Wildlife Ecology
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Lecture – 14
Population growth and regulation

[FL]. Today, we will carry forward our discussion on to on population ecology. We will look at some numerical examples of different population parameters and then we will move forward to look at the theories of Population growth and regulation.

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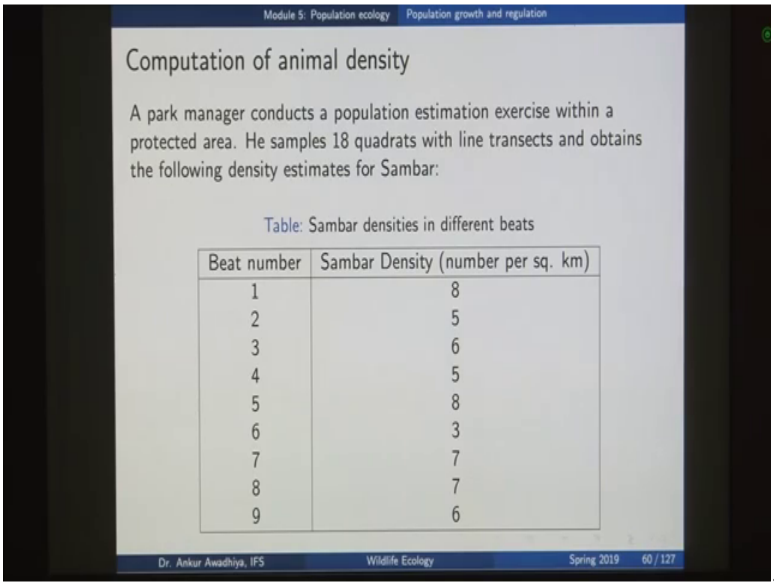

So, this is the first problem that we look at. A park manager conducts a population estimation exercise within a protected area. He samples 18 quadrates with line transects and obtains the following density estimates for sambar. So, here you have 18 different transects 18 different areas.

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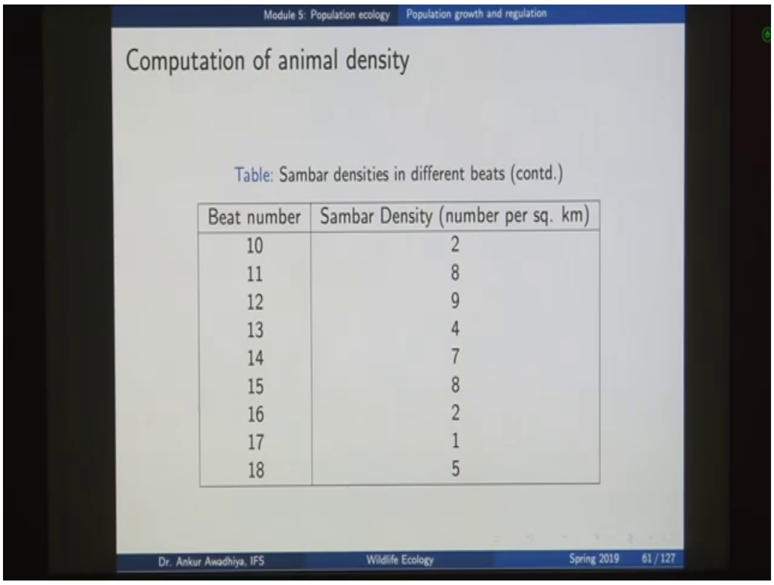

And we will consider that all of these beats have the same area and the sambar density, then all of these areas is figured out and the number per square kilometre is given here. Now the question is what is the average sambar density that is found in the park?

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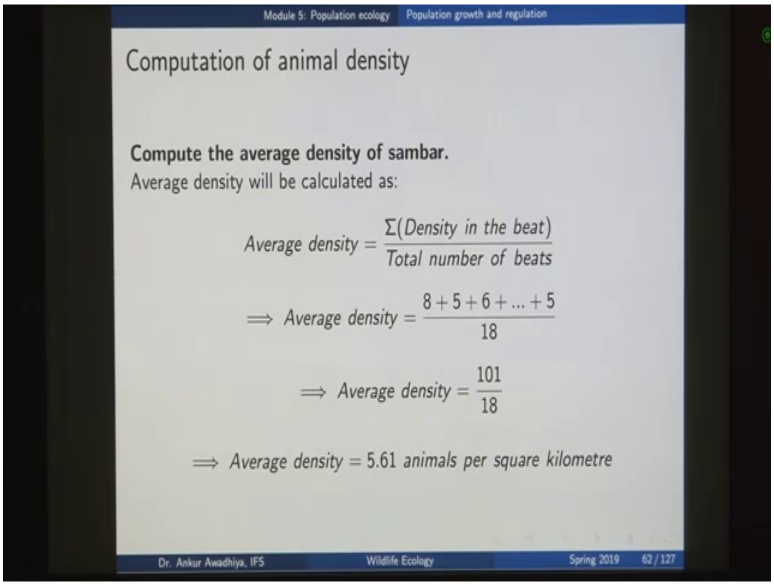

And we will make this assumption that these 18 beats are all the beats that we have here and the area is more or less homogeneous. When this case the average density of sambars will be given by some of these different densities that we have in the table, we have 8 plus 5 plus 6 plus 5 and so on till the last value which is 5 to till the 18th value which is 5.

So, we make a sum of all these different densities divide that by 18 and then we get the average density is 101 divided by 18 of 5.61 animals per square kilometre. So, this is a simple example of how we use sampling to get one estimate for the whole of the population. So, we took 18 different samples and for all of these samples, we computed the sambar density is using line transect.

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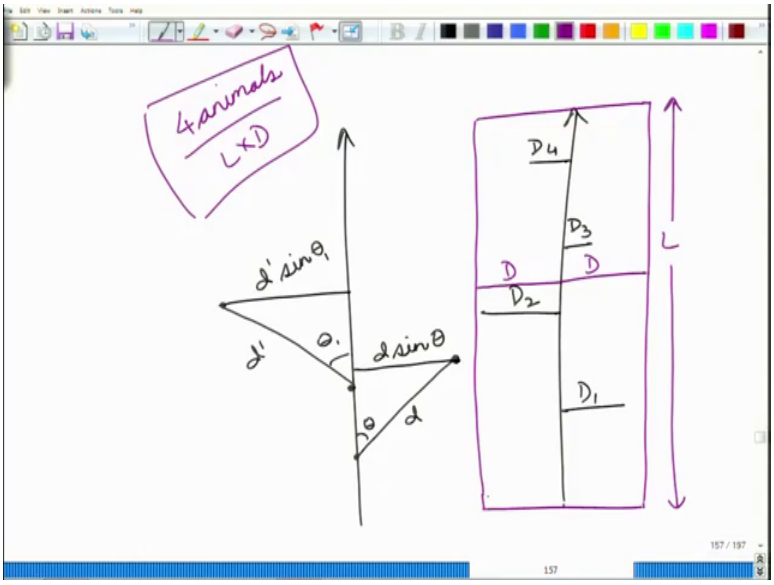

Now line transect is a method in which we move along a straight line. So, this is how we are moving and every time we spot an animal and suppose we are here. So, when you spot this animal we find out this distance and we find out this angle was that is done we can find out the perpendicular distance. So, if this is d this distance will be d sin theta.

So, this is the first distance then we saw an animal here and this was our location to probably this distance, this 1 is d 1 this one is theta 1. So, this one becomes d 1 sin theta 1 and so on. And by all of these different perpendicular distances we can compute the area that we have worked in total; so, with all of these different distances. So, let us call these as D 1 D 2 D 3 D 4 and so on with all of these we will find out a mean distance of the animals from this area.

So, suppose this mean distance comes to be say this value of D. So, this distance of D to the right and this distance of D to the left. And in this case we have observed 4 animals and with this mean distance we compute the area that has been covered by us. So, this is the area that has been covered. So, suppose this length is L. So, the area is L into D and from this we get the density of animals per square kilometer. So, this is what we have done and we have computed all these different densities and we can take a simple average of all of these different densities to find out the average density of sambars in this area.

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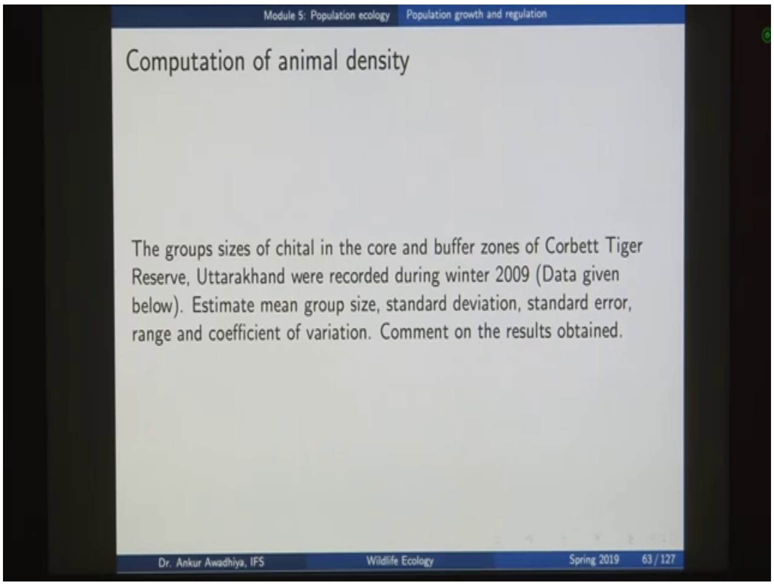

Now, such computations can then be extended. So, this is the second question the group sizes of chital in the core and buffer zones of Corbett Tiger Reserve Uttarakhand were recorded during winter of 2009 and the data is given. Estimate the mean group size standard deviation, standard error, range and coefficient of variation comment on the results obtained.

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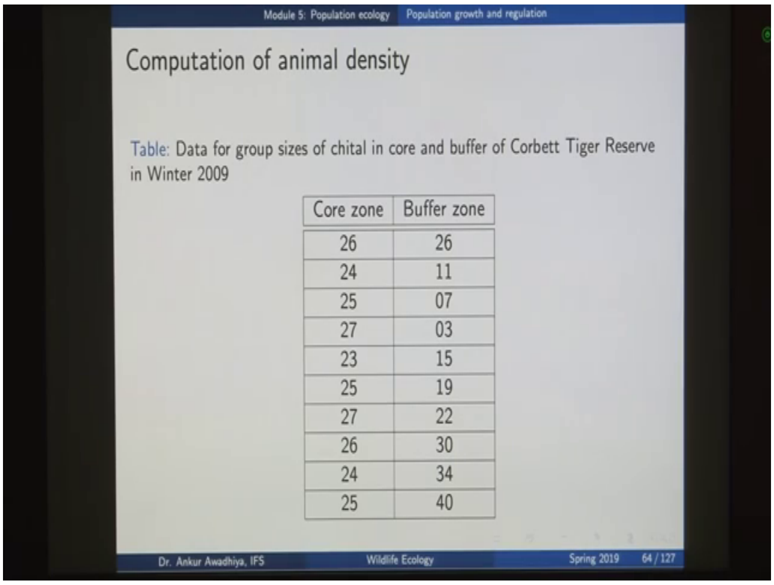

So, similar to what was done before here we have group the sizes of different groups. So, earlier we had densities in different areas, here we are looking at different groups and the sizes of all these different groups.

So, in the core zone we saw so, many groups and these were the number of animals in each group 26 24 25 27; so, these are all close together. Here are the values in the buffer zone. So, this is 26 11 7 3 15 and so on, so, there is a very large amount of variation. Now what kind of inferences can be make out of such a data? So, we begin by looking at the mean group size now for the mean group size what you do is, you take a total of all of these. So, for the core you make a sum of all of these and then the number of groups is 1 2 3 4 5 6 7 8 9 10. So, in these 10 groups this was the total number of animals that was seen. So, what is the mean group size?

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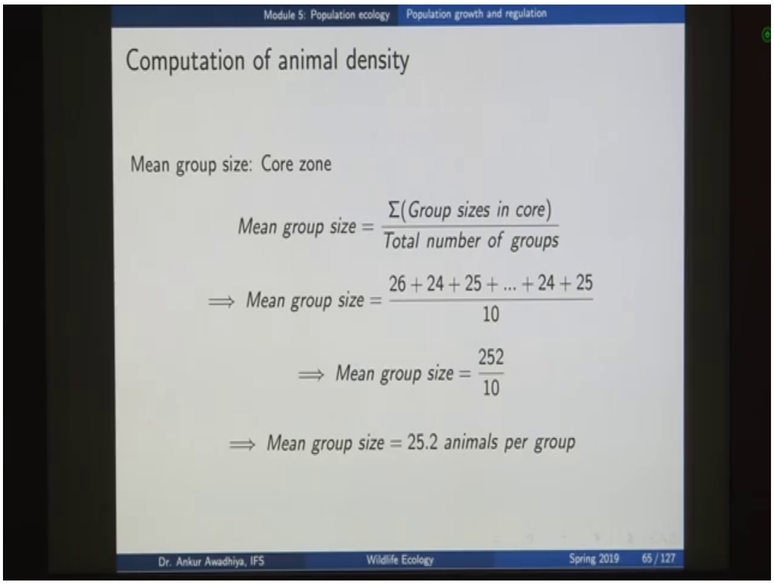

So, the sum of all the group sizes and the core divided by total number of groups. So, that comes to 252 by 10 which is 25.2 animals per group in the core area.

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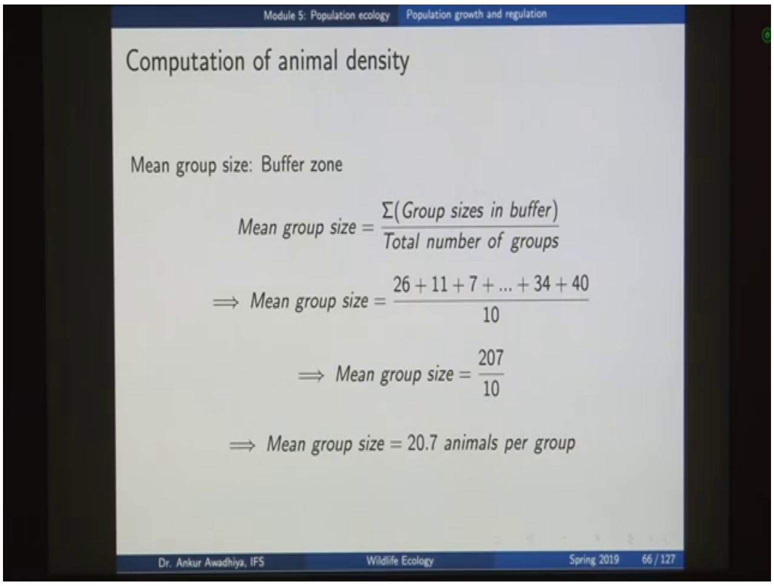

And similarly you can repeat this process for the buffer area. In the buffer area the number of animals per group is 20.7. So, one thing that we can see here is that the number of animals per group in the buffer area is less than the number of animals per group in the core area. Now by code we have such a difference; we can then correlate this to the ecological parameters that are found in this these 2 areas.

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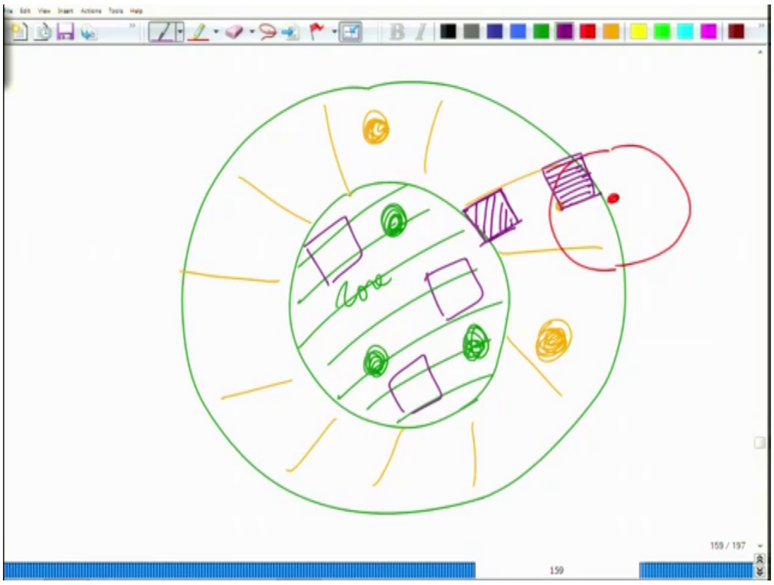

So, typically if you consider any tiger reserve. So, we have this core area, the core area lies in the centre and in this core area you have less amount of human disturbances and this area is relatively left untouched. Now this area on the outside goes by the name of the buffer area. Now why is this area called a buffer area? Because you might have say a village here. Now if you have a village there are situations that people might want to get into a tiger reserve or into a forest and cut some wood for firewood or maybe you have some animals that are living in the village and their getting into the forest areas for grassing or maybe you have some dogs that are living in the village in these dogs are also getting into the forest areas.So, for all of these different influences whether it is for firewood, whether it is for animals such as cows or for animal such as dogs or for things like pollution or the amount of dust that is being released or the sounds that are released, we can define a zone that goes by the name of the zone of influence of this village. Now we want to have this core area completely untouched. So, which is by we create a buffer region.

Now, in the case of the buffer region, you can have some zones of influence, but then this buffer region acts as a buffer. So, that the core is completely kept secluded. Now in the case of the buffer region you will be having grasses, but then probably the chitals will have to compete with the cows or maybe probably the chitals will have to remain vary of the dogs that are coming to this area.

So, in that case it is possible that chitals trying to avoid this area which is something that we can observe by looking at the numbers of chitals that are found in this area and also the group size of chitals that are found in this are.

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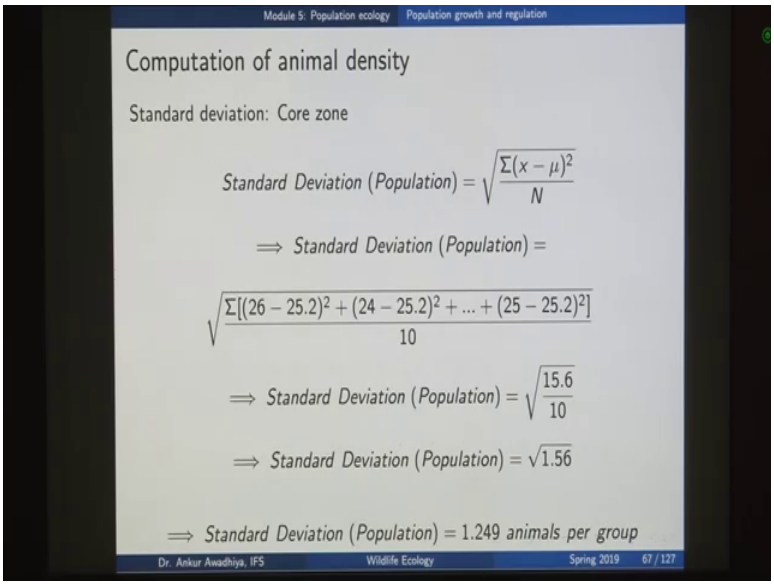

Now, from the group density, we can then move on to the standard deviation. Now standard deviation for the population is given by the square root of sum of deviations. So, in this case mu is the average value that we figured out earlier x is all the different values.

So, in the case of core, we saw that the averages 25.2 and the values are 26 24 25 and so on. So, when we are computing the standard deviation we will have these values 26 24 and so on minus 25.2 you take a square of all of these add all of these and divide them by the total number of observation that you have made. So, here you have 10 number of observations, you do this you get to a standard deviation which is 1.249 animals per group.

Now, what does standard deviation tell you? It tells you what is the amount of variation that we are seen in the group sizes. So, here the variation is 1.249 animals per group.

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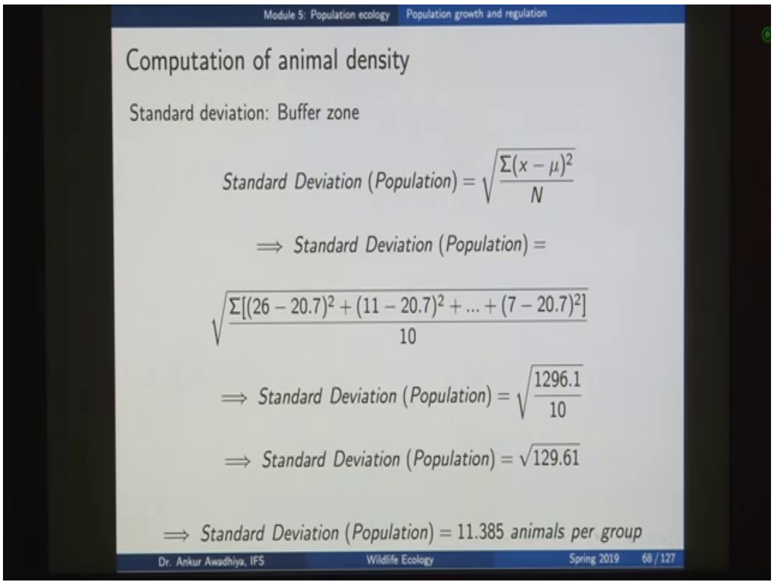

Whereas, in the case of buffer area when you repeat the same observation, you can see that the standard deviation is much greater 11.385 which gets as an indication that in the case of the core areas all these different groups are much more homogeneous.

So, if you look at a group here or a group here or a group here all of these groups are having the same sizes. But in the case of the buffer region if you are seeing a group here probably it has a smaller size, a group here has a larger size, a group here has probably a medium size and so on. So, the amount of variation in the group sizes is less in the core and its more in the buffer regions in this particular example.

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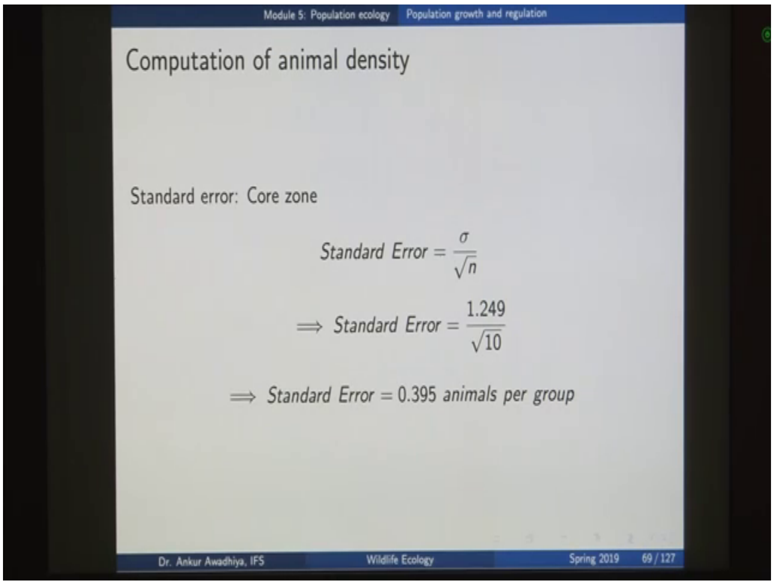

Now, from the standard deviation we can move on to find out the standard error, which is another way of expressing the same thing. So, standard error is given by sigma by root n. So, in this case for the core zone it comes to 0.395 and in the case of buffer it comes to 3.6.

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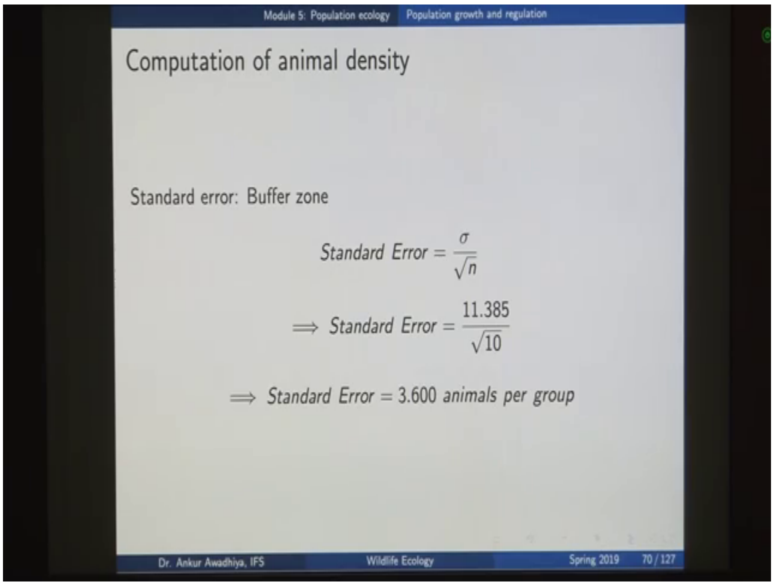

So, here also we are seeing that in the case of the buffer zone, the standard error is much greater than that in the core zone which is another indication that the group size is much more heterogeneous in the case of the buffer.

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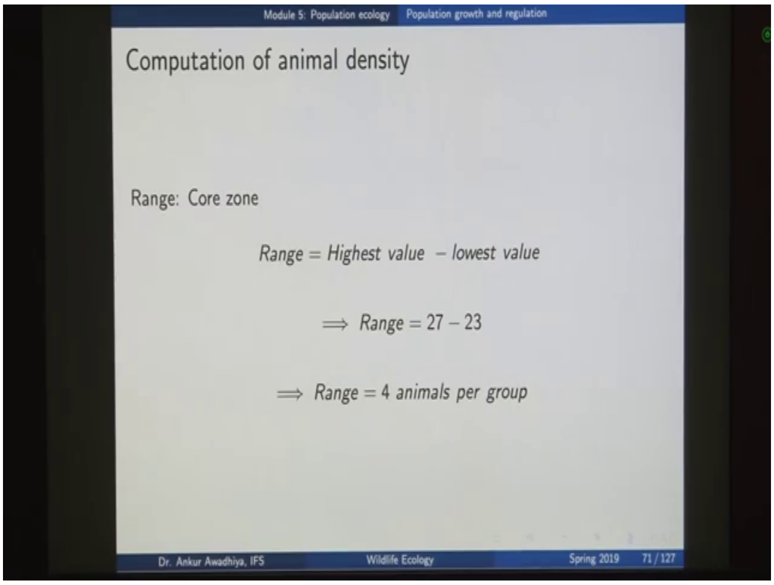

Then we can compute the range of these values. Now range is given by the highest value minus the lowest value. Now in the case of the core region all the group sizes for nearly the same the largest one was 27, the smallest one was 23, so, the ranges 4 animals per group.

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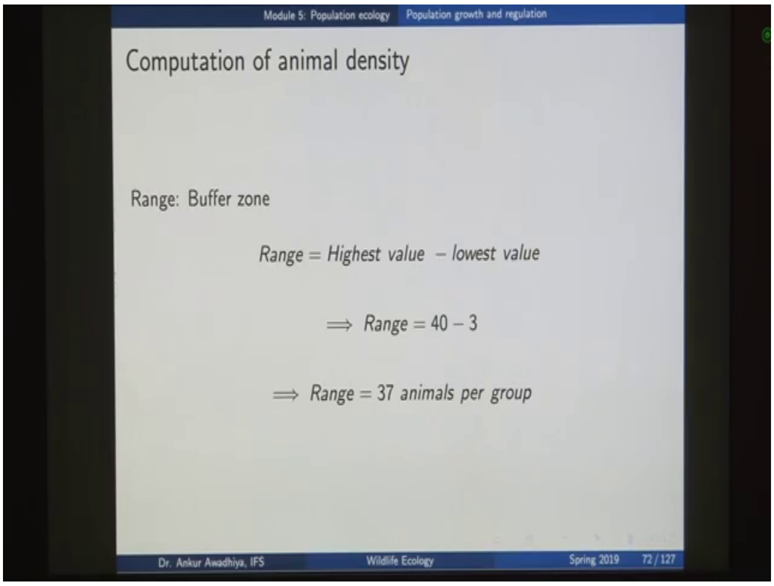

Whereas, in the case of the buffer zone groups, the largest size group was had 40 animals the lowest size group had 3 animals.

So, here the range is very large, so, we have 37 animals and the range. So, this is also telling this the amount of heterogeneity that is there in the buffer groups.

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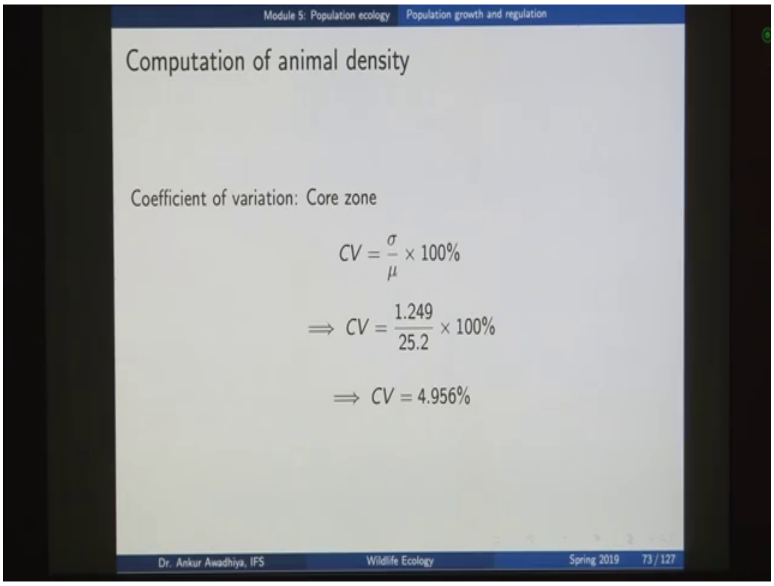
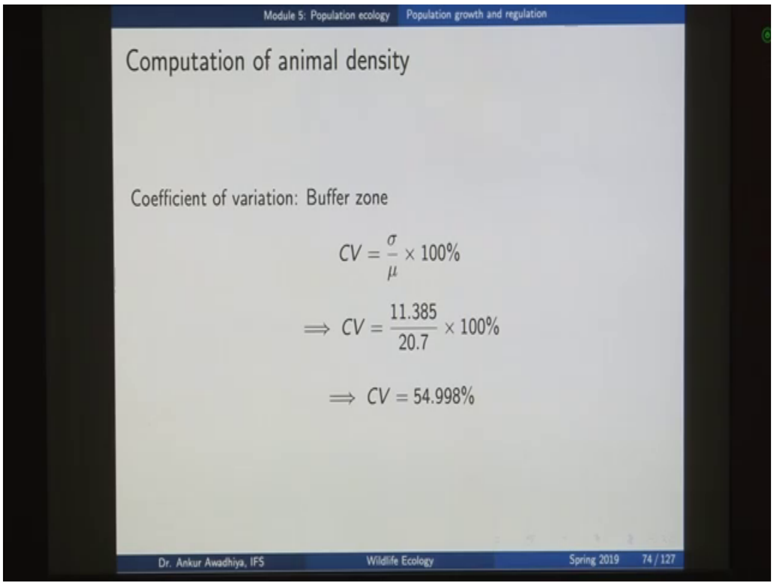


From here we can move on to find out the coefficient of variation. Now coefficient of variation is a term that helps us a look at these differences these variations very easily. Now in this particular example we had 10 groups in the core and we had 10 groups in the buffer area. So, that makes a comparisons very easily, but suppose in the core we had say 25 groups and in the buffer we only had 10 groups.

So, in that case when you want to make a comparison between both of these statistic. So, we go for a coefficient of variation. Now coefficient of variation is defined by sigma which is the standard deviation divided by the mean which is given by mu into 100 percent. So, it is asking this question what is what percentage of the mean value is the standard deviation. So, in the case of core it comes to 4.956 percent or close to around 5 percent, in the case of buffer it comes to 54.998 percent or close to 55 percent. (Refer Slide Time: 12:38)



So, in the case of core we are saying that the standard deviation is just 5 percent of the mean value. In the case of buffer the standard deviation is as much is 55 percent of the mean value. So, in this way we can make comparisons between both of these groups even if they have different sizes.

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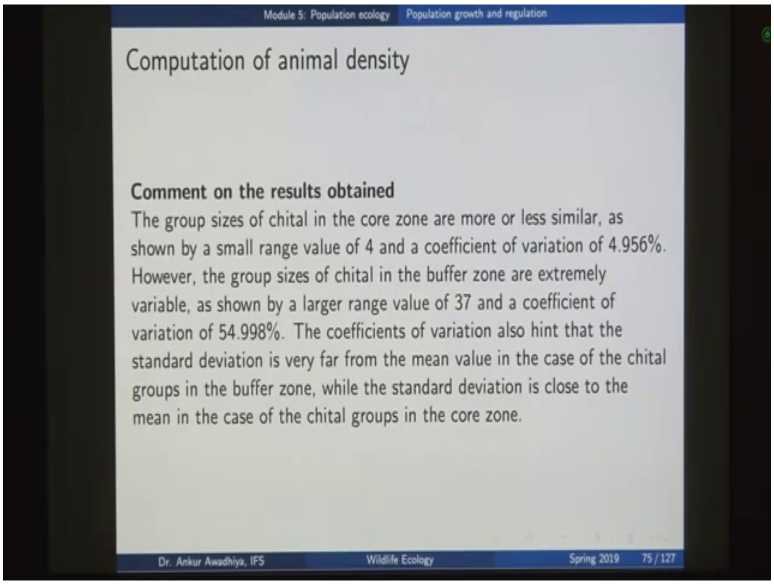

So, what do we infer out of these values? Now, the inferences that, the group sizes of chital in the core zone or more or less similar as they shown by this small range value and the small coefficient of variation of 5 percent. However, the group sizes of chital in the buffer zone are extremely variable as shown by the larger range value of 37 and coefficient of variation of 55 percent. These coefficients the coefficients of variation also hint that the standard deviation is very far from the mean value in the case of chital groups in the buffer zone, while the standard deviation is close to the mean in the case of the chital groups in the core zone.

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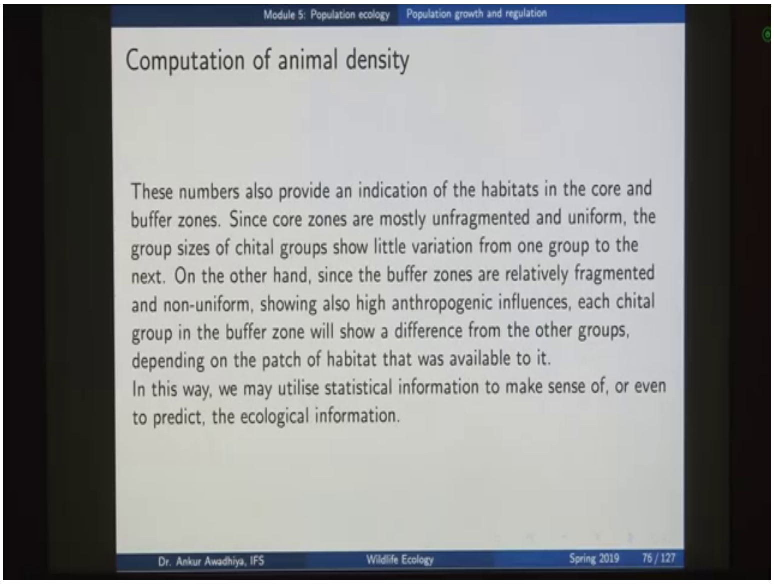

Now these numbers provide an indication of the habitats in the core and the buffer zones now the core zones are mostly unfragmented and uniform. So, the group sizes of chital groups show little variations from one group to the next. On the other hand since the buffer zones are relatively fragmented and non uniform, showing also high anthropogenic influences each chital group in the buffer zone will show a difference from the other groups, depending on the patch of habitat that was available to it. In this way we may utilize statistical information to make sense of or even to predict the ecological information.

So, what we are saying here is that, if we considered the chitals in the core zone. So, this zone and this zone and this area are all the same there is hardly any difference. But then in the case of the buffer zone, if there was a chital group that was residing here versus chital group that was residing here that would make a very big difference. Because this particular chital group is close to the core zone, it is away from the zone of influence of the villages and so, it is having a much more protected environment in which to grace and in which to increase its population. Whereas, in this particular chital group it is so, close to the human influences that, it might be having a vary to print impact on the on the group behaviour.

So, in this case because the amount of variation is greater in the buffer area, in the amount of variation is less in the core area so, that is also manifesting itself in the group sizes of chital in the core area and the buffer area. So, just by looking at group sizes of animals in different areas, we can mix some inference about what is going on in the ecological terms, which also makes it very pertinent to know different population parameters. So, in the last lecture we looked at different population parameters, in this lecture we are making a correlation between what the population parameter said and what is the actual ecology of that area. If we are seen differences it means that there is some ecological undercurrent that is flowing there.

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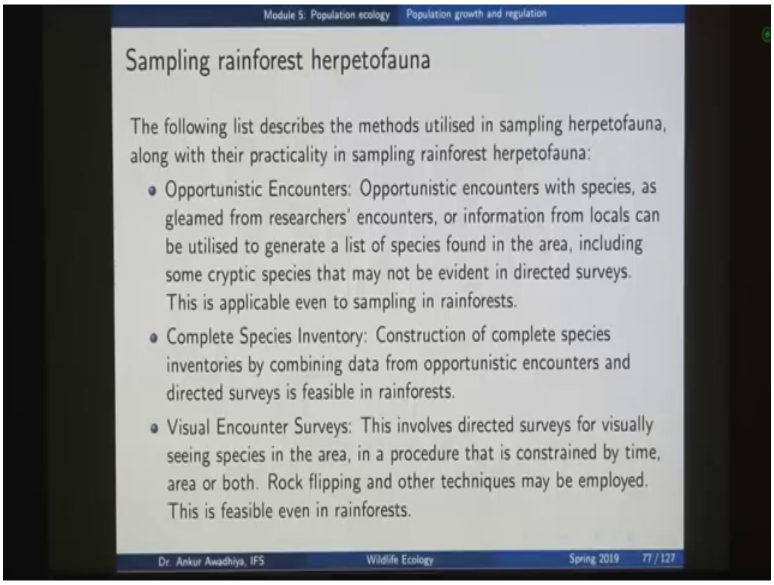

Next we look at sampling of rainforest herpetofauna. Now in the case of larger animals, it is easier to see the animals to count the animals to get to a density of animals what about this smaller animals? If you wanted to say no the number of snakes that are there per unit area in a forest. So, how do you go about and catch a snake? A snake will not make itself visible to you because you want to count this snakes. This snake would probably lie beneath some rock or maybe it would lie in some tree, but so on.

What about other smaller animals, which is see frogs in the case of frogs you want to know how many frogs are there per unit area. So, how do you make an estimate of the number of frogs? You can very easily see the number of tigers that are there in an area, but frogs are very difficult to see and count.

So, what are the methods that we make use of? So, in the case of rainforest herpetofauna, harpetofauna is basically reptiles and amphibians these are the methods that are available; one is opportunistic encounters. So, opportunistic encounters with the species has gleamed from the researchers encounters or information from locals can be used to generate a list of species that is found in that area including some cryptic species that may not be evident in directed service. This is applicable even to sampling in the rainforest.

So, there is a rain forest you want to know how many animals are there, what are all species of animals are there. So, we looked at the species discovery curve or the species accumulation curve.

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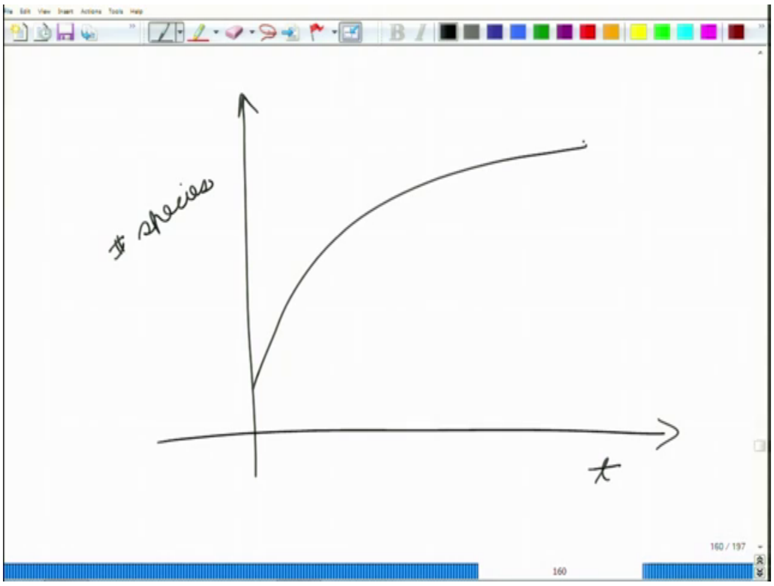

And which you have this time on the x axis and the number of species on the y axis. And we saw that it increased and then it started breaking to a level of saturation now to know more and more about the species that are found in a rain forest area you could go for an opportunistic encounter opportunistic encounters means that you went into the forest and there was a chance encounter of some animal.

So, you went into the rainforest and you saw a frog that was red and yellow in colour and probably you had never seen this frog before. So, in that case we will add 1 more species to the species accumulation curve so, that is an opportunistic encounter. Now opportunistic encounters can also be used to understand the relative population densities of different animals in the rainforest. So, you went into a rainforest in say January and you saw that there were say 5 animals that you saw in the whole period of 1 day. You went again you saw 4 animals; you went again you saw 6 animals. So, on an average you are seeing 5 animals per today.

Now, you went to the same rainforest in the January of the next year and probably you are seeing only 2 animals per day. So, that would give you an indication that the population size is reducing. So, that is an opportunistic encounter. The second method is complete species inventory; construction of complete species inventory by combining data from opportunistic encounters and directed surveys is feasible in rainforest. So, you are just increasing the amount of effort that you are putting in to get to a very close approximation of the number of animals and the number of species that are found this area.

Next is visual encounter survey. This involves directed surveys for visually seeing species in an area, in a procedure that is constrained by time area or both. Rock flipping or other techniques may be employed and this is feasible even in rainforest. Now what do you do in the case of a visual encounter survey? We will get into the rainforest and you will say that I am going to survey this area for the next 1 hour. In this 1 hour you are putting all your attention all your effort into seeing and counting this species. So, what you will do is suppose you are looking for frogs in that area; so, you get into this area.

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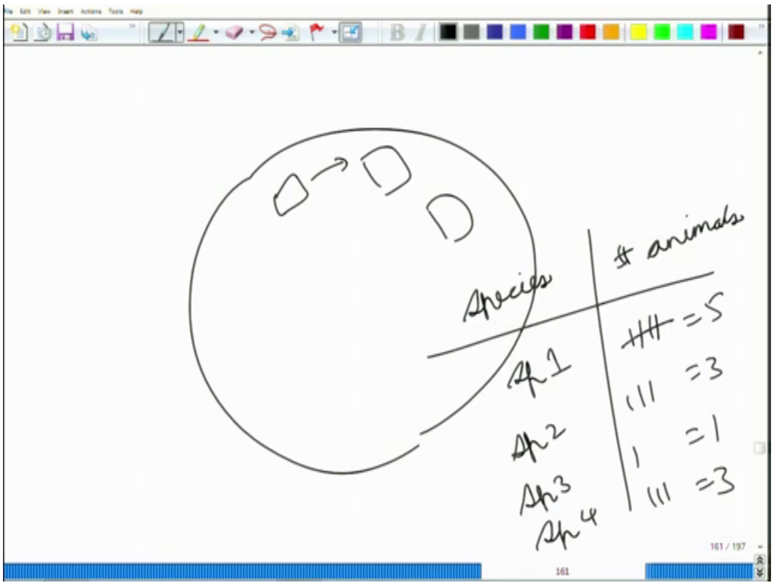

So, this is a small area that you are looking and then in this small area you go and there is a rock line here. So, you left this rock and suppose you saw 3 frogs there. You catch those 3 frog put them into a bag. Then you move to the next rock here also you obtain this rock, providing you saw 1 frog you take it put it into the bag you go to another rock. And then in this area for the next 1 hour you are just going to 2 different rocks, flipping those rocks and taking out all the animals that are there and now you are constraining yourself in terms of area and in terms of time.

So, you are saying that this is the area that I am trying to investigate and I am going to investigated only for 1 hour. And in that period you suppose collected 300 frogs. So, then after 1 hour is left you will take out all the frogs one by one, you will see what species there, what is the number of animals that you have. So, essentially you will make a table. So, this is species, this is number of animals. So, suppose first one is species 1 you saw an animal, then a species 2 you saw 2 animals, then species 3 you saw an animal, then species 1 use saw another animal then species 4 you saw 3 animals, then again you saw 2 animals of species 1 one of species 2 1 of species 1 and so on.

So, for all of these 300 animals you will make this list of what all species are there and how many animals did you see. So, at the end of this period you will see that this is 5 this is 3 this is 1 this is 3 and so on. And probably you will repeat this measurement at some other point of time in some other area to make an estimate of the relative density of different species and different areas.

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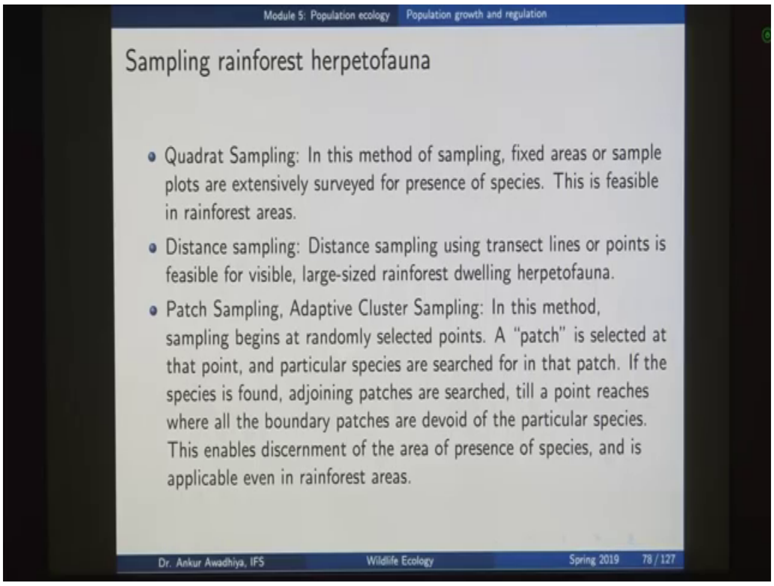

Next is a quadrant sampling; so, quadrant sampling as we have seen before, fixed areas or sample plots are extensively surveyed for presence of species. Next is distance sampling; distance sampling is what we saw in the case of transact lines a short while back. So, you can go for transact lines, you can go for point these samplings or you could go for a patch sampling.

A patch sampling or an adaptive cluster sampling in this method sampling begins at randomly selected points; a patch is selected at that point and particular species of searched for in that patch. If that species is found adjoining patches are searched till a point reaches, where all the boundary patches are devoid of the particular species. This enables discernment of area of presence of species and is applicable even in the rain forest areas.

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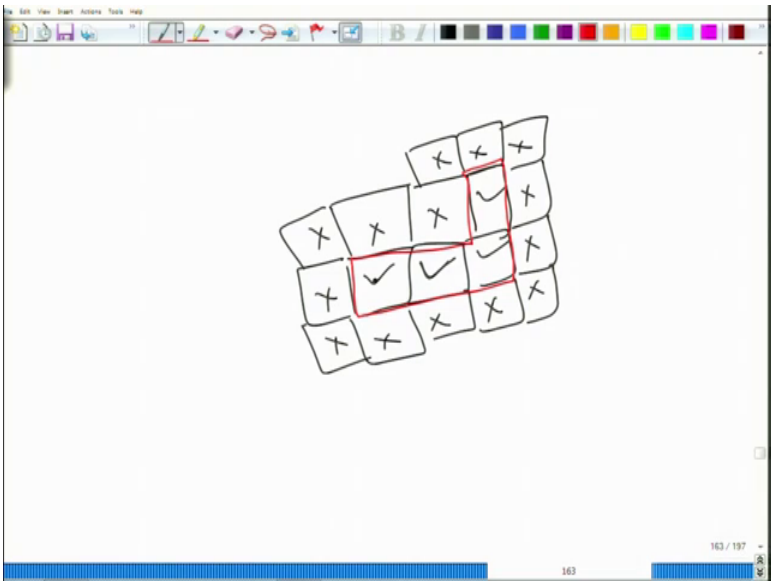

So, what do you do in the case of a patch sampling is that, you will begin at a random point and at this point you take this patch. So, a patch may be say 5 meters by 5 meters patch. In this 5 meter by 5 meter patch you are now looking you are actively searching for the animals. Now suppose you found the animals here. So, you count the number of animals next you go on serving all the surrounding patches. So, these are the surrounding patches that you have suppose you found an animal here, here, here, here, here, here, but you did not find animals here or here.

So, then because you found an animal here, now you will go for the patches that are surrounding this particular patch, probably you found an animal here an animal here nothing here. So, then for this particular patch now you will look for the surrounding patches. And you will continue this exercise till a point reaches where you do not find any animals in the surrounding patches. So, in this case we will say that this particular species of animal is found in this much of area and in for this area we can compute the number of animals that are found in this area.

Now, the size of the patches we will depend on which particular species you are interested in. For some species you may go for a larger size patch, for some species you may go for a smaller size patch. So, these are all different methods of estimating populations and their parameters.

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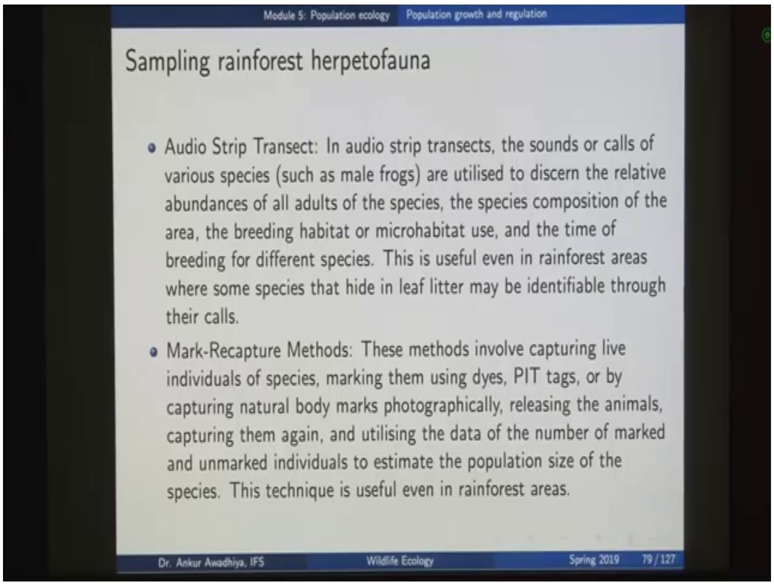

You would go for an audio strip transect. Now in audio strip transects the sounds or calls of various species such as male frogs are utilized to discern the relative abundance of all adults of the species. The species composition of the area the breeding habitat or microhabitat use and the time of breeding for different species. This is even useful and rain forest areas get some species can hide in the leaf litter may be identified through their calls.

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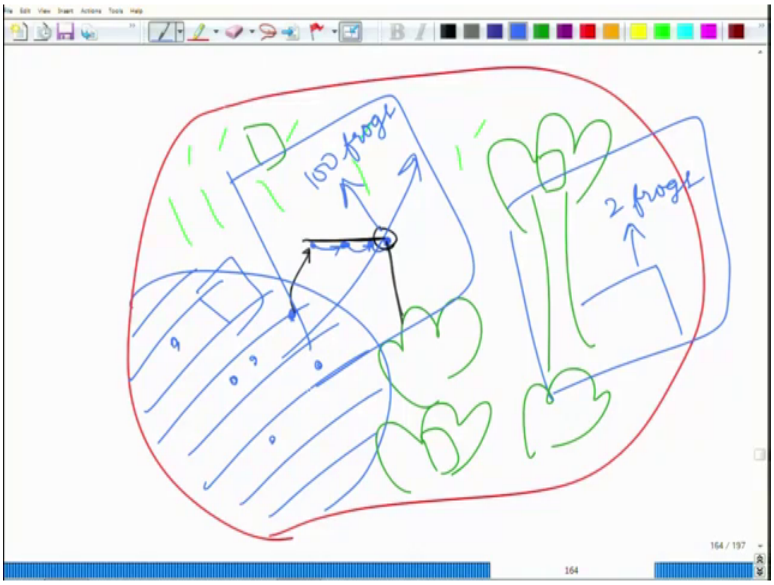

So, what we are saying here is that, you have some frog species you have this big area of the rainforest and then say there are some trees here, there is a small water body here maybe the other areas have some grasses or maybe you have some shrubs somewhere. Now you cannot go and search inside a shrub or you cannot go and dive into this water body to search all the frog samples. But then what you could do as a surrogate is that, you go to this area in the breeding season and in the breeding season the male frogs will about calls.

So, now what you can do is, you can put a tape recorder at this area. So, you can say float 1 tape recorder here, put a tape recorder here, put 1 in the trees put some in the shrubs and so on and then you can record the voices of these male frogs. Now different species give a different kinds of calls. So, we can even identify different species even though we are not able to see them, but we can identify them through their vocalizations. So, we can identify the species and the number of pearls that are made give you an estimate of the number of animals that are there in this area.

So, this is another way in which we can locate the population of different animals in an area. Next is a mark recapture method. So, what we saw a short while back. So, mark recapture or a capture recapture method is it can works capturing the species marking them using dyes or pit tags. So, pit tags are a small or are small are transponder tags that you can put beneath this skin of an animal. So, that remains with a animal and you can use it you can scan those tags later on to understand whether this animal is marked or not and what was the; what was the number of this animal. Or by capturing natural body marks photographically, releasing the animals, capturing them again and utilizing the data of the number of marked and unmarked individuals to estimate the population size of this species.

So, in this case what we are doing is, suppose we get to know from our experiment that the frogs are only found in this particular lake. So, in this case we will capture some frogs from this area, we will mark them by say a dye or using a pit tag, we will release them again, we will allow them to mix randomly with all the population of frogs that are there in this pond and we will take out another sample and look at the number of marked individuals that are there in the second sample. And use that data to make an estimate of the total number of animals that are there in this particular pond.

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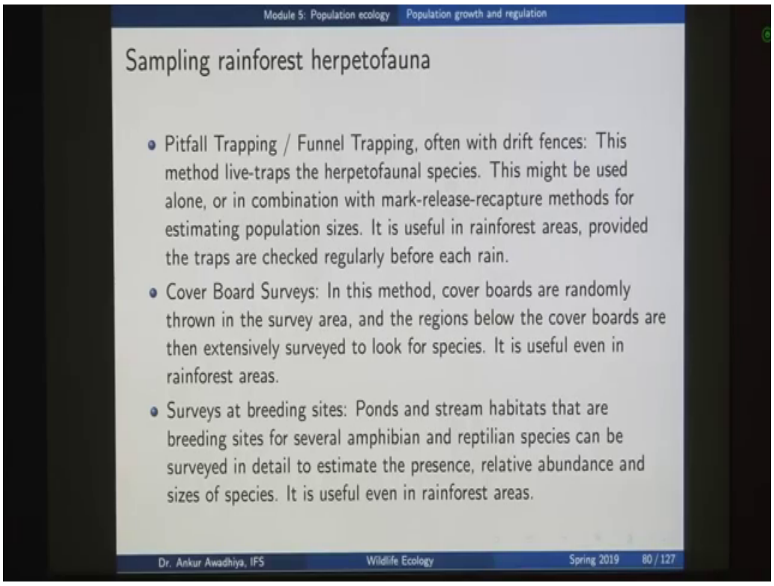

Next you could go for a pitfall tracking or a funnel trapping. Now this method live traps the herpetofaunal species and this may be used in combination with mark release recapture methods for estimating the population sizes. So, in this case what you are doing is, you know that these frogs are there in this water body and probably they will come out after sometime and probably they will go into the grasses. If this is the behaviour of such an animal so, in that case you will set up a pitfall trap. So, in this case you set up 2 plastic curtains and at this point you set up a bucket.

Now, when this frog comes to this area. So, you have this frog here, it once it gets to a wall it tries to move along the wall. So, that his behaviour of the animal. So, it becomes from here to here, then it jumps from here to here and then in the next jump it falls into the truck. Now in this case you can capture your angles and then this pitfall trap is a method that can be used to estimate the relative density of animals. Because you can set up a pitfall trap here and you can say set up a pitfall trap at this location. Now in this bucket you probably saw you probably were able to capture 100 frogs in this trap you were able to capture only 2 frogs.

So, then you can say that this area that was being covered by this trap is having less density of animals, then this area that is being covered by the first track. And then you can use it in combination with the mark recapture technique because here you are able to capture the animals in a life state. So, you can mark them and then you can reduce them again for the mark recapture method. Next you could go for a covered board survey. Now cover board survey in this method cover boards are randomly thrown in survey areas and the regions below the cover boards are then extensively surveyed to look for species.

So, in this case what you are doing is, you are taking some cardboard boards. So, their around say this much in size and once you have those boards you just flip them over into the forest area wherever the land you just go and you can look for the species below them. So, this is one way of doing a random sampling in your particular area. Another one is survey of the breeding sites ponds and stream habitats that are breeding sites for several amphibian and reptilian species can be surveyed in detail to estimate the presence relative abundance and size of the species. So, this is also another thing that you can do.

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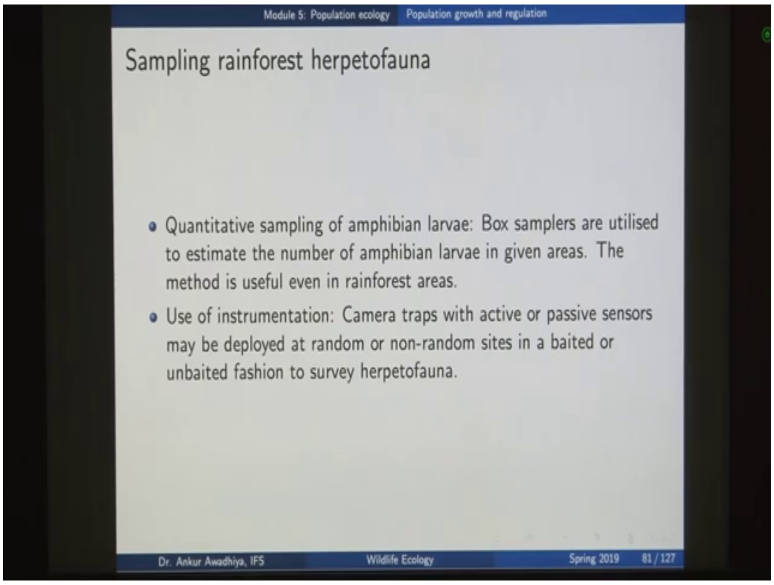

So, we population estimation is such an important requirement for management of populations or management of habitats, that we have figured out so, many different techniques to measure these population parameters. You could even go for a quantitative sampling of amphibian larvae. So, for instance you are not able to capture the frogs, but when you go to the points. So, you are able to capture the larvae. So, in that case you can do a quantitative sampling of the larvae's well or you can go for instrumentation. So, in the case of instrumentation you can put a camera traps. So, a camera trap is a device that has a sensor. So, that if an animal comes near to it; it takes a photograph.

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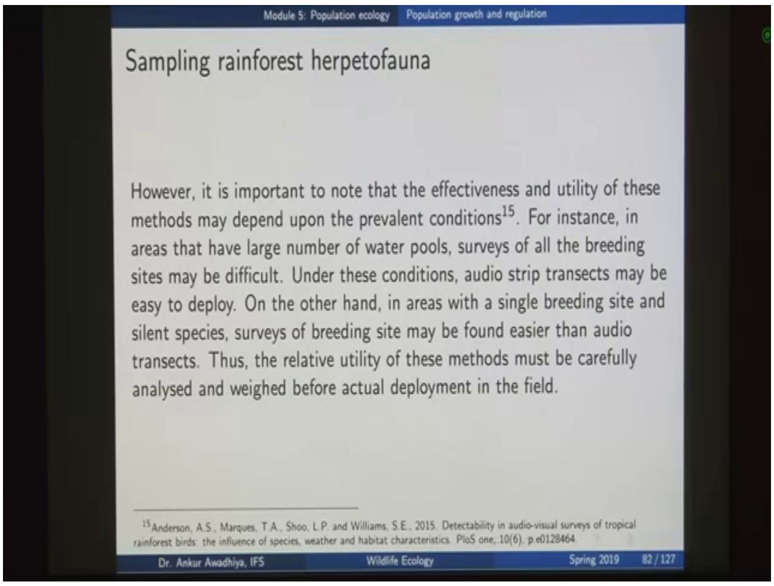

So, then camera trap is also way another way of getting data about these animals. Now, it is important to note that the effectiveness and utility of these methods may depend upon the prevalent conditions. In areas that have large number of water pools, surveys of all the breeding sites may be difficult under these conditions audio strip transect may be easy to deploy on the other hands in on the hand in areas where a single breeding site and silent species.

So, in the case of silent species you cannot go for an audio strip transect. So, you can go for a survey of breeding site and the relative utility of these methods must be carefully analyzed and weight before actual deployment in the field. So, all of these are different methods of serving the herpetofauna.

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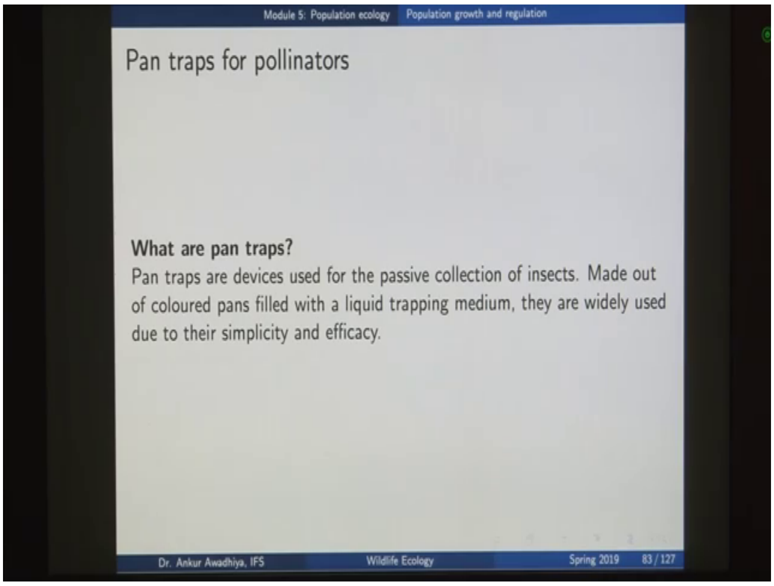

What about if you want to survey for insects? So, in the case of insects a very a common technique is that of using the pan trap. Now what is the pan trap? Pan traps are devices that are used for passive collection of insects; they are made of coloured pans filled with a liquid trapping medium and they are widely used due to their simplicity and efficacy.

Now you might ask what is the need to know the population size of insects? Well let they are important because they are important pollinators or maybe they are also some vectors for diseases. So, we need to know the population sizes of different insects; because they will give us an indication of the amount of food that will be available to insects; to the animals up to the pollination season or they will give us an indication of the amount of food that is available to the birds that are (Refer Time: 32:30) or the level to which you might observe the spread of some disease if these insects are vectors for those diseases and so on.

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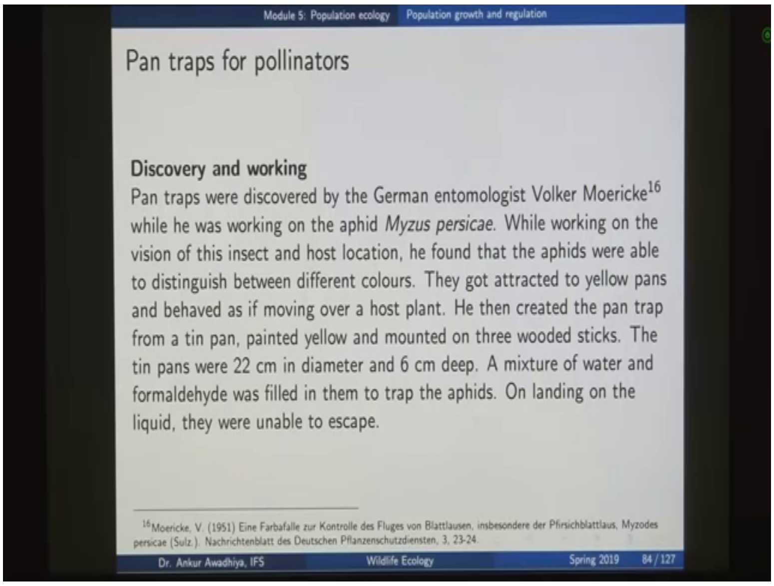

Now, a short history pan traps were discovered by the German entomologist was a Volker Moericke aphids and aphids are small insects and this guy found out that in the case of aphids they this small different into different colours. And in the case of yellow colours they were attracted to it. So, he thought why not make use of this phenomenon. So, then he constructed a pan trap and this pan trap was made from a tin pay tin pan was which was which is the goes by the name of the pan trap it was painted yellow in colour and it was mounted.

So, you can this was the first size 22 centimeters in diameters and 6 centimeters in deep, and then he added a mixture of water and formaldehyde. So, how do these pan traps work?

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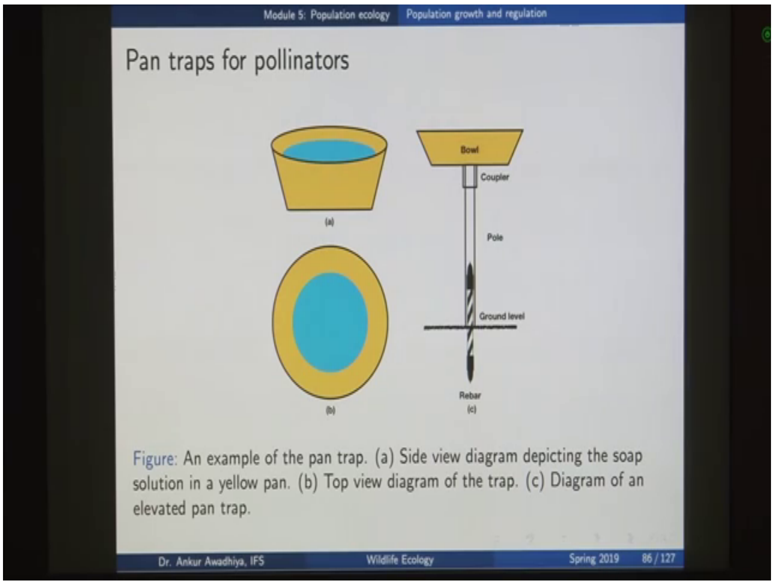

Now, in this case you have this is small pan. So, this pan is yellow in colour and then you add this water. Now in this water you can add a few drops of soaps to reduce the surface tension and this is the top view. So, in this pan you will be having this yellow coloured surface and you have the water in the centre and then you could this trap onto a stick and then you place it somewhere.

Now, if you have insects that come to this trap and they try to land on the surface of water so, water has a high surface tension. So, there are a number of insects that are able to move out of it, but then when you add soap to water, so, the surface tension reduces. And so, if there is any insect they tries to land here as soon as it lands on the surface of water it drops. So, it comes down it dies, but then you can make an estimate of the number of insects and that were caught in this trap in the dead condition.

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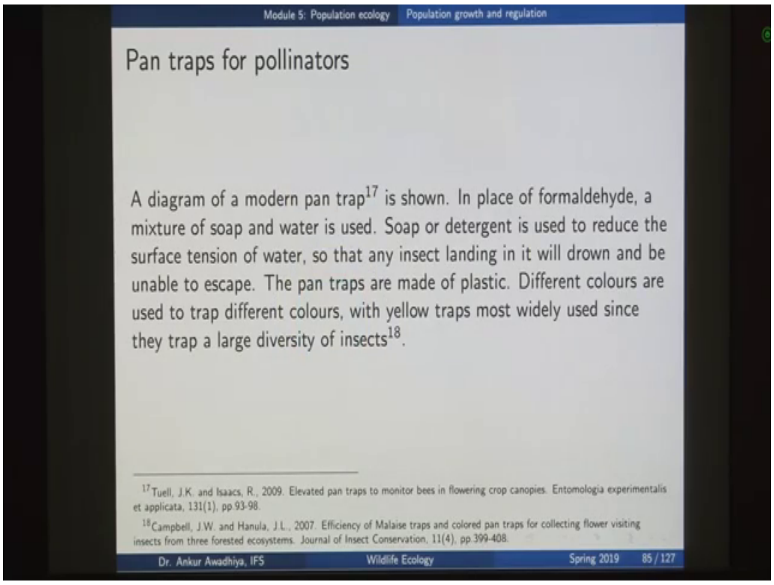

So, in place of formaldehyde, so, you can go for formaldehyde which again a toxic or you could go for a mixture of soap and water. These days with the pan traps are made of plastic and then you can use different coloured pan traps. So, different colours because different insects respond to different colours. So, there could be some insect that pollinates plus that are red in colour. So, that will be more attracted to red coloured pan traps.

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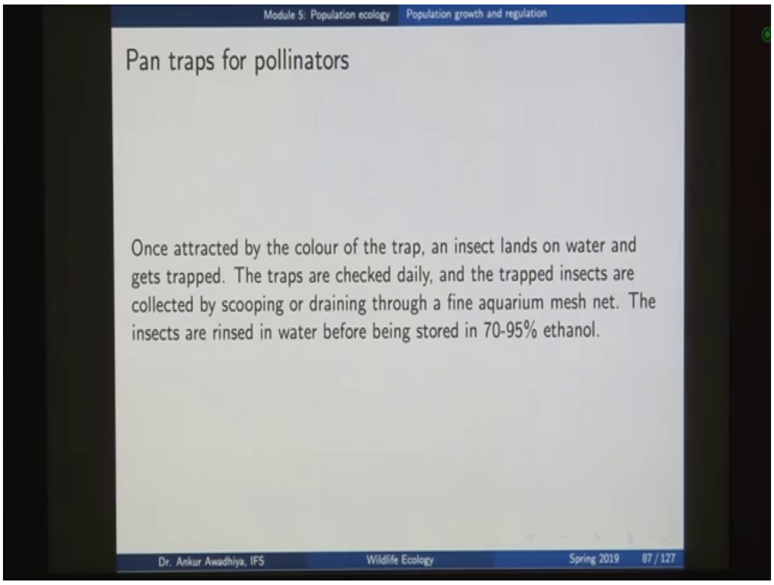

Now, once attracted by the colour of the trap, an insect lands on water and gets trapped these are checked daily and then you can take these insects out, you can wash them you can then make a note of what species of insects are found in, what is the proportion of animals that are trapped there.

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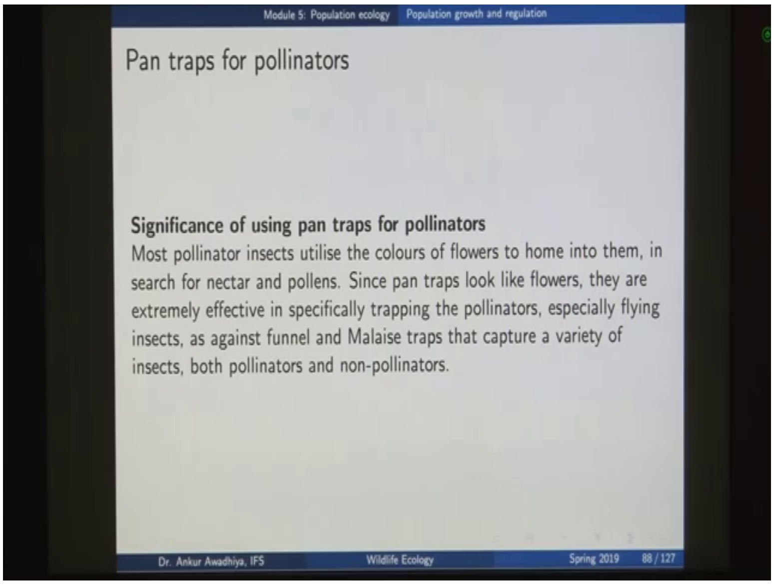

Now, what is the significance? Most polinator insects utilize the colours of flowers. So, these traps look like flowers and they are also coloured like the flowers and then in this particular case you are capturing most of the pollinatives. So, you are able to differentiate between pollinating insects and non pollinating insects.

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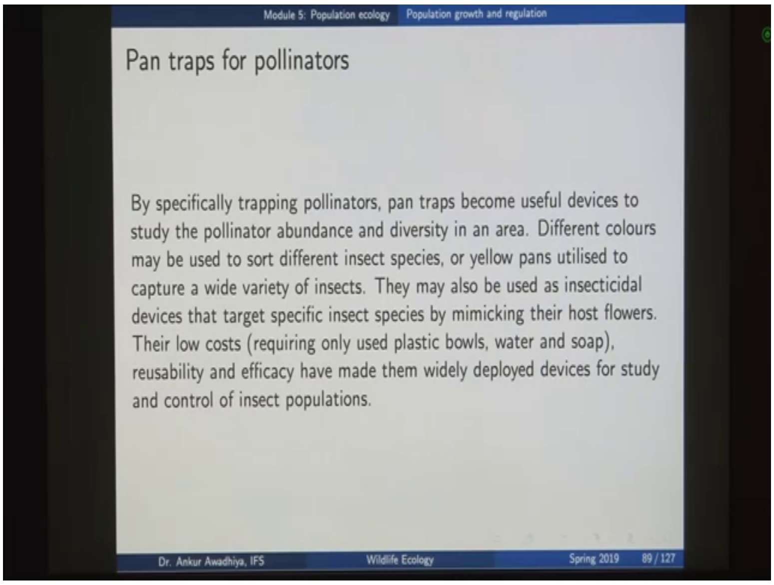

And then you can use this data and you can combine it with the data from, those traps that are not capturing only the pollinators that are more or less random in capturing the insects. So, from that you can make an estimate of the total amount of pollinators that are, there the total amount of non pollinators that are there. So, it all depends on the parameter that you want to where in this population.

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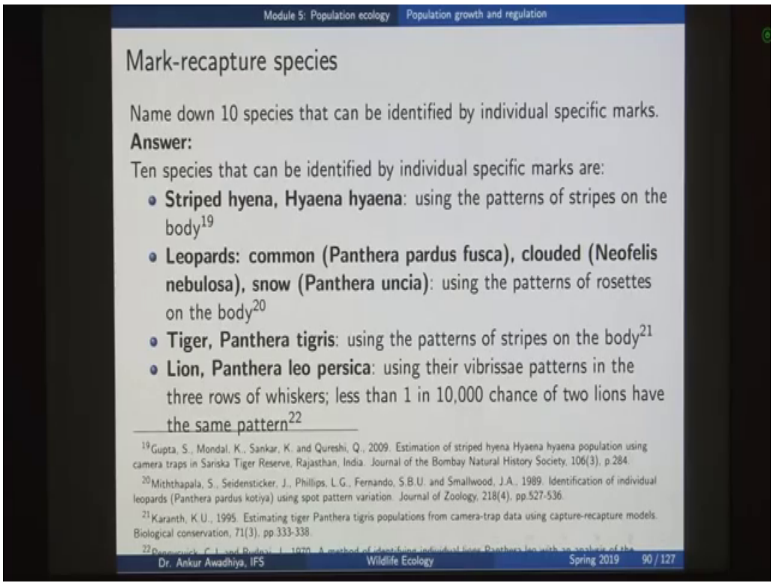

Next in the case of the mark capture recapture taking what we had done was.

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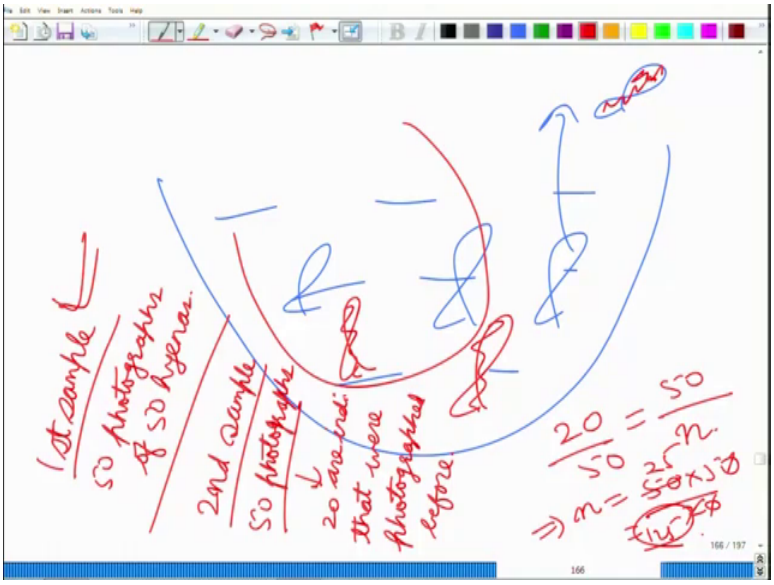

So, in the classical example you have this pond, you have some fishes and then you had taken this fishes out and then you had mark them in red colour and then you had release them back into the water and then you had taken out another sample and then try to make an estimate of how many normal fishes and how many red colour fishes do you have?

Now, another modification of this mark capture mark capture mark release the capture method is that, you can use of the already existing body patterns that are there in the animals. So, for instance in the case of striped hyena, they have specific body patterns. So, you can distinguish one individual from the next individual. So, you can just click a photograph of an individual, once you have this photograph that is as good as trapping this individual and marking it.

Because in the case of capturing and marking you are capturing this animal you are painting it say red in colour. In this case you can capture a photograph of this animal and then you can see the body pattern that is prevalent in this particular animal. Now once you release this animal, the next time you click a photograph that is as good as taking the next sample. So, in the next sample; so, suppose in the first sample. So, you put your camera traps for say 10 days, in those 10 days you are able to capture 50 photographs of 50 hyenas, now you wait for some more time and then you take a second sample.

Now, in this second sample you are again able to capture 50 photographs. Now out of these 50 photographs it turns out that 20 are individuals that were photographed before.

Now in this case what we can say is that out of 50 animals that were captured in the second case, you have 20 animals that were mount. And this ratio has to be the same as the total number of marked animals in the population that was there in the first sample divided by the total population size of the population. So, in this case we can capture we can calculate n is equal to 50 into 50 by 20 is 125.

So, even though in this case we are not capturing the hyena, we are not painting it in some colour, but we are able to make use of the body colours the body patterns to identify the individual and just by taking a picture of the animal we can do the same experiment of capture mark release recapture. And these kinds of patterns are prevalent in a number of species. So, you have hyenas, you have leopards.

So, in the case of leopards clouded leopards snow leopard they all have different patterns of rosette in their body. Tigers you can identify a tiger using its stripes every tiger has a different stripe. Lions in the case of lions you can look at their whiskers and their whiskers have a specific pattern that is specific for every individual.

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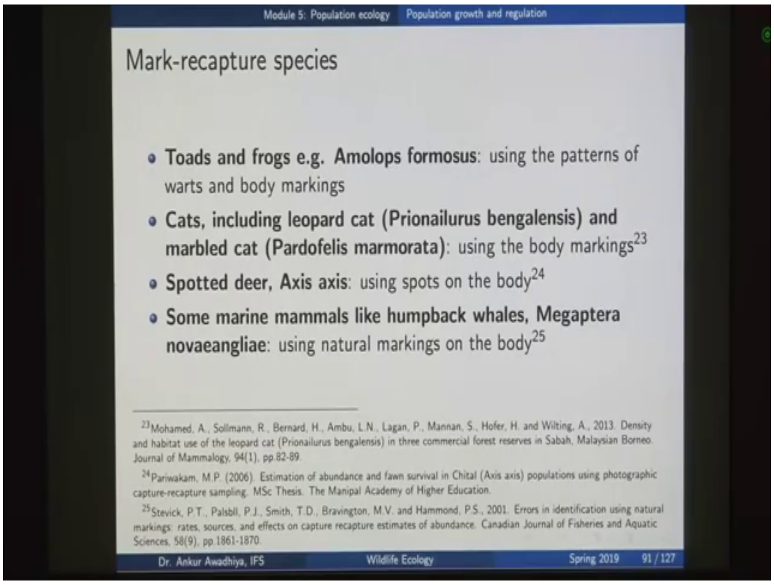

You can look at toads and frogs, there are a number of toads and frog that have specific body markings and every individual can be distinguished from another individual from the body markings.

Cats such as leopard cat or marbled cat; here also you have different body markings spotted dear like the chital. So, chital also as spots on its body you can identify different chitals using their spots or some marine mammals which is humpback whales. So, in the case of humpback whales, you also have the natural markings or you can even look at crocodiles.

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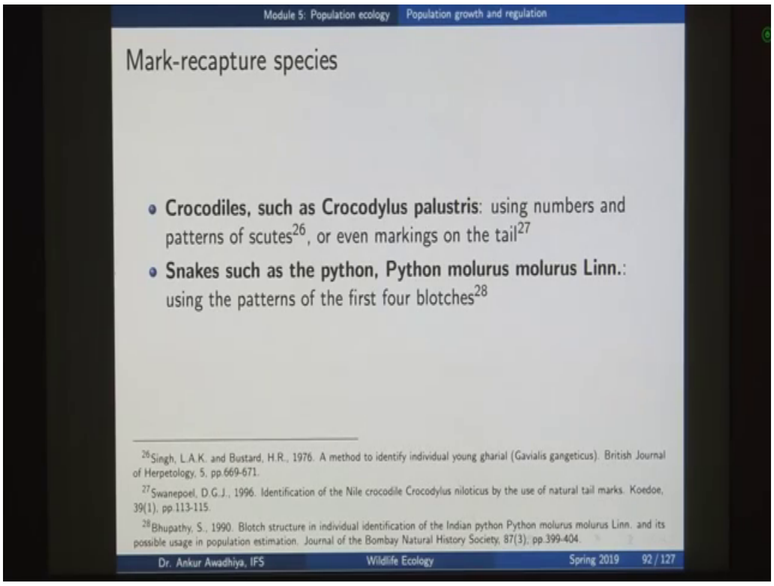

So, crocodile have different patterns of scutes on their body or you can even have markings on the tails or you can have a look at the snakes. The different snakes have also different patterns of the blotches or even in the case of those species that do not have a body mark, you can look for those body marks that have naturally come up on body.

So, for instance you are witnessing a troop of monkeys and there is a monkey that has a scar on its face, a probably there is another monkey that has lost one of its limbs or there is another monkey that has lost a lot of power off on its body because of some kind of disease. Now using all of these different variations you can have a monkey that is old and has grown a bit paler in colour. So, with all of these different body patterns, you can identify the animals and if you are able to identify the animals you can make use of the capture mark release recapture method just using photographs.

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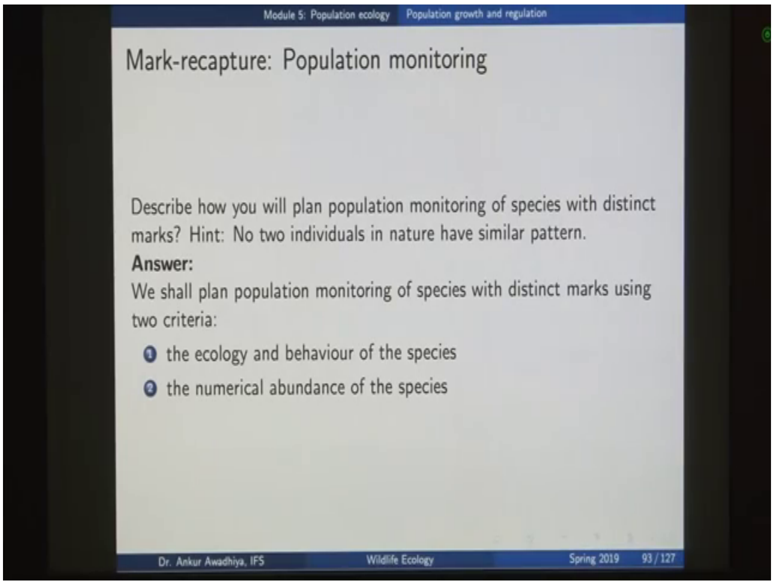

Now, if you are using this method of mark recapture. So, how can you plan a population monitoring of species? Now in this case you do not have any 2 individuals that have the same body pattern. So, how can you make use of this data? So, we can plan this exercise using 2 criteria the ecology of the species ecology and behaviour and the numerical abundance of the species.

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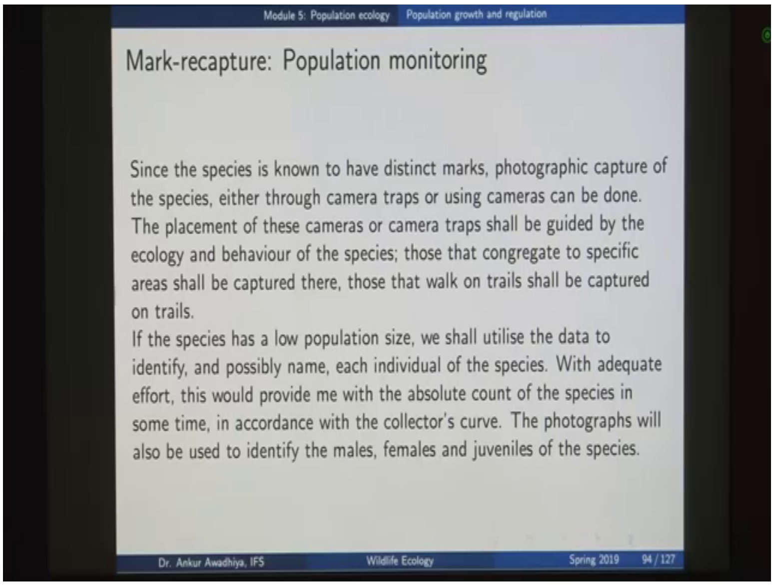

Now, since the species is known to have distinct marks, photographic capture of the species either through camera traps or using cameras can be done the placement of these cameras or camera traps shall be guided by the ecology and behaviour of the species, those that congregate to specific areas shall be captured there and those that walk on trails shall be captured on trails.

So, for example, a good example of animal that walks on the trail is tiger. So, if you want to picture a tiger if you want to take photograph of a tiger, you put your camera trap and an area that has a trail. So, a trail is the small road because a tiger does not want to move in those areas, that are thorny or that are rocky so, that prefers a cleaned out area. So, you can put a camera trap for the case of tiger on it fail or for those animals that congregate to specific sites. So, an example is that of chital; so, chital congregates in the grasslands in the night times. So, you can if you want to take those pictures you can put a camera trap there as well.

Now, if the species has a low population size, we shall utilize the data to identify and possibly name each individual of the species. So, for those population that have a small size, you can go ahead and you can name each and every individual of the species, this is what we do in the case of tigers. So, when we say that Panna Tiger Reserve has say 35 tigers. So, we know each and every tiger by its name using its body patterns. And with adequate effort they should provide us the absolute count of this species in sometime in accordance with the collectors curve. The photographs will also be used to identify the male's females and juveniles of the species.

Now, why do we why do you want to know the males female and juveniles? Because that gives you an indication of how this population is going to perform in future. If you have a population that is all full of males or all full of very old females in that case the population may suffer a decline.

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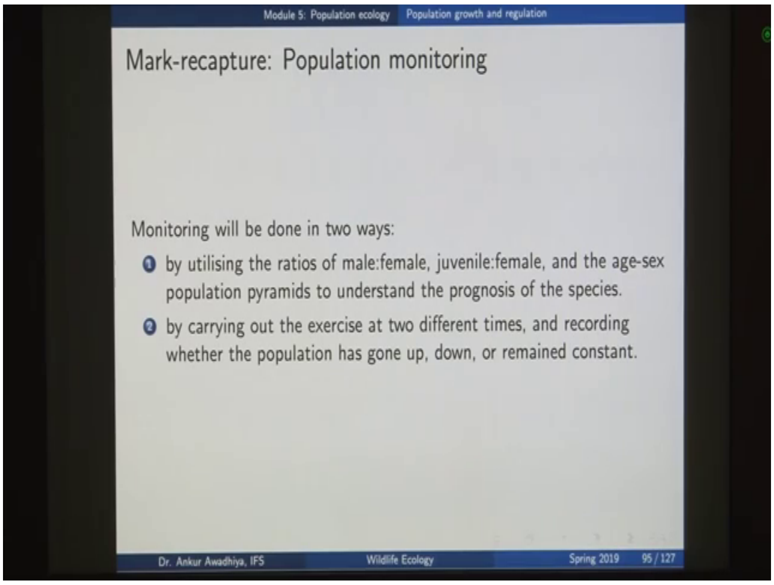

Now, monitoring; monitoring can be done in 2 ways; one is by using the ratios of male to female or juvenile to female or the age and sex ratios and pyramids to understand the prognosis of the species. So, if you say go to forest area and you see that most of the females are accompanied by juvenile.

So; that means, that the population is flourishing well. So, they are getting enough food and so, they are reproducing well. On the other hand if you go to a forest and you only of those males you do not see a female. So, it is possible that the population might crash very soon. And second is by carrying out the exercise at 2 different times and recording whether the population has gone up down or remained constant.

So, for instance you went to into the forest and first time you measured 100 chitals per square kilometre per 100 square kilometres the next time you went there and you measured only 20 chitals per 100 square kilometers. So, the population is suffering a decline.

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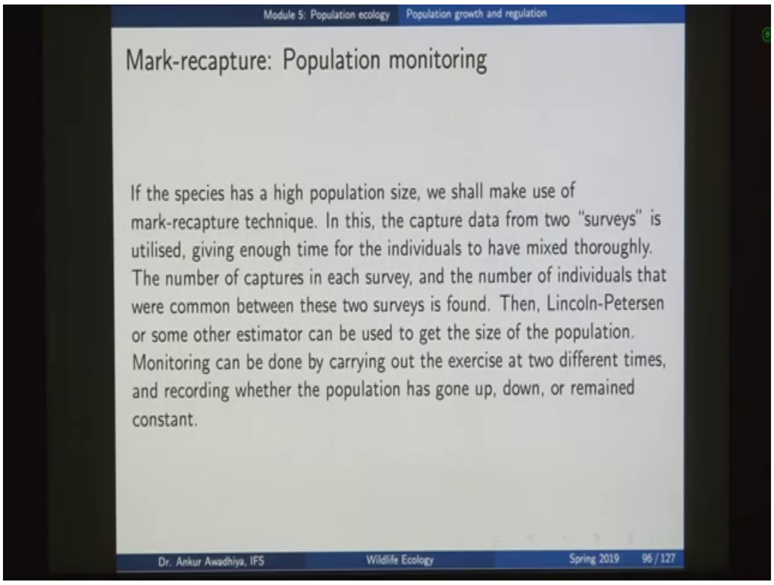

Now, if the species has a high population size, then we shall make use of the mark capture recapture technique. So, in this case capture data from 2 surveys is utilized to give an a estimate of the number of animals that are there. So, for smaller population sizes, you can go ahead and count and name each and every individual in the case of larger populations, you can go for the mark recapture technique.

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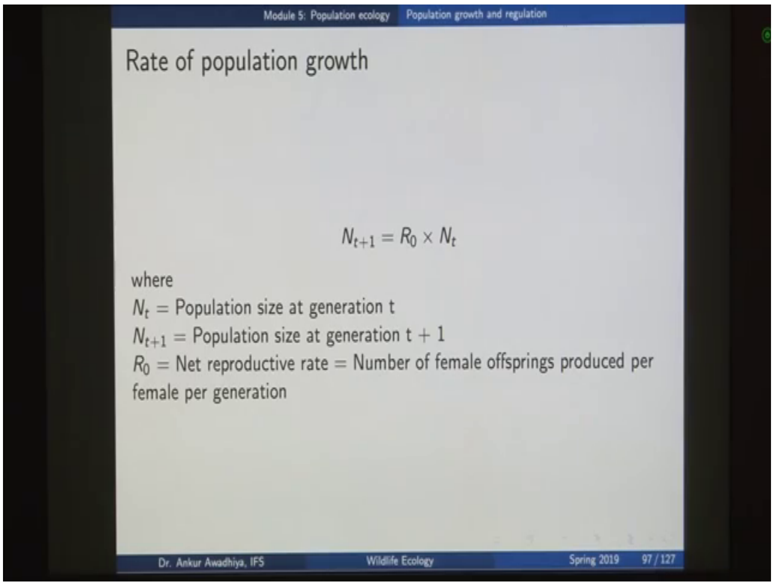

Now that is all about the try to look the population dynamics, till now we were interested in measuring the population parameters the demographic parameters.

Now, we want to know that if you have n number of individuals today, what will be the number of individuals in future. How does this population grow or how does this population decline or how does this population remain constant and what can we do about it. So, the first simplification is that we say that the rate of population growth is given by this equation.

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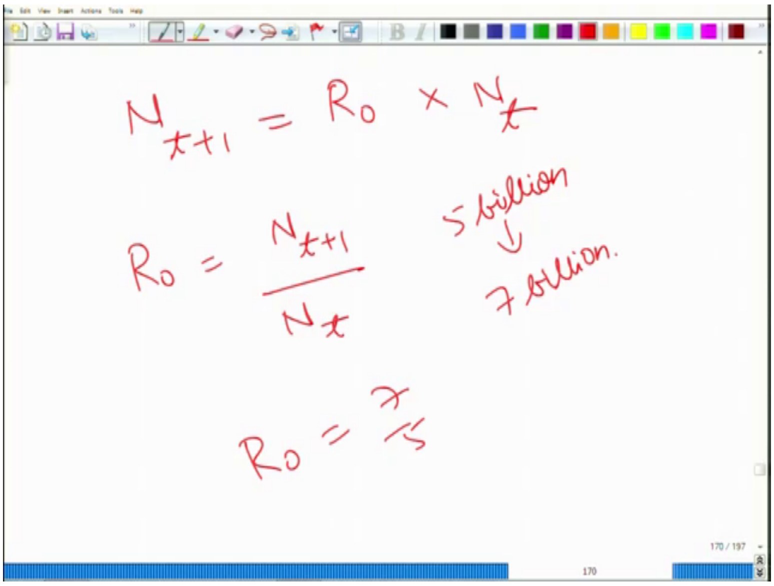

Now, in this equation you have the number of animals at t plus 1 time is given by R naught into the number of individuals at the tth generation. So, the R naught is given by the number of individuals at t plus 1th generation divided by the number of individuals in the tth generation. What it means that, suppose if you consider my parental generation and during my parental my parents generation, suppose the population of earth the population of human beings on earth was say 5 billion and in my generation it has increased to say 7 billion.

So, in 1 generation it has increased from 5 billion to 7 billion. So, R naught will be given by 7 divided by 5. Now if R naught is greater than 1 that it means that the population is increasing, if R naught is less than 1 then it means that the population is reducing and if R naught is equal to 1, then it means that the population is constant.

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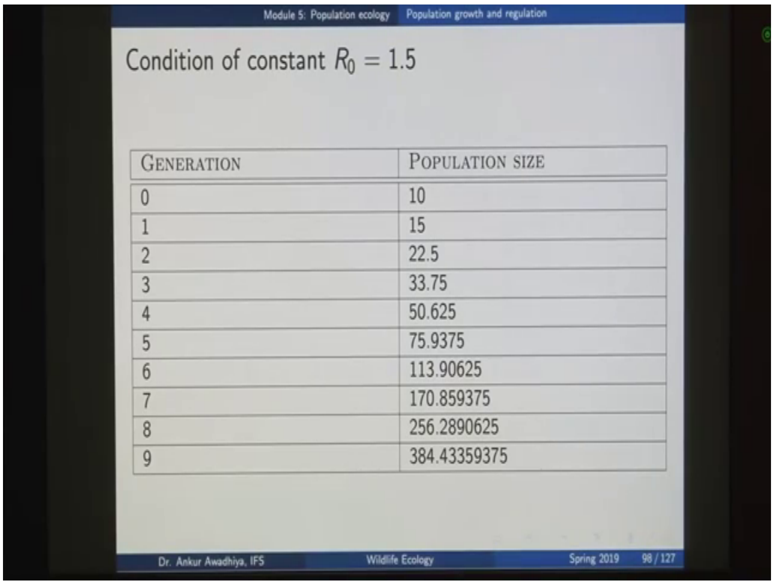

Generation	Population size
0	10
1	15
2	22.5
3	33.75
4	50.625
5	75.9375
6	113.90625
7	170.859375
8	256.2890625
9	384.43359375

But then if you look at one scenario in which we consider R naught is equal to 1.5 and let us locate different generations and we start with an initial population size of 10. So, in the first in the 0th generation we had population size of10.

In the first generation the population size will be R naught into the number of individuals in the previous generation. So, 1.5 into 10 is 15. In the next generation it will be 15 into 1.5 is 22.5 in the next generation it will be 22.5 into 1.5 is 33.75 5 and so, we see that in the 9th generation we have moved from 10 individuals to 384 individuals or another words what we are observing is an exponential rise of the population.

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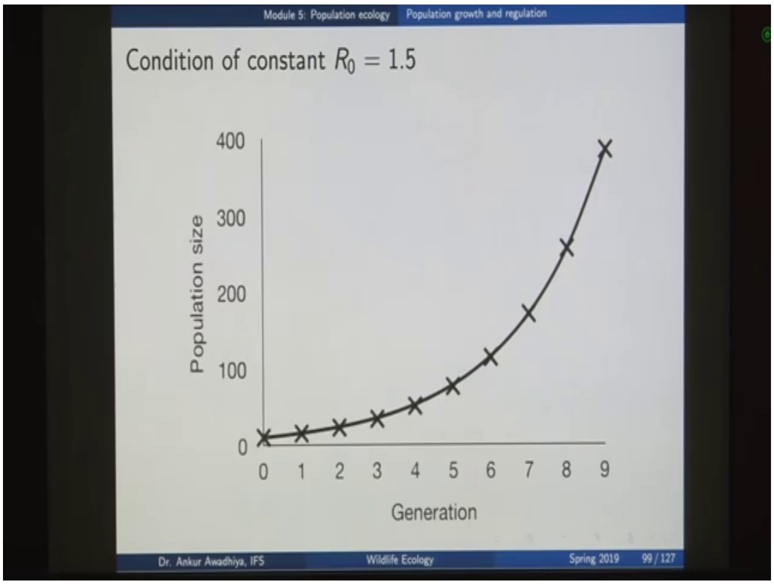

So, here we are looking at the generation time and we are looking at the population size. So, we moved from 10 individuals to around 400 individuals in a very short period of time. Now, such a population growth is possible in certain circumstances.

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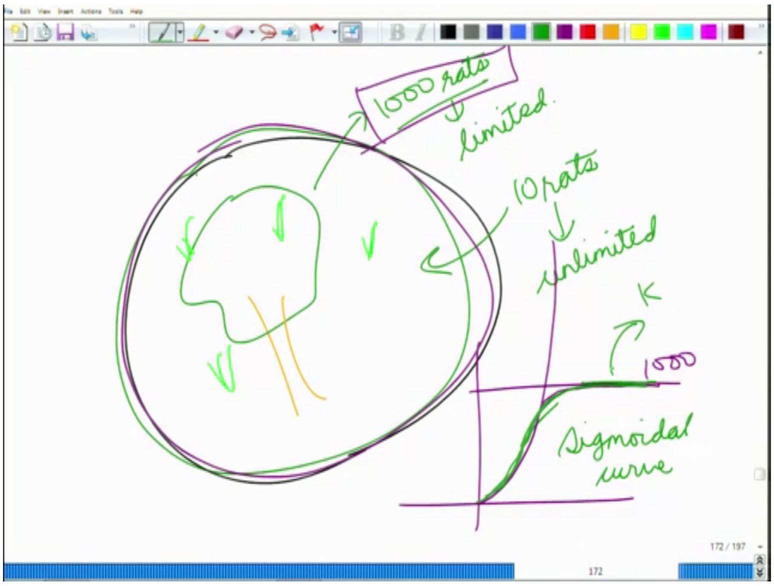

So, for instance you have an island and in this island you do not have any predators, you only have save grass or you have some trees that bear fruits and then in this island you put in 10 rats and these rats do not have any predators to kill them. So, in this case because the resources are available in plenty so, the rats will be able to multiply themselves.

And when they multiply themselves, they will get into this population growth curve which is an exponential growth curve like this or just before. But then will it continue till infinity. So, in this curve how does it end? Does it just gone increasing; increasing; increasing because if that happened, then we would have a situation in which we have infinite amount of resources, but then actually we do not have infinite amount of resources. So, this curve should come to a decline after a time.

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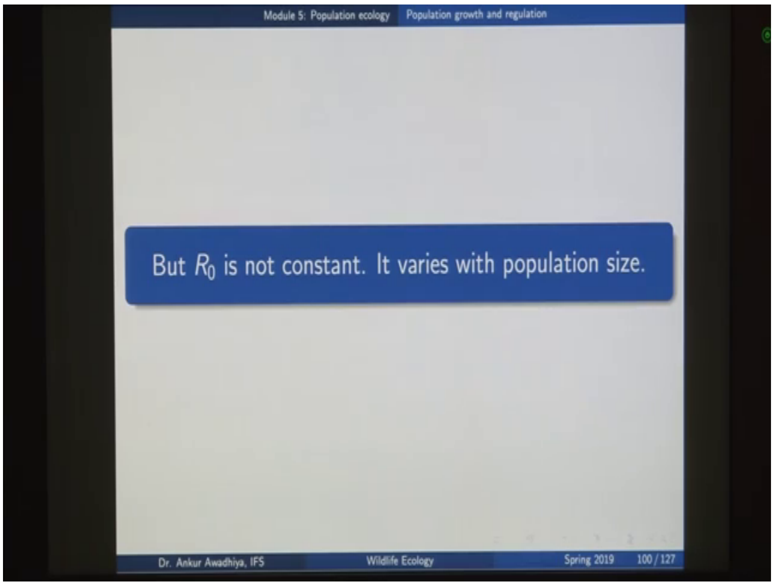

So, R naught cannot remain constant and it has to do something with the population size. Because in this island if you started in the beginning you have all the resources that are available to the 10 rats. Now after their population has increased and suppose now we have 1000 rats. So, in that case the resources that are available on this island will probably become start becoming limiting for the population growth. So, earlier we had unlimited resources when we only had 10 rats, but in the case of 1000 rats now the resources are now getting limited.

So, whether the resources unlimited or limited depends on the number of individuals that you have in the population. If you have very less number of individuals then the resources are practically unlimited; if you have more number of individuals in the population then practically the resources are becoming more and more limited.

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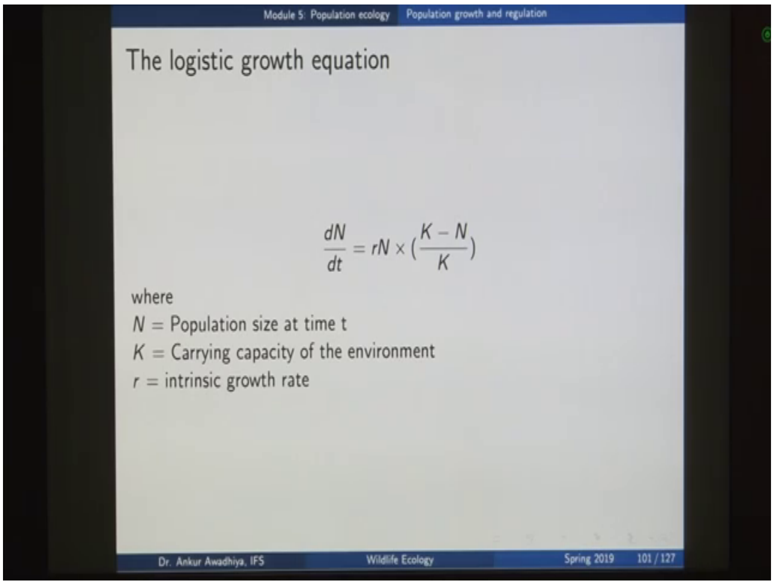

Now, to put that mathematically, we use this curve which is known as the logistic growth equation. Now this says when if N is the population size at time t. So, the rate of increase in N that is dN by d t is given by r into N. So, r is the rate of growth or intensive growth rate into N. So, if you have less number of individuals. So, the total growth in the population will also be less. If you have only 2 mice they can only give rise to N number of a springs if you have 200 mice they can give rise to much more number of a springs.

So, you have dN by d t is proportional to N the rate at which the population will grow will depend on the size of the population and that is related to this growth rate which is given by r. But then this factor is also modified by the resources that are available for this population to grow which is given by this term K minus N divided by K, where K is the carrying capacity.

So, carrying capacity says that suppose in the case of this island you had only resources that are available to 1000 rats that cannot support more than 1000 rats. So, in that case your population will not just go on increasing exponentially, but as soon as it starts reaching this stage of 1000 it will start declining and then when a decline settle become a bit more it will become more or less constant at 1000. So, you will have an s shaped curve. So, this curve which is s shaped goes by the name of a sigmoidal curve and this value that you will get at the top represents K which is the carrying capacity of the environment or the number of individuals that the environment can support.

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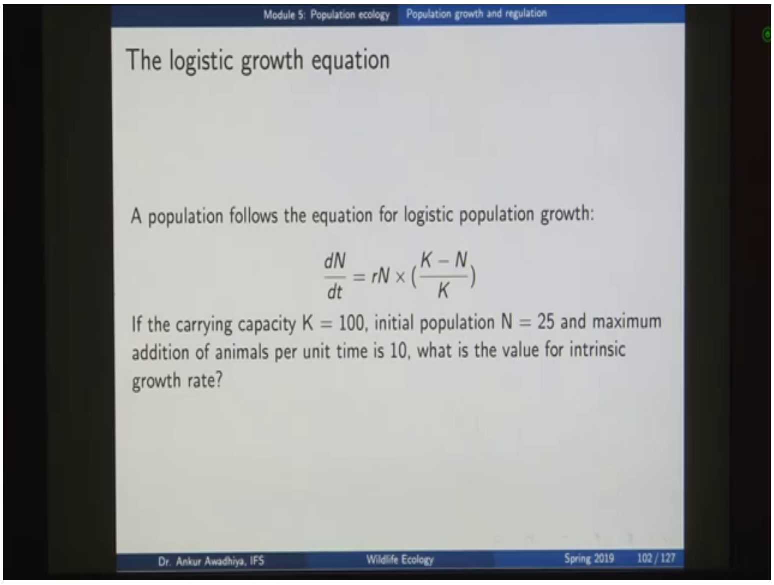

So, now look at let us look at some example a population follows the equation for logistic population growth which we saw before; the carrying capacity is 100 the initial population size is 25 and the maximum addition of animals per unit time is 10 which is r is 10. So, in that case what is the no. So, the maximum addition of animals per unit time that is dN by d t maximum rate is 10. So, what is the value of the intrinsic growth rate what is the value of r?

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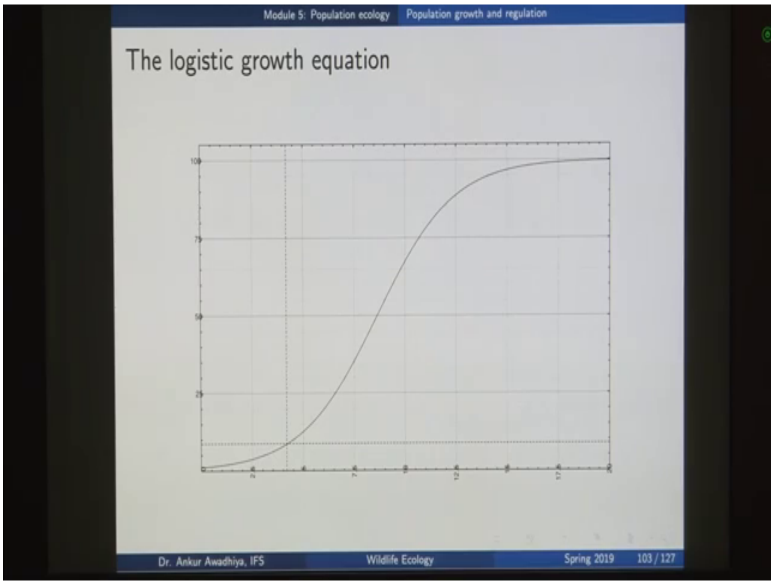

So, now, if we plot this equation this is how it look like. So, this is the time t this is the number of individuals and we start with the very less number of individuals then it goes on increasing like this. Now this phase in which it is more or less flat this phase something like this, it goes by the name of the lag phase it is called the lag phase.

Because the number of animals is so, less or the number of organisms is so, less that their population growth rate cannot be very large. Then after they have crossed a certain threshold after they have become a bit more substantial in size. So, then their population increase becomes even greater. So, then it becomes this curve something like this, which is known as the log phase. So, lag phase log phase then it tries to become more and more stationary. So, as it reaches the carrying capacity of 100 it start becoming flatter and it is known as the stationary phase.

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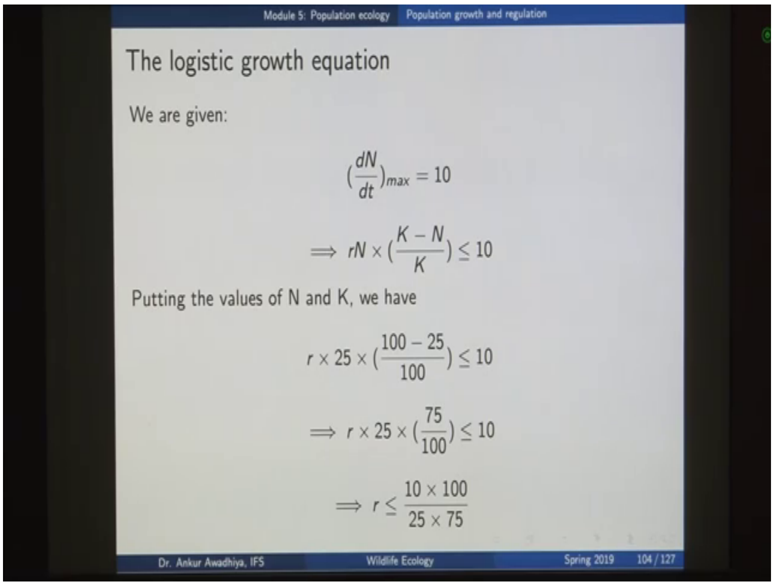

So, in this case we are given that d N by d t maximum is ten. So, we can say that this value is less than or equal to 10 after putting all the values we say that we see that r is less than or equal to this value 10 into 100 divided by 25 into 75 which tells us that r is less than or equal to 0.533.

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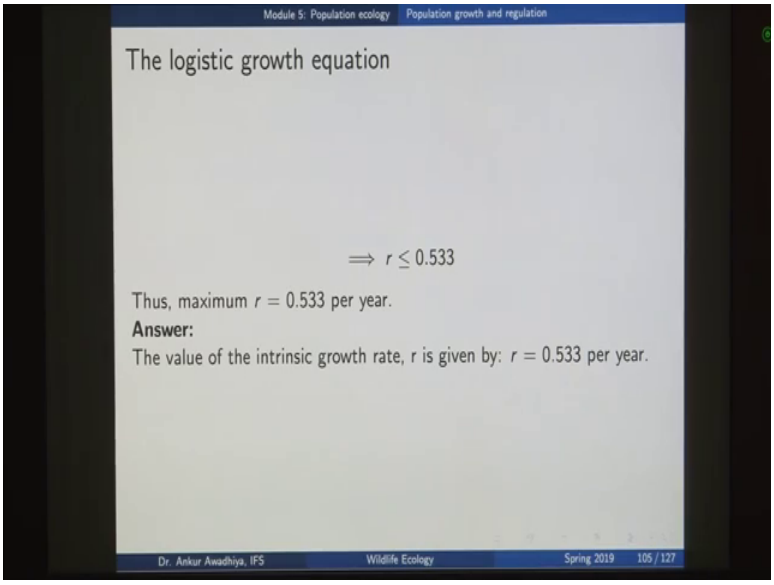

So, with this we can say that the maximum value of r is 0.533 which is the intrinsic rate of growth.

Now, y is that the maximum value of r because that is the value of r that will observe in the beginning that will observe here and then this value will start getting modulated because of the sizes coming close to the carrying capacity of the environment.

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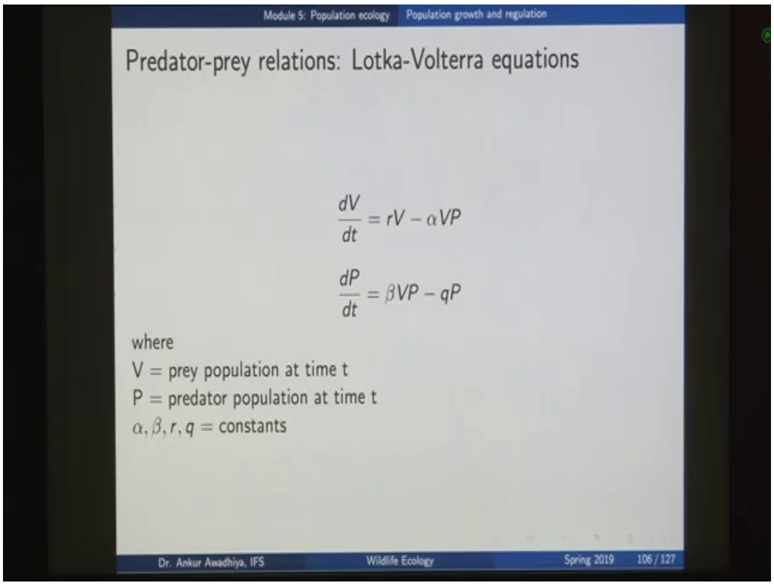

Now there are there is this other set of equations that goes by the name of the Lotka Volterra equations that tries to that helps us understand the relationship between 2 different species. So, in this case we are trying to look at if we have a community in which you have a predator organism and a prey organism let us see tigers and chitals. So, if you have a certain number of chitals a certain number of tigers, how will their population vary when they are interacting with each other.

So, in this case the Lotka Volterra equation says that, if we say that V is the prey population or the chital population how does chital population change with time? So, the rate of change of chital population is dependent on the size of the chital population. Because if you have more number of chitals they give rise to more number of a springs, so, it is proportional to V. So, this proportionality constant is r. So, d V by d t is equal to r into V, but then this is also modulated by the number of tigers that we have in the system. If you have more number of tigers, if you have more number of capital P, then d V by d t will be lesser.

So, it varies as d V by d t is r into V minus alpha into V into P. Now this is also dependent on the value of V because if you have if you already have a very large population size, then the rate of growth will be lesser because of because that will be reaching the carrying capacity whereas, the rate of growth of the predators will be given by beta into V into P. Now it is dependent on the number of predators, but it is also dependent on the number of preys because if you have more number of preys then you are getting more food for the tigers if you have more number of chitals you have more food for the tigers and so, the rate of growth of population of tigers will be more and you have minus q into P.

So, this q is telling you the death rate of the tigers and p is the number of tigers. So, here you have the Lotka Volterra equations and which you have dV by dt is given by r into v minus alpha into V into P and dP by dt is given by beta into V into P minus q times P. Now you do not need to get into very integration of this equation, but then we just need to understand how these equations help us understand the population dynamics.

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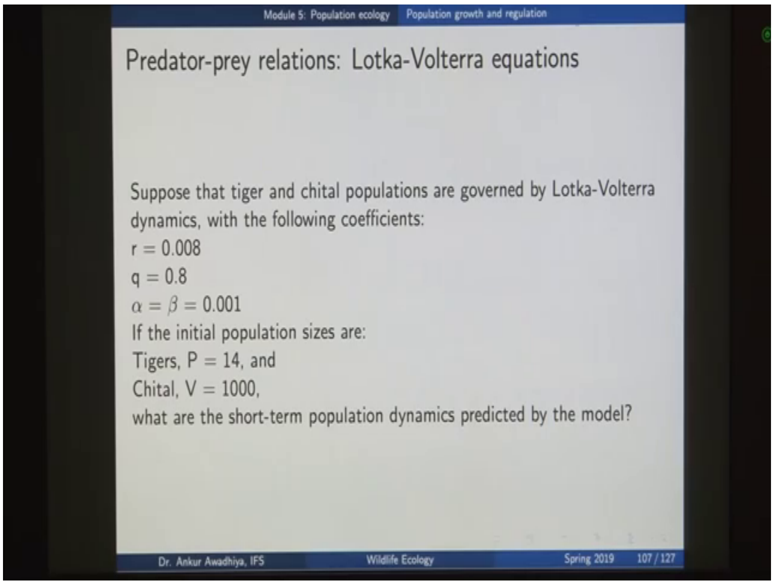

Now let us look at this example. Suppose that tiger and chital populations are governed by Lotka Volterra dynamics with the following coefficients. So, we are given the values of r q alpha and beta and the initial population sizes are given.

So, you have 14 tigers and 1000 chital. So, what are the short term population dynamics that predicted by the model?

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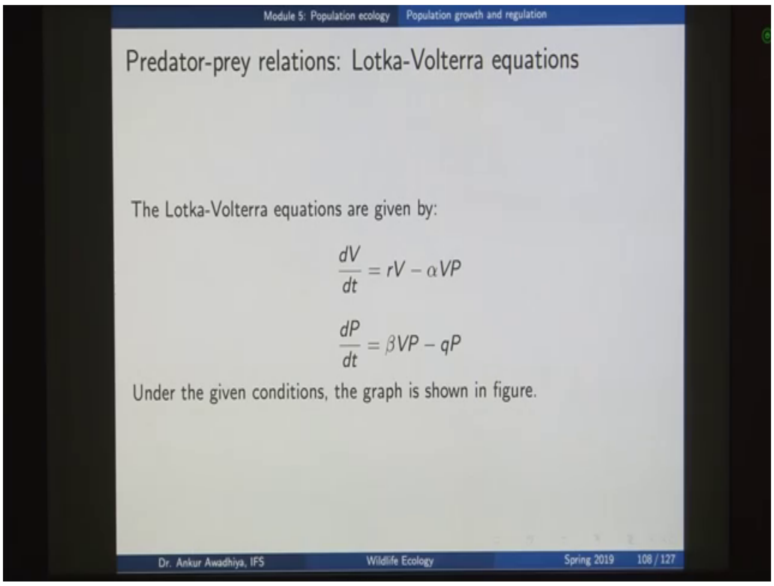

So, in this case if you plot these equations with the values of alpha beta r and q and the initial values of V and P this is what we will find.

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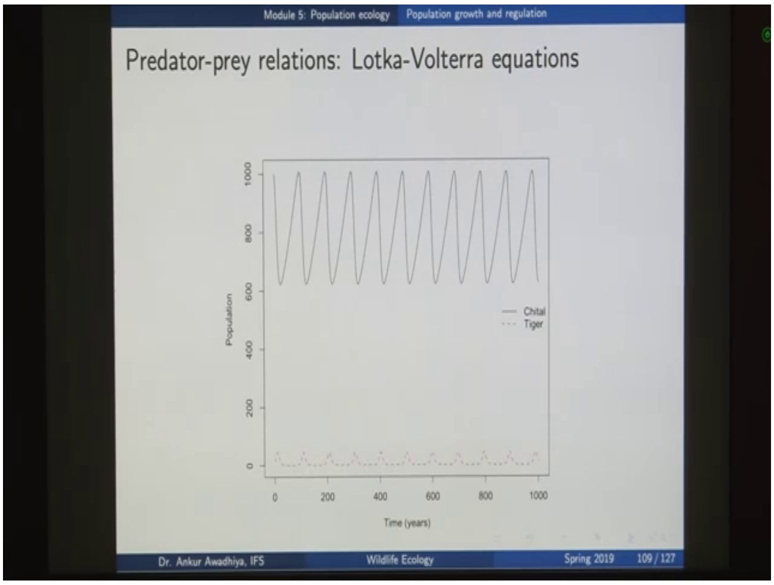

So, in this case the top one is showing you the chital population and the bottom one is showing you the tiger population. What is happening in this case is that you started with 1000 chitals, but you already have a very large size population of tigers your 14 tigers. So, 14 tigers now start preying upon the chitals. So, the population of chitals declines to a certain extent because they are reproducing, but at the same time there also getting predator upon.

So, when the chital population reduces because they are being eaten by the tigers and contrast the tiger population will increase. This will increase because it is getting ample amount of food because of the chitals. But then after a while we will observed that the number of chitals is now less, now if the number of chitals is less. So, you have less amount of food that is available for the tigers. If less food is available for tigers so, their growth rate will reduce; when that happens this population will start declining. Now when this population starts declining if you have less number of tigers so, chitals are not predated upon that much. So, the population of chitals will grow up again.

So, in this manner we will find that you have chital population is high. So, it will increase tiger population and reduce itself, now when chital population is less. So, it will reduce tiger population. So, this will increase and then this process will go on again and again. So, we see these cyclical situations because of the Lotka Volterra equations.

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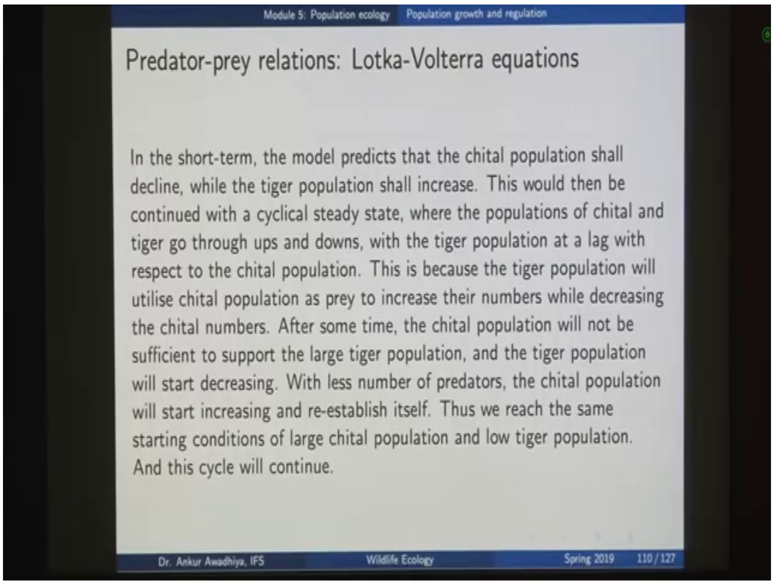

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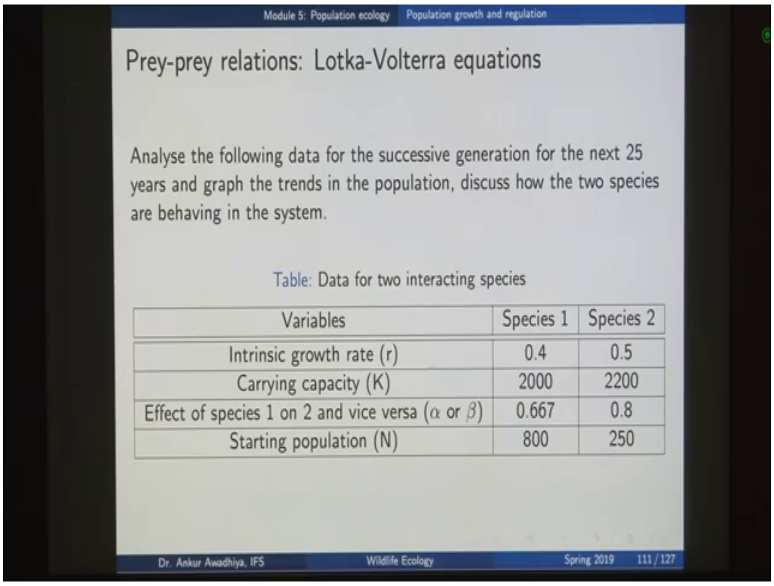

And similarly we can look at interactions of 2 different species 2 different herbivore species. Now, in this example we are looking at the intrinsic growth rates for 2 species are given, the carrying capacity is given 2000 and 2200 and the effect of species that is alpha or beta is given as this and the starting population is given. Now here you observe that in the case of species 1 you have 800 individuals you can have maximum 200 individuals. In the case of species 2 you have only 250 individuals and you can increase it to 2200 individuals what will happen if you plot these curves?

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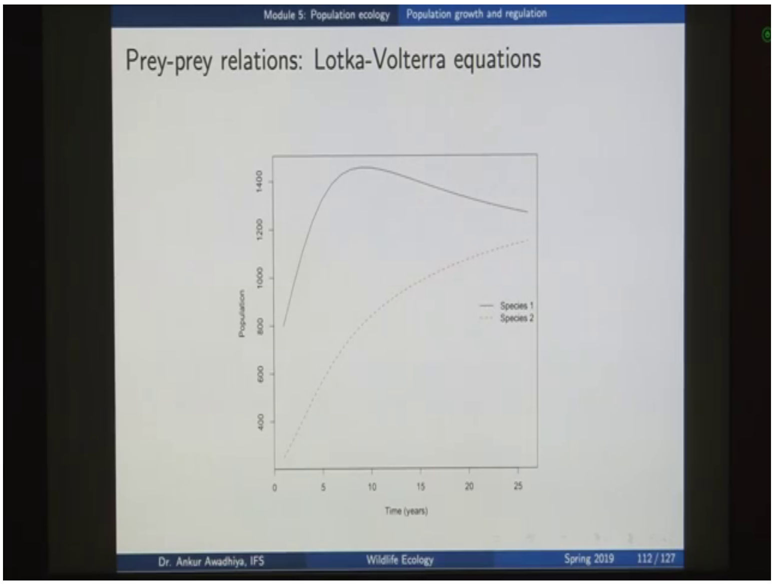

So, remember that species 1 has 800 individuals in the beginning. Now when both of these species are interacting together. So, from 800 it starts increasing, but then it is not able to reach to its maximum; the maximum value was 2000, but then it never reaches 2000; it starts decreasing even before it has reached 2000 why because you have this other species that is also computing.

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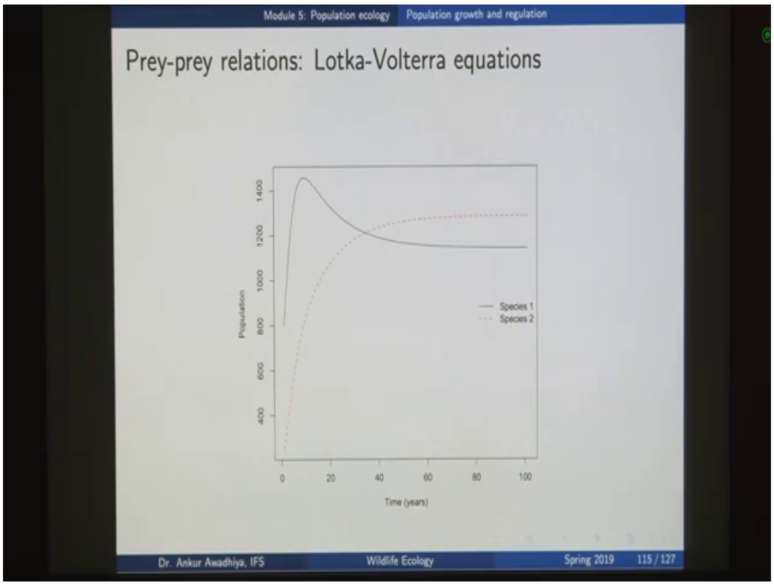

And if you look at the values after a few more generations, we will find that this species 1 that had started with 800 individuals it goes to around 1400, then its reducing and then it becomes constant where is this second species which started with a very low value of 250 it increases and then it becomes constant at close to around 1200.

Now, we can observe here that none of these species is able to reach the carrying capacity; it does not reach 2000 or 2200 individual because both of these species are competing against each other. But then by looking at these mathematical analysis we can make an estimate of what is going to happen in future. So, for instance you have these 2 species, you wanted to conserve these species and you said this population is going to increase till 2200, but then that will never happen because of the population dynamics.

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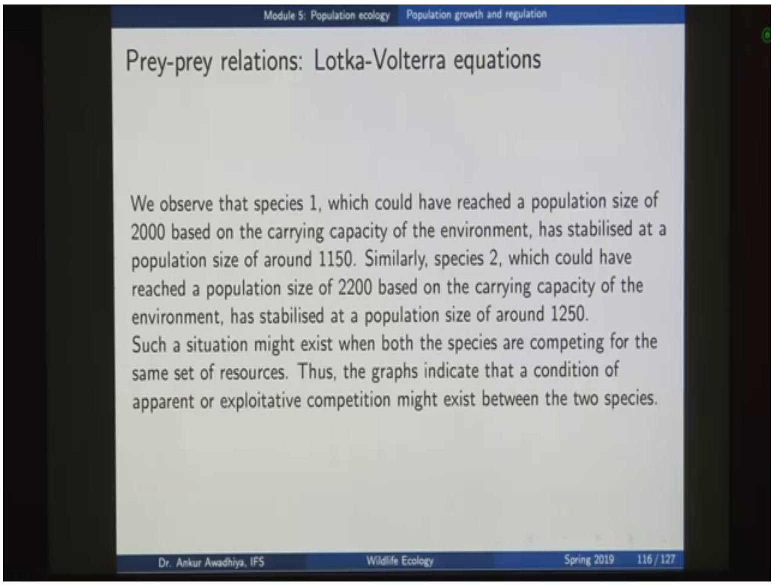

So, equations such as these the Lotka Volterra equations, the logistic grows rate equations help us understand the population dynamics and can help us understand the prognosis of a population, how is it going to behave in future and how can we think at this population. If you have a species of chital if you do not give it any predators it will go on increasing and then it will eat up all the grass and then the whole population will collapse.

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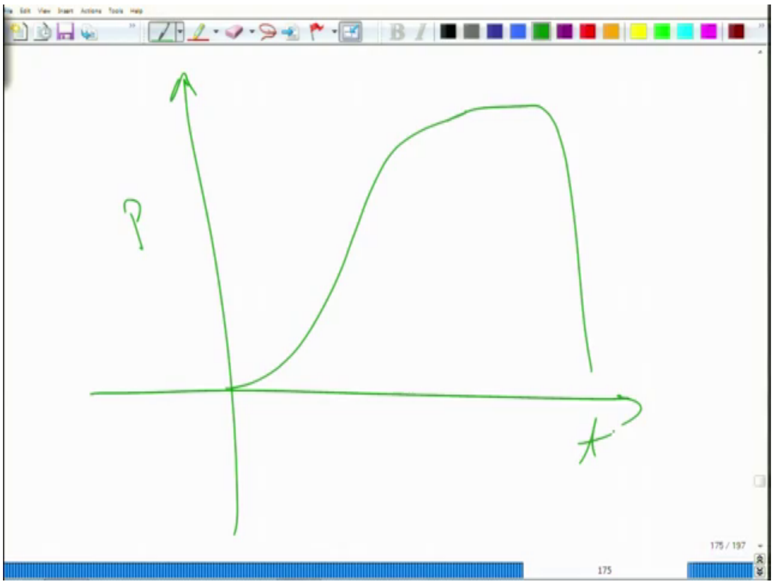

In that case we will have a situation like this, the population increases then it becomes stiffening and then it collapses, but then if you have a tiger here. So, the your tiger will keep the population in check and will allow this system to remain study for a very long period of time. So, that is all for today.

Thank you for your attention [FL].