird population also increases and that saves the crops.

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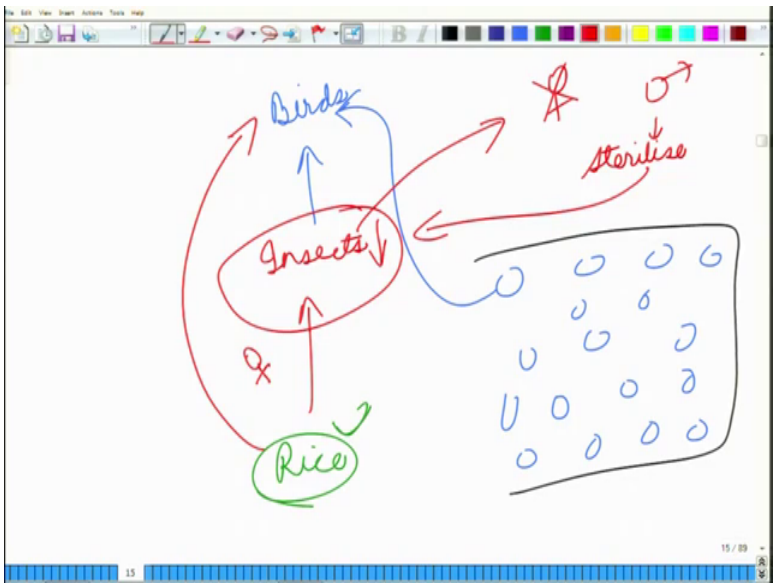

So, here we had your say a rice and rice was being eaten by the insects and the insects were being eaten up by the birds. Now, if the insect population increases in turn birds will have more amount of food and the bird population will increase which in turn will

reduce the insect population. So, this is how a natural control works. Now, in the case of a biological control what we do is if we know this system and we are seeing that the insects are increasing, why cannot we bring birds from outside?

So, let us say that we have an aviary and in this aviary, we are raising a number of birds. So, we are giving them controlled situations, controlled conditions, we are giving them plenty of food, we are taking care of their other nutritional requirements where we are saving them from diseases pests and parasites. So, you will have a large population of birds here.

Now, what you do is when you are growing your rice, you let loose of these birds. So, these birds can always come out and they can substantiate the already existing bird population. So, in that case the number of insects will drop considerably. Now, whenever you are using such a method, you need to ensure that these birds are not also eating your rice because if that happens this will not solve your problem.

You want to have those birds that are only eating the insects and if you can release those birds in large numbers, you will have a control over your insects. So, this is the basic idea of biological control. So, it is reduction of pest by biological introductions of predators; now in case of predators, you can also make use of parasites or diseases or by genetic manipulations of crops or pests.

Now, when we talk about genetic manipulation probably you can have a particular rice variety that is more resistant to the impacts of insects. So, probably it has some other chemicals and its leaves that is not suitable for the insects. So, in that case the insects will not be eating this particular variety of rice. So, you can go with some genetic manipulations or you can go with some breeding procedures through which you select for those rice varieties that are more resistant to the insects or you could go for a genetic manipulation of the pest.

So, in this case probably you can catch hold of all the or a large population of these insects. So, you take these insects out you select them. So, you select the females, you select the males and then, you let the females probably you kill these females and all these males that have been collected you sterilize them.

So, if you have sterilize these kneel. So, in that case they will not be able to produce office springs and then, you release these males back into the system. So, what will happen is if you have any female insect here. It will try to mate with this particular male and because this male is sterilise; so they will not be able to produce the off springs. So, you can go for a genetic manipulation of the pest as well or probably you could give it certain genes such that it becomes a sterile after a while or you could go for these direct sterilization of pest or by mating disruption by the use of pheromones or sex attractants.

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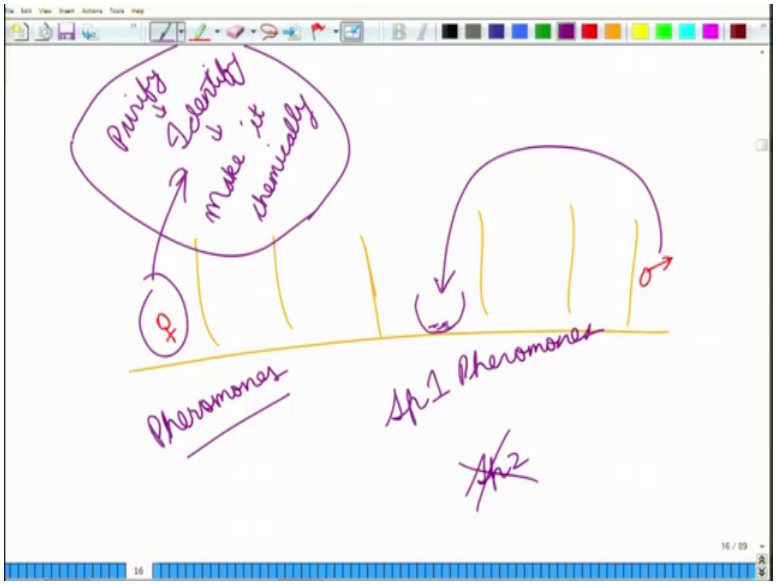

Now, if you have a large sized field, so you have a number of crops, a number of plants and you have say a female here you have this female insect here and a male insect here. Now, how does the male insect get to know that it has a female here so that it will be able to come here to this location. So, in this case the females release some chemicals that are known as pheromones.

So, these are certain sexually attracting chemicals and when these chemicals are released the male gets to know that yes there is a female there and I should go in that direction. Now, you can make use of this information to disrupt their mating cycles. So, what you can do is, you can just say set up a small trap in this area and in this trap you put some pheromones. So, once you have once you know what is the particular chemical that is there in the pheromones, you can just set up a small trap and you can put that chemical here.

So, in that case and when if its concentration is greater than what the female will be releasing; so in that case the male will think that yes there is a female here and it will just go and it will be captured in that particular trap or at least if you are not even using a trap, the male will get confused it will not be able to find the female and in that case it will not be able to mate. So, you can make use of these pheromones or the sex attractions, also for the control of these pest populations.

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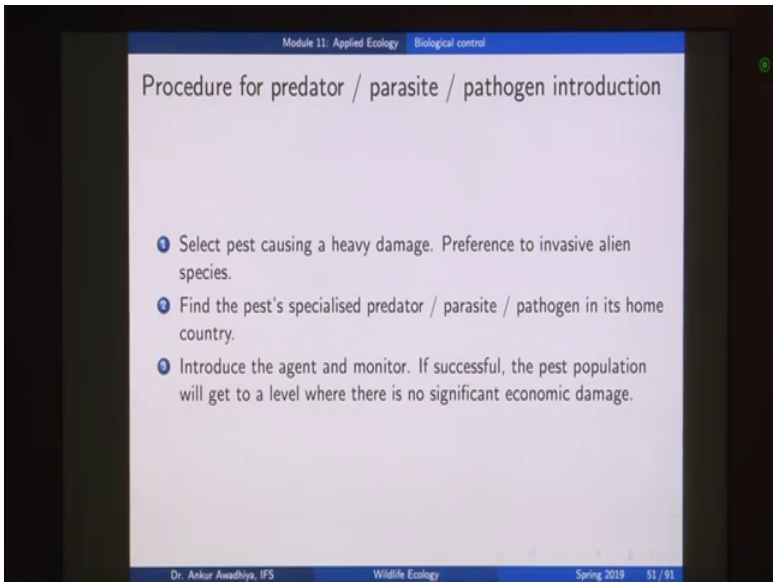

Now, the most common way in which we make use of the biological control is by using the predator or parasite or pathogen because for things such as your pheromones, it has to go with through a number of stages. You will first have to identify what is the chemical. So, you will have to identify the chemical.

Firstly, you will have to purify this chemical from the females and then you will have to identify this chemical, then you will have to find out a method to make it chemically. And in a number of cases these pheromones are extremely specific to the particular species. So, for instance, if you find out the pheromones for one particular species let us say species 1.

So, you have the pheromones. Now, if you try to use it in another field that has pest of species 2, it will not work because these pheromones are extremely species specific. And so, every time you have a new species of pest you will have to go through all of these cycles purify, identify and then make it chemically in large enough amounts and in an

economical way, so, that you can use it for your biological control. So, in a number of cases, it is much easier to find out a predator or a parasite or a pathogen. So, in this case the steps are one you select the pest that is causing a heavy damage and you give preference to the invasive alien species.

Now, why do you give a preference to the invasive alien species? Because, if your species is invasive that means, that it has a very large amount of spread, it is out competing all the natural vegetation or your your native organisms and so, it is a big problem; so you give preference to an invasive species. You also give preferences to alien species. Now, an alien species is a species that is not national to your area, but has come from somewhere else.

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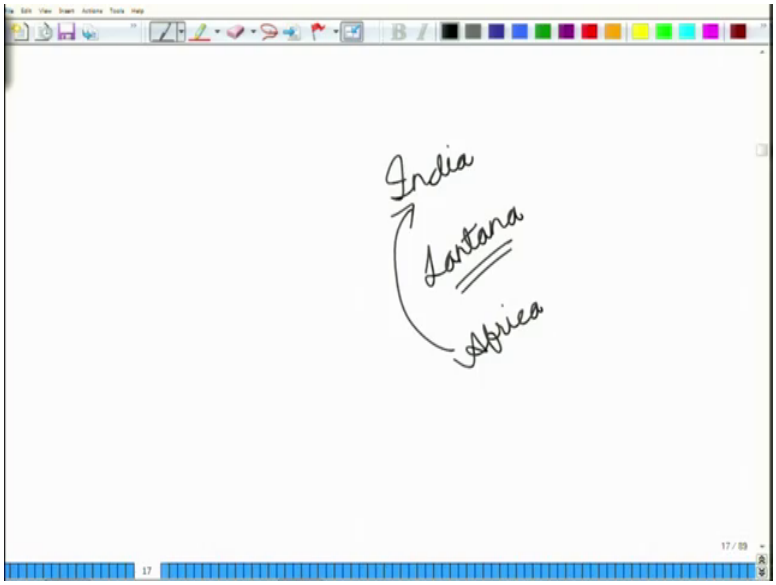

So, for instance, when we talk about India, we have a number of species such as lantana. Now, lantana is a species that is not native to India, but it has come from Africa; so it has come from Africa. Now, in this case because this is not a native species to your area, if you find out a pest or if you find out a predator for lantana so that predator when it comes when you release it in India; it will only be feeding on lantana because this particular predator does not know or it does not like the native vegetation that is found in India.

So, in this case you can increase the specificity because you will find out a predator and this will be a predator that will not be impacting your native species. So, for instance, we

had talked about the role of the birds where is it; this one. So, we had found out, we had discussed about using birds for your pest control.

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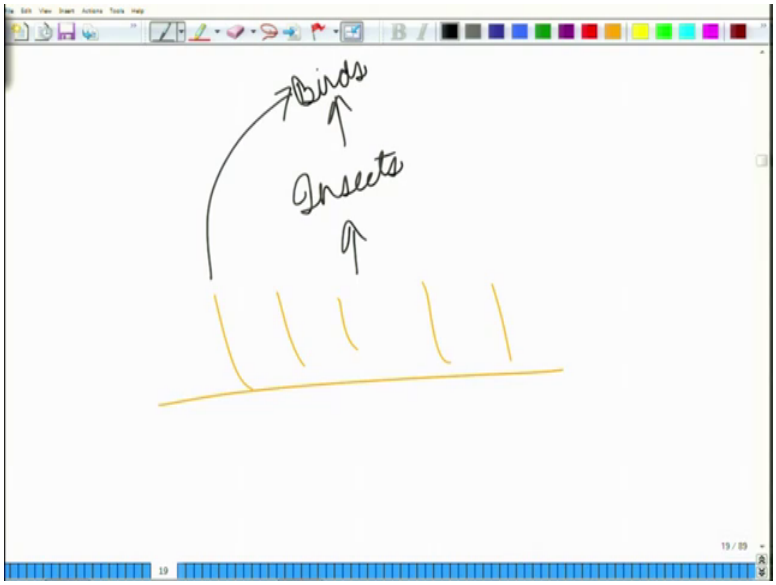

Now, in this case if you have your crop fields and there are see insects that are feeding on your crop fields and you release certain birds into this area, you use it as a natural predator and if these birds start feeding on the crops as well; so that will not serve the purpose. Now, similarly if you find out a species that is an alien species, when you get a predator for that alien species, it should not be one that can eat up your native vegetation.

So, in this case it makes much more sense to go for invasive alien species. Then, you find out the pest specialized predator. Again, we are emphasizing on this word specialized. It should not be a generalized predator, it should not be feeding on anything and everything that it can lay its mouth on. So, you find the pest specialized predator or parasite or pathogen in its home country and then, you introduce the agent and you monitor. If successful the pest population will get to a level, where there is no significant economic damage.

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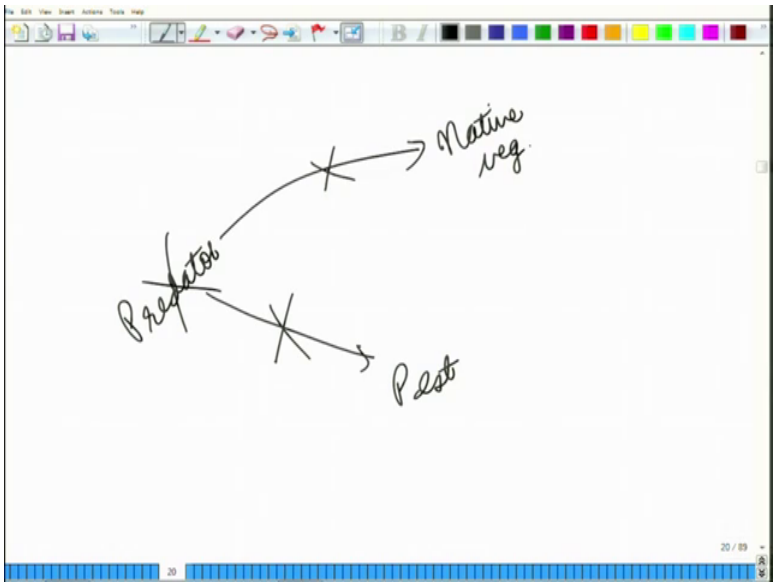

Now, in this particular case when you are bringing in a species from outside and let us say you brought a predator to your country and this predator did not like the pest. So, it is feeding on the pest when it is there in the native country, but it is not feeding on the pest when you have released it in India.

But then there is a large chance that this predator will also not recognize the native vegetation. Now, if that is the case if this predator is not liking the native vegetation, it is not liking the pest. So, in that case in a short time the population of the predator will also go down. So, this ensures that you are not bringing in more and more alien species into your area.

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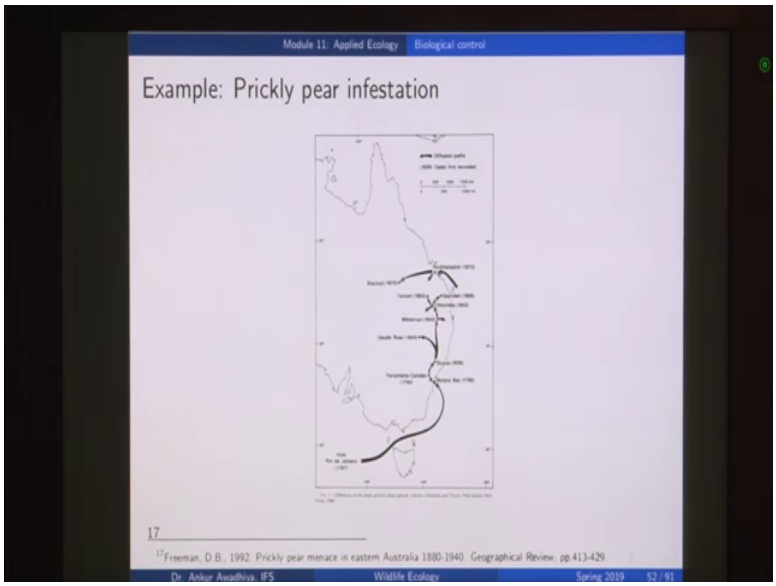

Now, to give an example we look at the case study of the prickly pear. Now, prickly pear is an open share species. So, it is a species of cactus.

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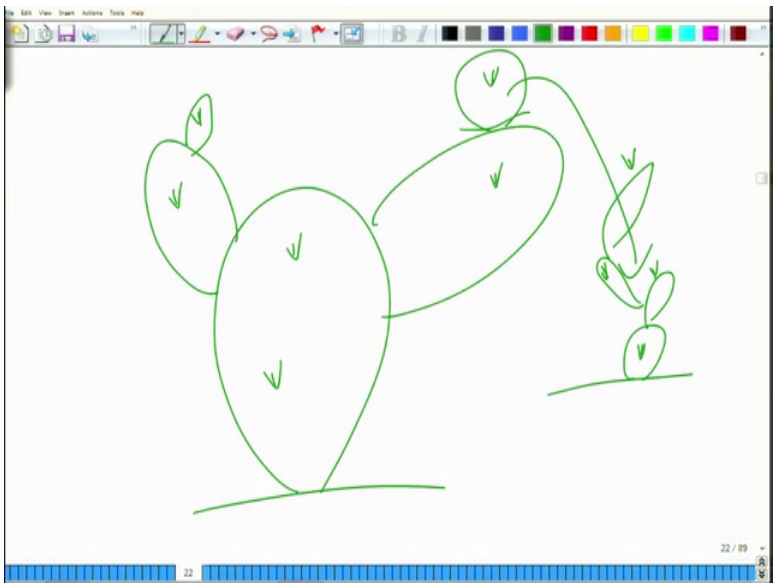

And you will often have seen it in the textbooks; it looks like this and it has these thorns, it is green in colour and also it has a lot of cells that are doing photosynthesis at all times, it is able to store moisture. So, in the case of Australia which is a very dry land, this species is able to grow very fast.

Now, this is species primarily grows through vegetative propagation. So, for instance if there is a huge weight a large wind and if some portion of this pear it gets broken. So, it falls on the ground. So, it will start growing from there. So, it will give out another chute and then it will start growing vegetatively. So, it grows mostly by vegetative propagation. Now, in the case of Australia, this prickly pear was brought from outside it was brought from the Americas because it looks good and people wanted to use it as a hedge plant.

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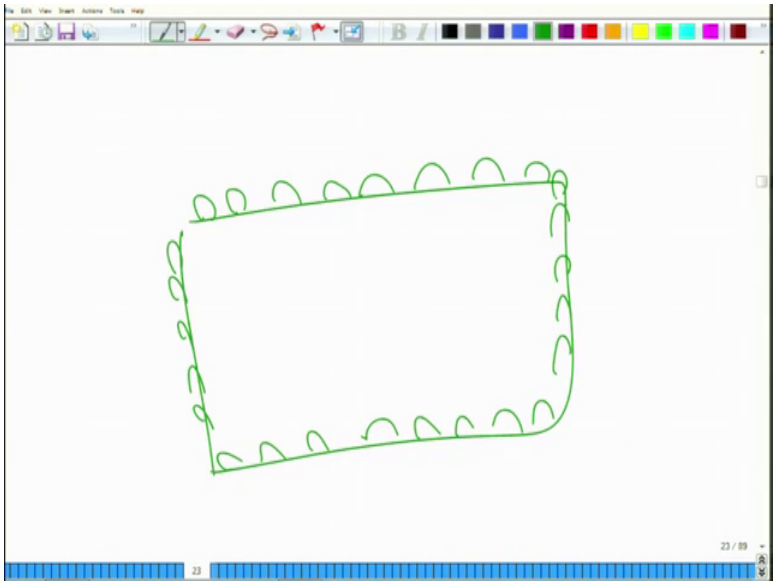

So, for instance if you have your garden, now in place of a fencing this whole garden, you can just grow these open chia on the borders and because it has a number of thorns. So, animals will not be able to get into your garden or into your farm lay for that matter and because it grows very easily, it is very easy to propagate it vegetatively. So, it is a preferred species and it also looks good.

Now, if you look at the invasion of this species in Australia, it started in the year 1787. So, at that time it was brought to these areas and then, through time we can see how it got dispersed to different areas. Now, by the 1920s it so happened that it had become a large size pest.

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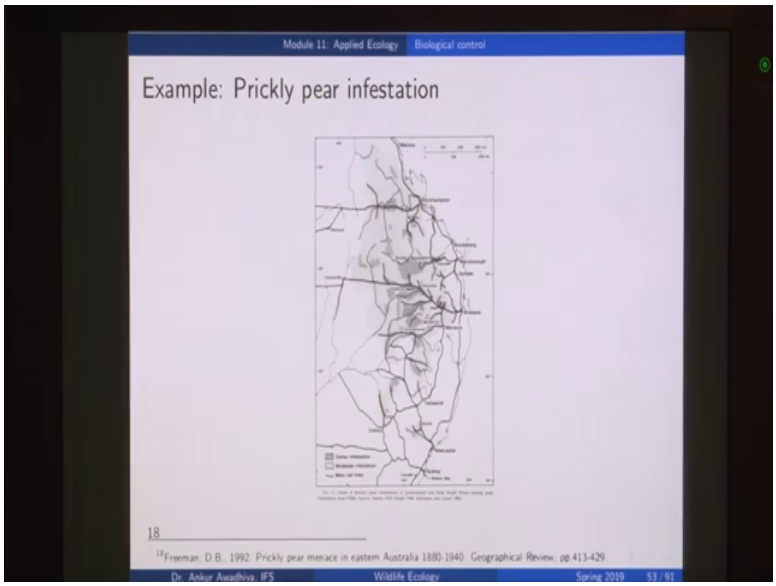

So, in place of being restricted to these areas, it started going into the national environment and its it started establishing itself there. Now if that happens and in the case of Australia because you have a large amount of dry area that is a very suitable habitat for the prickly pear; now if you have a lot of prickly pears, then you cannot use these areas for any other purpose as well.

So, you can you cannot use it for ranching, you cannot use it for cultivation of anything , but then the second problem with prickly pear was that it when it grows it makes a very abundant mat like structure when it is there on the ground.

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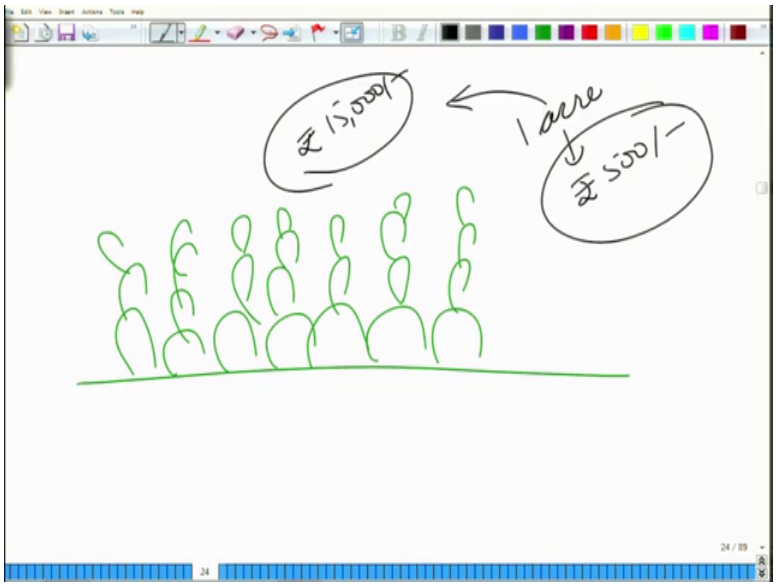

So, you will have this ground and this ground will be full of these prickly pears and in this case if you want to remove these; so it is very difficult to remove these because or of these are having thorns. So, you cannot remove this manually plus they grow very fast. So, even if you have removed these and even if a small portion gets left behind, it will start growing up vegetatively and when you are using these lands for say ranching purposes the cost per unit land is less.

So, for instance let us say that if you have 1 acre of land and 1 acre of land is say costing you 500 rupees because these are very outskirts areas. And the these lands are full of this prickly pear and if you remove prickly pear, if you want to remove this prickly pear; then per acre it is going to cost you say 15000 rupees. So, there is no way somebody would want to buy up a land that is worth 500 rupees and then, pay 15000 rupees for it. Now, this is the situation that happened in the case of Australia.

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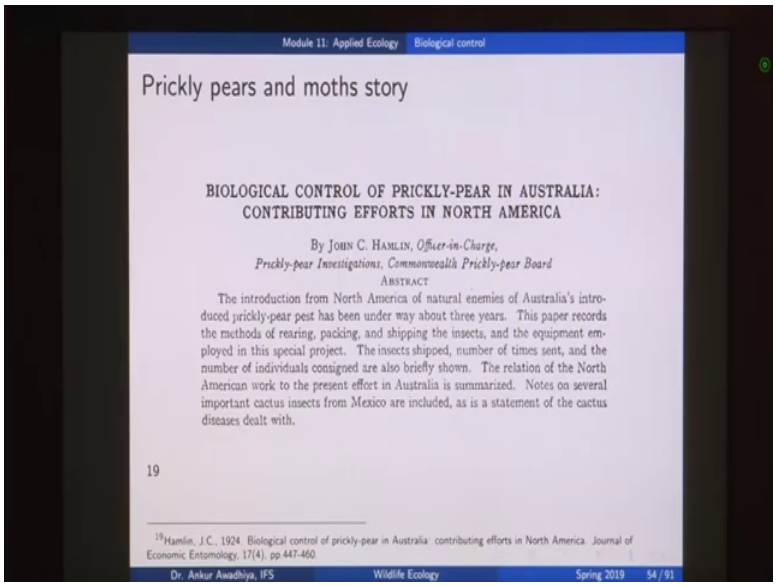

So, people started looking for their predators and their predators could be formed from the Americas and we have this paper and if you look at the year it says 1924. So, this is a the issue of using the biological control mechanisms. It is not a new mechanism, it has been used for a very long time. Now it is nearly a century that it has been in use. Now, it says biological control of prickly pear in Australia contributing efforts in North America. The introduction from North America of natural enemies of Australia's introduced prickly pear pest has been underway about 3 years. So, it essentially started in the year 1921.

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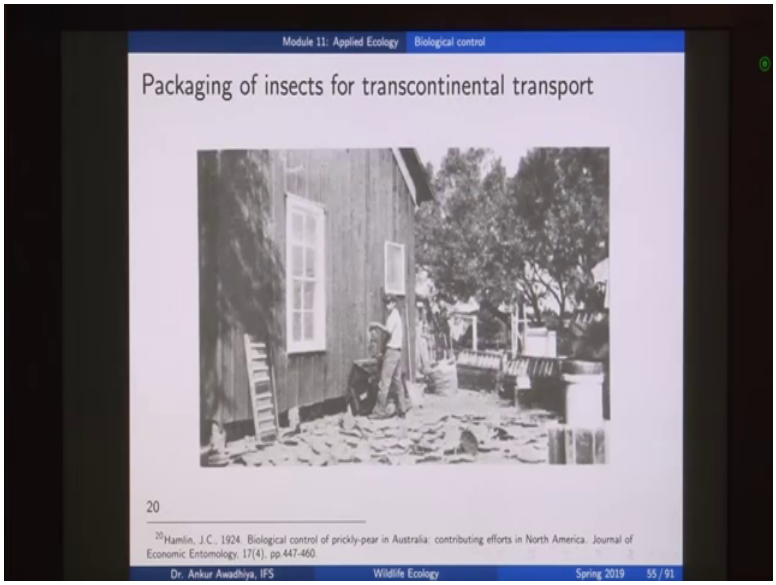

Now, what did people do? They took the prickly pear that was growing in North America and then, from there they started to look at different predators or different organisms that were feeding on it and then, they used to bring out all these prickly pears and then, they would pack it up in these boxes. So, that these could be shipped to Australia and a number of species were tried and most of them did not work, but then there was this particular moth species that actually worked.

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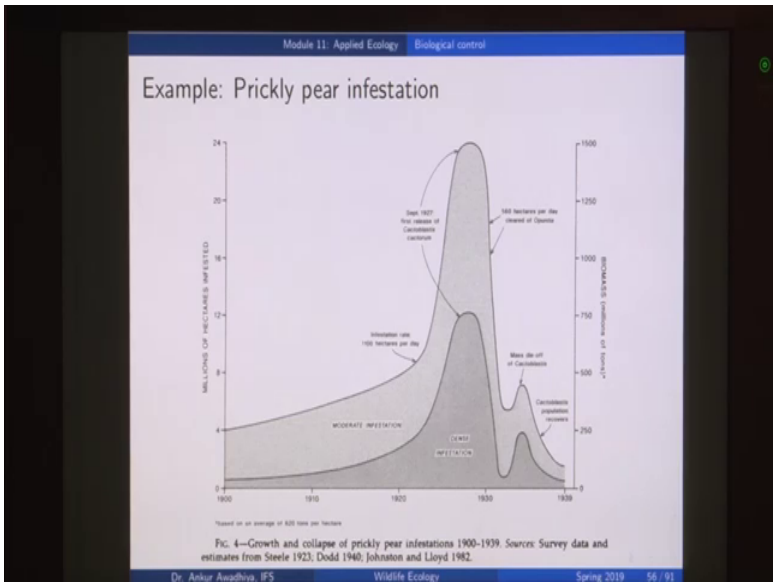

Now, in this case what we are saying is that there was this moth species that is known as captive blasters. And if we look at the growth of the prickly pear; so by 1920s so this job started in 1921 and by this time, you had this much amount of area. So, you have these millions of hectares; so roughly you had 7 million hectares that were all full of prickly pears.

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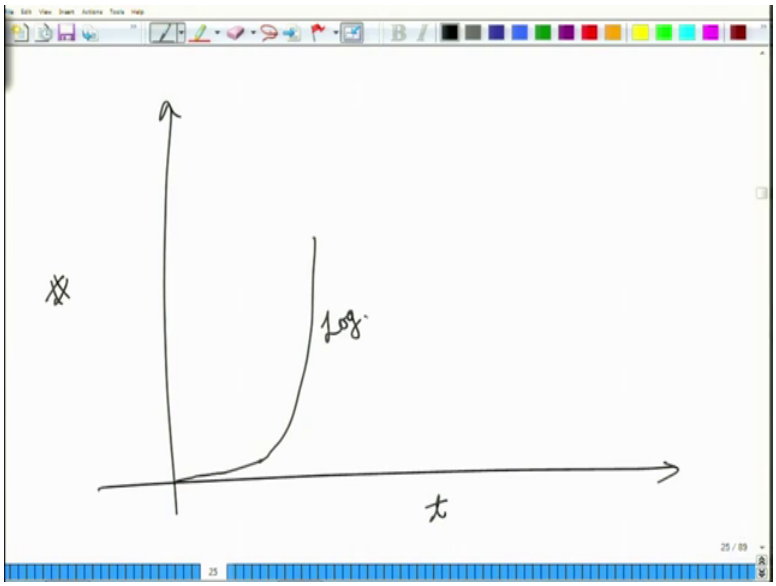

Now, we have seen in the case of population growth curves that if you have a species that has been introduced into an area. So, here if you look at the number of organisms versus time; earlier the growth will be very less because it is in the lag phase. Now, in the lag phase you do not have enough number of parents for the population growth, but then it will start getting into the log phase. Now, here we can see a very similar thing.

So, here we have a lag phase till this time and then we have started getting into the log phase. Now, in the log phase it says that we had as many as 1100 hectares of area that were getting infested by prickly pear every day. Now, we are not talking about weeks or months or years 1100 hectares every day were getting infested because of these prickly pears.

So, once they started looking at different predatory species for this and then in September 1927, they started realizing these particular moth and now you can see how the population declined. So, it started declining right there, but then in a very short time it declined completely. Now, what does this moth do?

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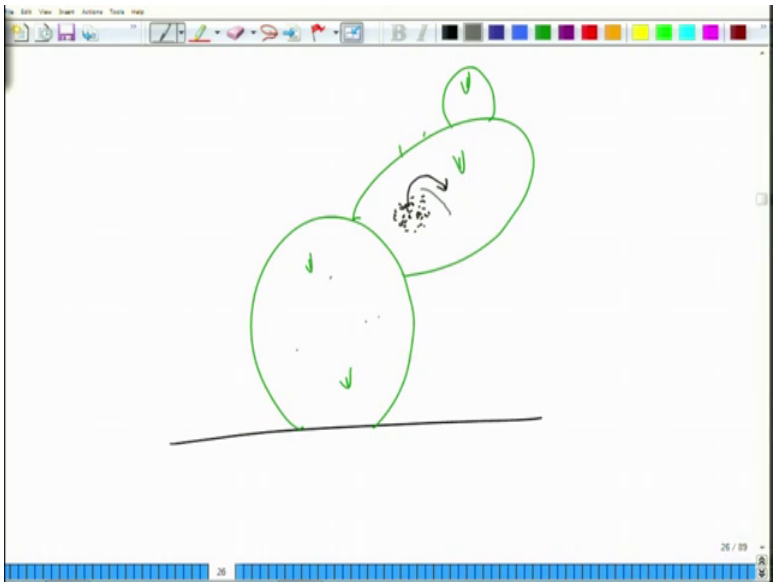

So, this moth when it infects a prickly pear; so let us say this is the prickly pear, the characteristic of this particular species is that it lays its eggs in a large cluster. So, there will be a large cluster of eggs that will be laid on one particular plant. So, you have a number of predators that are attacking the same plant at the same time. Now, what will these eggs do? When the larvae come out, they will start getting to the inside of this prickly pear and they will start eating it from inside.

Now because you have a large number of insects, a large number of larvae that are there on the same plant; so there is a very little chance that this plant is going to survive because there are so many predators that are feeding on it at the same time. Also when these larvae get to the inside when they have made these holes in the plant; so a number of other pathogens can also enter through these holes.

So, we have a number of bacteria, some fungi that also infect these plants once these holes have been made. And because this is a concerted effort that is happening on one particular plant at one time; so we see a large drop in the population of the prickly pear. Now, again if you remember the class on population dynamics, we have the pre population.

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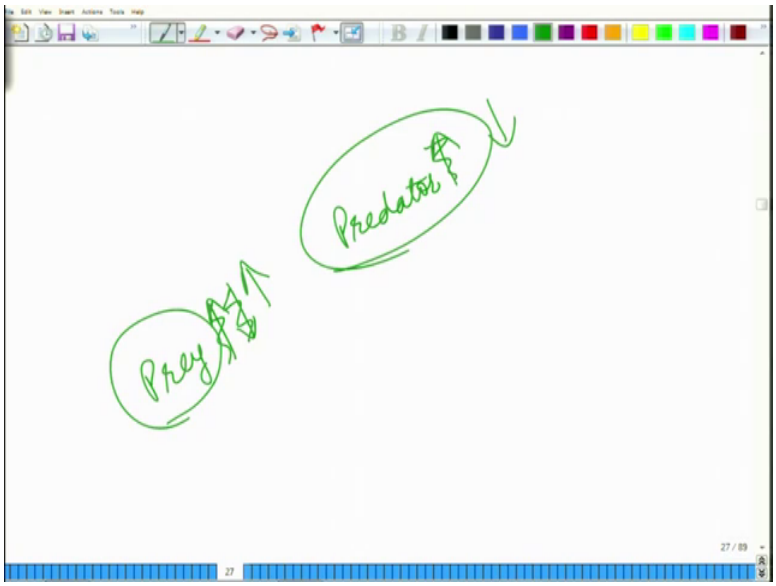

So, in this case you had a large number of prey and you release the predator. So, the predator started feeding on the prey and the prey population started reducing and at the same time the predator population started increasing because they were having ample amount of food. Now, after a while you will get a situation where you have a very small prey population and you have a large population of the predators. Now, in that case when your prey population is less, the predator population will start to crash.

So, it also starts reducing because it does not now have ample amount of food that is available. Now, once that happens and when the predator population goes down, then we see another increase in the prey population because, now you do not have ample number of predators to predate upon the prey and this is what we are seeing here in the natural circumstances build.

So, the prey population in this case the prickly pear it dropped and then it started increasing again and here the cause was a mass mortality or in the case of the predator population. Now, after a while they again started to increase in numbers and then they started to feed on these prickly pears again and then the population has now been brought under control.

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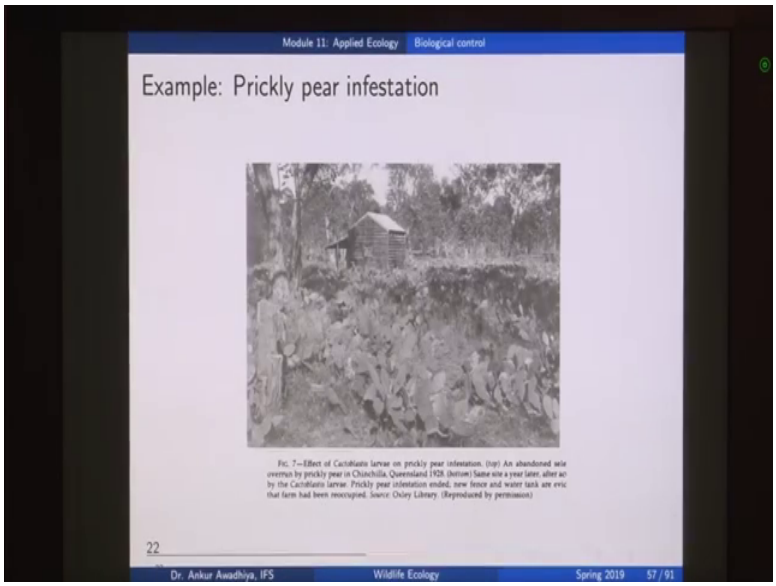

Now, if we look at the situation of before and after, here you are seeing a particular ranch area where you have this house and all this area is now full of prickly pear. Now, if you have so many of these cacti that are there in your ranch, you will not be able to grow any crops, you will not be able to use it for ranking, you will not even be able to get to your house. So, in this case the house gets abandoned, but then if you look at the picture right 1 year after.

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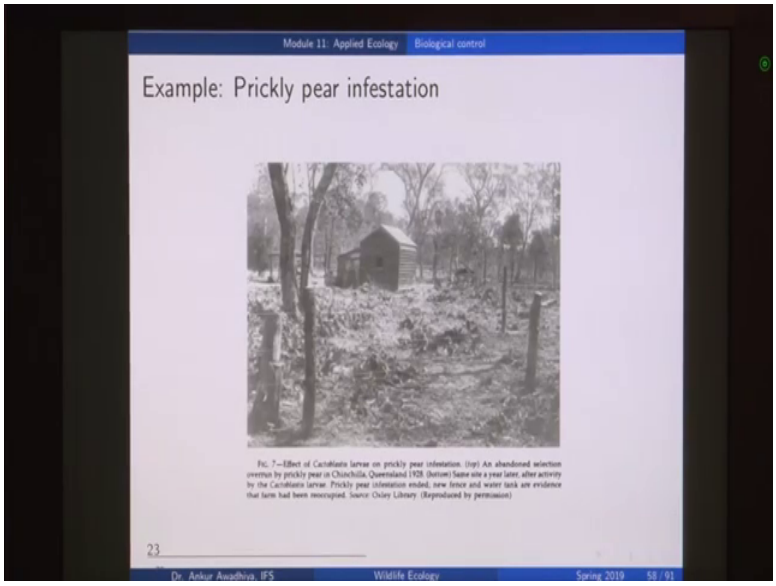

So, here we can see that all the prickly pears, they have been eaten up and so, there is no prickly pears that is seen in this area. Now, biological control in this way is very good because the impacts will be very dramatic if you are able to release a large number of the predators.

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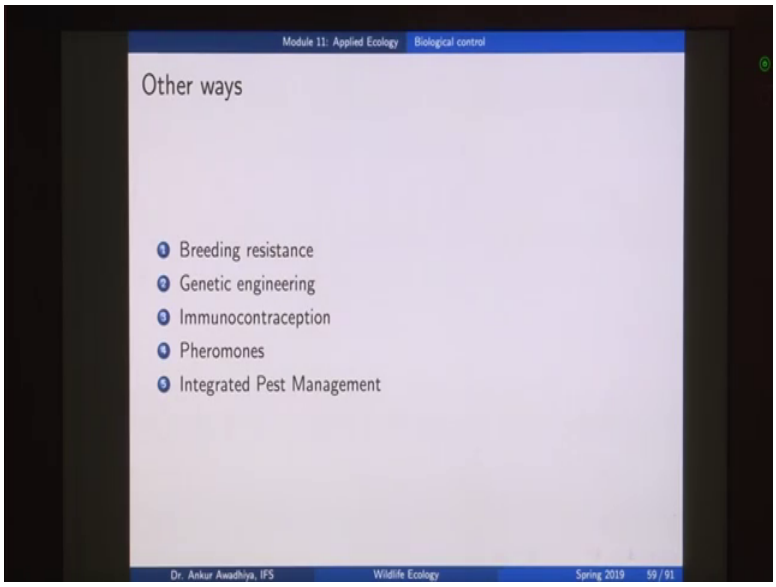

Other ways of doing the biological control including breeding for resistance; so for instance if you have your crops such as the wheat crop.

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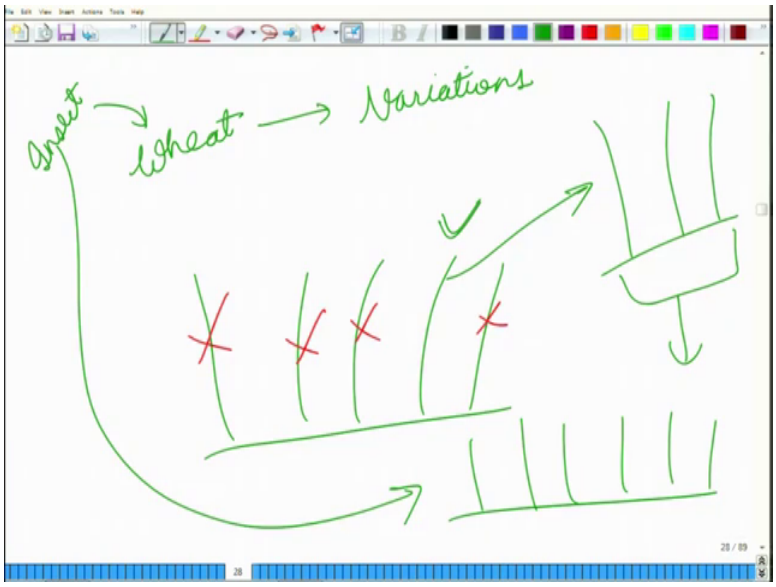

Now, wheat again if we talk about it in the evolutionary terms, every population will be having some variations. So, when a wheat is getting infested because of some insect, there will be certain plants or there will be a number of plants that will die off, but then there will be certain plants that are spared because they have certain specific traits that make them more resistant to the impacts of this particular insect.

Now, in the case of breeding what you do is that you select for these plants and then, you made these plants together. So, you have a number of plants that are now that you know that these are resistant to this particular insect. So, in case of collecting seeds from everywhere you only collect seeds from here and then, you use this as a founder population to get a number of wheat plants.

Now, all of these will or say most of these will be having the characteristics of resistance to this particular insect. So, now when this insect tries to invade into this particular crop, it will not be able to kill off a number of wheat plants. So, this is known as breeding for resistance. So, in this case you are not reducing the number of your pest, but at the same time you are generating resistance in your crop so that it is able to resist the pest. The second option is that of genetic engineering. So, you would have heard of BT cotton.

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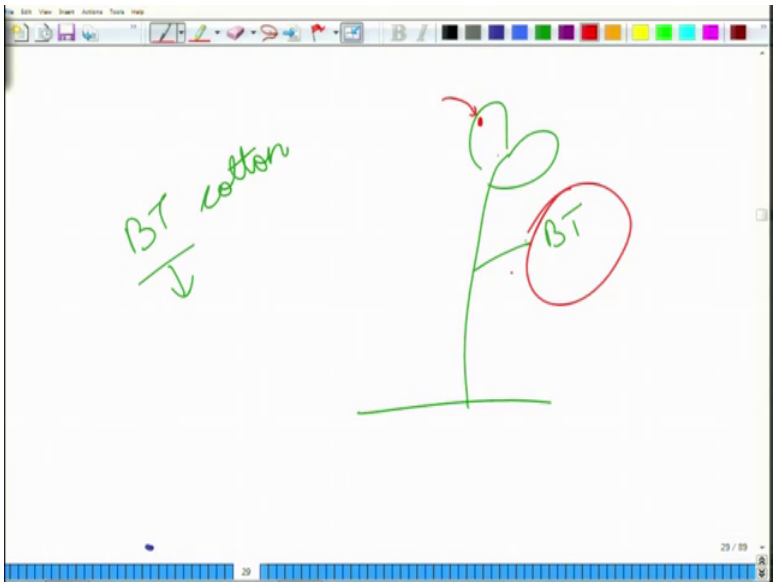

So, when we say BT cotton, here BT refers to a particular bacterium which is known as Bacillus Thuringiensis. Now, this is a particularly bacterium that produces a protein that is known as a tri protein and when insects eat this particular protein, then this protein will

get into their intestines and it will kill off those particular insects. Now when you introduce this particular gene into your crop of cotton; so you will have a cotton plant and in this plant, it is all the cells of this plant they are also producing the same BT protein or the tri protein.

Now, in this case if you have an insect that is coming and trying to feed on this plant, the insect will get this protein and the insect will die. So, you can make use of genetic engineering also to control your pests or you can make use of Immunocontraception. Now, in the case of immunocontraception which is generally used in the case of deer populations when they are becoming pest, what you do is you can take out.

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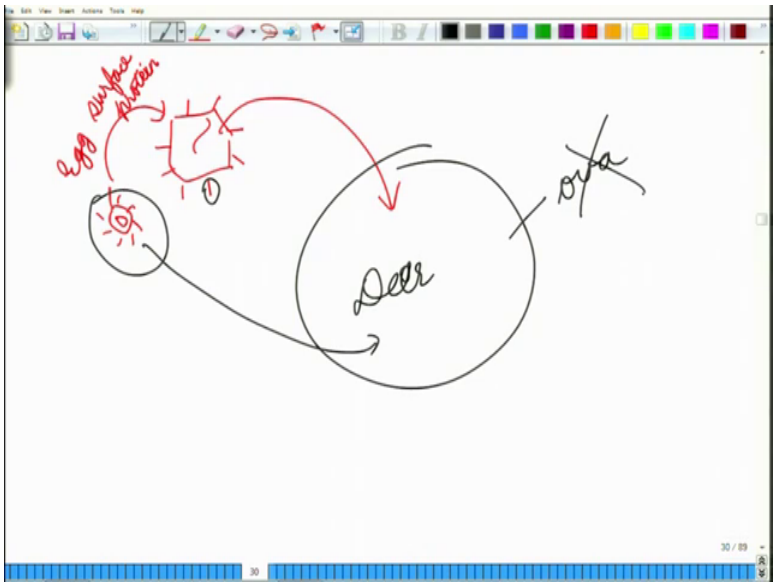

So, let us say you have this particular organism which is a deer. Now, in this case if you look at an egg of a deer. So, this egg will be having some surface proteins. Now, you can take one of these proteins out and then, you can probably grow it inside a virus. So, now, you have made a genetically engineered virus that is showing this particular surface protein on its surface.

So, you are putting the egg surface protein onto the surface of the virus. Now, you infect your deer population with this particular virus. So, what will happen? The deer population every individuals will start giving off an immune response. Now, this immune response will be against the surface of the virus. Now, the surface of the virus is now having the egg protein; so or the ex phase protein.

So, what will happen in this case is that you will have a number of antibodies that are made in this deer. So, you have a number of antibodies that are made in this deer which are against this particular protein that is being shown in the surface. Once that happens you will have a situation that all the eggs that are there in the female deer's they will also be acted upon by the antibodies and now this deer will be will become infertile because it does not produce any ova. So, all the ova that are inside these deer are killed and so, this deer becomes infertile.

So, you can make use of things that are known as immunocontraception in which case you are using the immune system to perform contraception of these animals or we can make use of pheromones as we have seen earlier in the case of insects or you could go for integrated pest management which we will come to in a short while.

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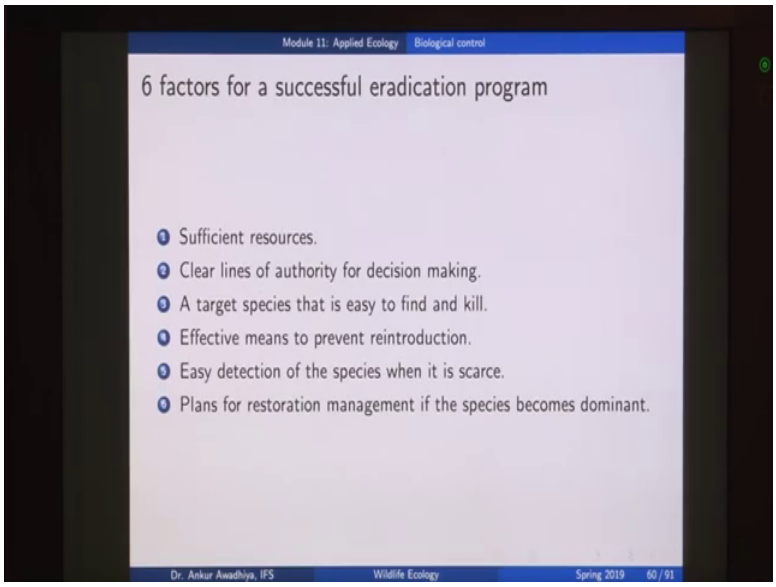

Now, there are 6 factors if you want to have a successful eradication using your biological control. You should have sufficient resources. Now, in this case you when we talk about prickly pear you needed to go to America and get different kinds of predators for your prickly pear bring them to Australia breed them so that you have a large enough population release them; do some controlled release; look at the experimental results and then release them at a larger scale; all of this requires time, all of this requires money and all of this requires manpower. So, you need to have sufficient resources. You need to have clear lines of authority for decision making.

So, if you are bringing these predatory insects from Americas into Australia. So, there has to be a mechanism that you are getting permission from the customs for instance. If you want to release it in some area you should have the power to make the decision to release these insects. So, clear lines of authority are also needed. You need to have a target species that is easy to find and kill; in this case the prickly pear was very easy to see and you need to have an effective means to prevent reintroduction.

Now, it does not make any sense if you are killing off the prickly pear and people are bringing prickly pear again to use in their gardens; so that it releases again into the environment. So, if you are going for any such mechanism there has to be an effective means to prevent reintroduction. So, you need to tell everybody that they should not be bringing more and more prickly pears and they should not be using these prickly pears in their gardens and probably some amount of penal pellets as well.

Then, you need an easy detection of the species when it is scarce. So, even if you have say a few prickly pears that are remaining somewhere you need to know that they are there. Because if you stop your biological control after a while, then these prickly pears might again start to grow. So, in that case you need to have a way of finding out each and every individual in this area so that you can exterminate the population completely for a complete eradication.

And in the case of prickly pear, it has not yet been eradicated, so, even though it has been going on for nearly a century we still have some patches where we have prickly pear. So, the process is still on. So, it takes time and you need to have plans for restoration management if the species becomes dominant. So, probably if in this case if the moth became a dominant species, you would need some mechanisms to control that as well.

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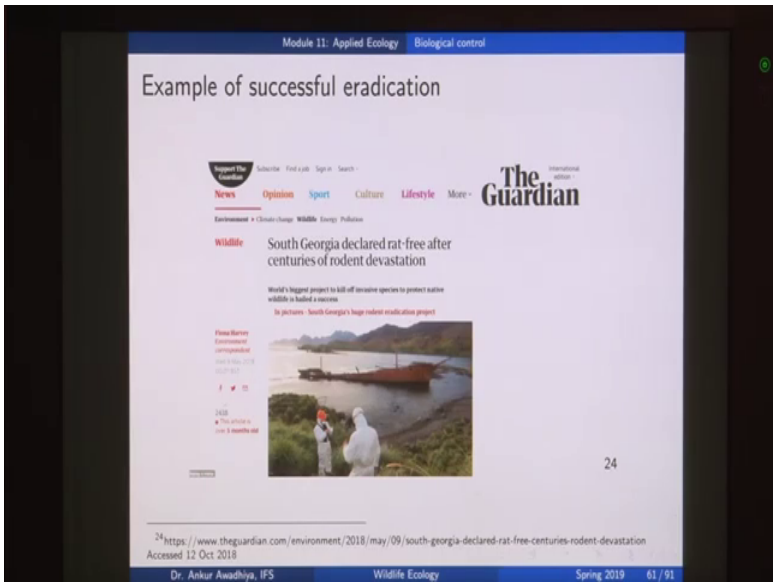

And a good example of successful eradication is these islands the South Georgia Islands, where all the rodents were taken off. So, they were given baited pills with that were laced with poison and now you do not have any rodents on these particular islands.

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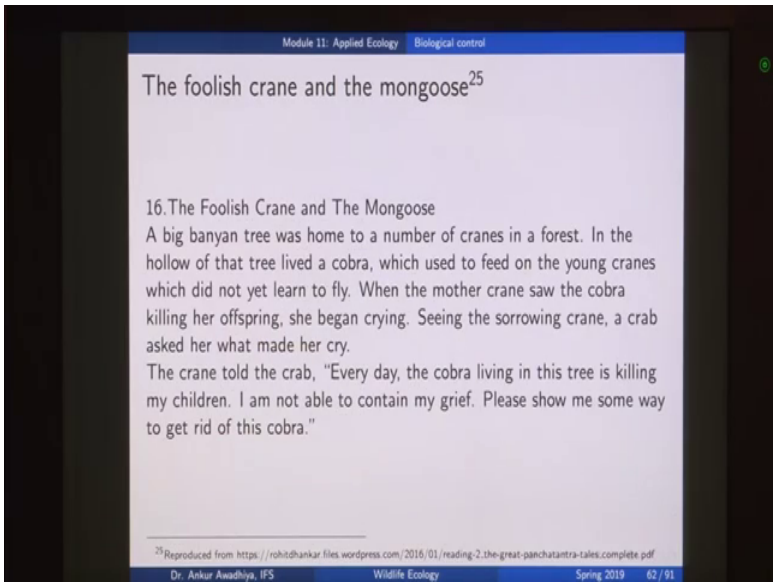

Now, before we move forward, there is this particular story from the Puncha Tantra that plays a role in the case of biological control. So, this is the story of The Foolish Crane and the Mongoose. A big banyan tree was home to a number of cranes in a forest. In the

hollow of that tree lived a cobra, which used to feed on the young cranes which did not yet learn to fly fry.

When the mother crane saw the cobra killing her offsprings, she began crying. Seeing the sorrowing crane, a crab asked her what made her cry. The crane told the crab, “Every day, the cobra living in this tree is killing my children. I am not able to contain my grief. Please show me some way to get rid of this cobra.”

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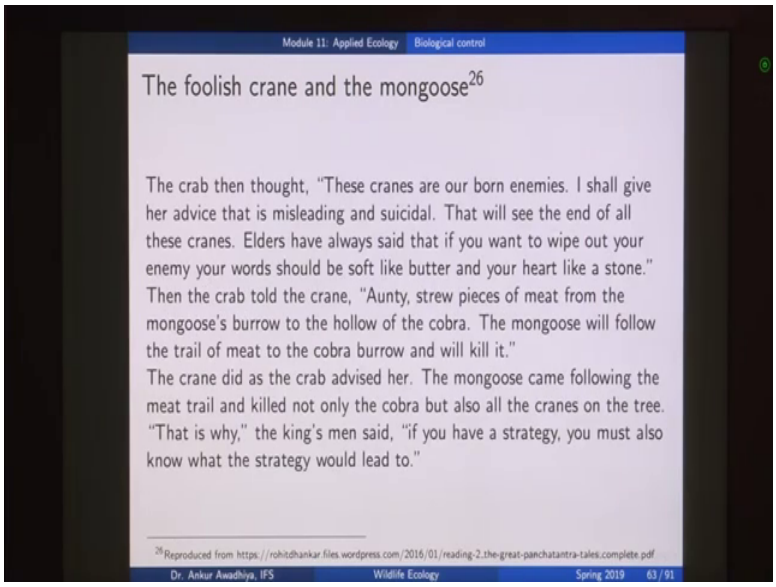

The crab then thought, “These cranes are our born enemies. I shall give her advice that is misleading and suicidal that will end see the end of all these cranes. Elders have always said that if you want to wipe out your enemy your words should be soft like butter and your heart like a stone.” Then the crab told the crane, “Aunty, strew pieces of meat from the mongoose’s burrow to the hollow of the cobra. The mongoose will follow the trail of the meat to the cobra burrow and will kill it.”

So, in this case what the crab is suggesting to the crane is to use a biological control in the form of a mongoose. So, we are seeing very similar situation here.

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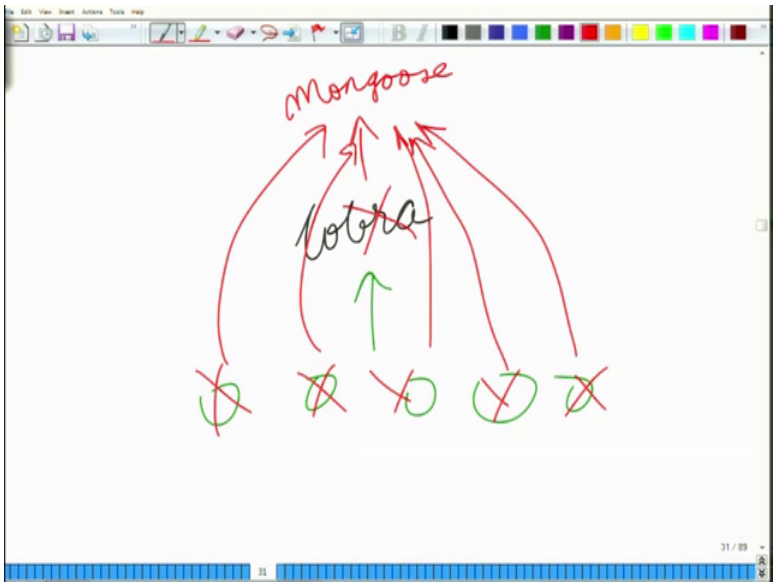

So, you have a population of cranes that is being eaten up by a cobra and now the crab is suggesting that why do not you bring a mongoose to this area so that the mongoose feeds on the cobra and the cobra is destroyed. The crane did as the crab advised her. The mongoose came following the meat trail and killed not only the cobra but also all the cranes on the tree.

"This is why," the king's men said, "if you have a strategy, you must also know what this strategy would lead to." So, in this particular case this biological control failed because the mongoose ate away the cobra, but then it started feeding on all of these cranes and so, the crane population also decimated. So, all of these cranes also died; only the mongoose remains now.

So, whenever we are bringing in any particular species that is used for a biological control, we need to ensure that this species will not have a negative influence on our native vegetation, on our other crops, on the people who are living in this area, on the animals that are living in this area. So, all of this is extremely important.

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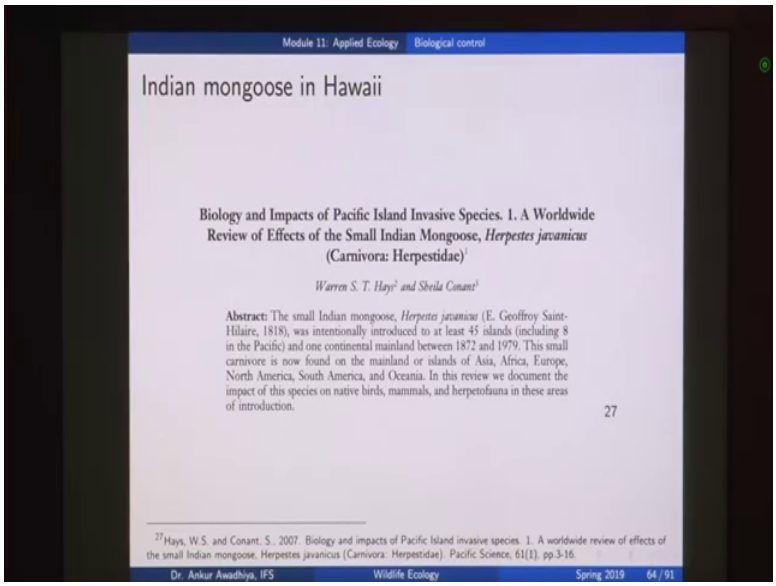

And the twist to this story is that the Indian mongoose has now become a pest species in Hawaii. Now, in the case of a number of Hawaii and Islands, the small Indian mongoose was introduced to these islands. Now, it was introduced to remove some pest and then, it removed the pest and now it has become a pest in itself which is the same story as what we have seen in Puncha Tantra.

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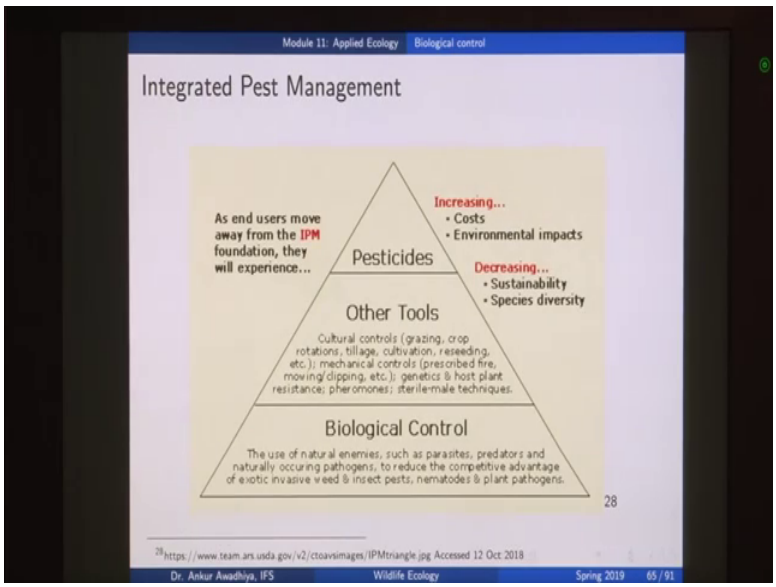

So, this brings us to the next topic which is integrated pest management. Now, in the case of integrated pest management, we integrate all these different options that are available

with us. So, we have the options of biological control, we have the options of pesticides, we have the option of cultural controls and so on. Now, biological control is probably one of the most cheapest options because you bring these predators, the predators prey on the pest, the pest population goes down and at the same time the predator population increases and the more number of predators you have the more amount of pest that is getting killed.

So, this is one of the cheapest options that you have, but then you need to integrate it with the other options. So, along with the biological control, you should also have the cultural controls. So, for instance things like crop rotation. So, you put you make use of biological controls, you make use of cultural controls, you probably make use of some amount of pesticides where they are essential and then it is not either or situation, it is using both of these at the same time.

So, in this particular lecture we had a look at biological control. So, we started with what is the pests, what are the kinds of damages that it does, what is an ecological damage, what is an economic damage, when do we call a pest a controlled pest, when do we call it an uncontrolled pest and then, we looked at different options that we have. We looked at the option of using pesticides, but then pesticides have their own issues, they are extremely cost intensive, they require a huge amount of labour to put those pesticides and they also inflict a very great amount of damage to the environment.

So, we have other options one of the options is a natural control which makes use of the load curve volterra dynamics that we have seen. So, if the pest population increases, the population of their predators will also increase. We make use of some cultural operations in which case we burn up the crop residues or we go for crop rotation and things like that or we can go for a biological control which is essentially in amplification of the natural control. So, in the case of a biological control you bring in the predators of your pest species, you grow them in an artificial environment and then you release them; so that they are able to eat all the pest.

Now, biological control has worked in a number of situations, but then in some situations the predators that were released to kill off the pest also became a pest in themselves and a good example is the Indian mongoose. So, we need to think which method will work in which scenarios. Even in the case of biological control, we should go for in for a

controlled release in a very small area earlier and then if the results are good if we see that these predators are not killing of other organisms; only then we should be going for a large scale operation.

An integrated pest management makes use of all these different options that are available to us so that we have an effective control over the pest at a reduced cost and without having much impacts on the environment. So, that is all for today.

Thank you for your attention. [FL].