Wildlife Ecology
Dr. Ankur Awadhiy
Department of Biotechnology
Indian Institute of Technology, Kanpur

Lecture – 13
Population parameters and demographic techniques

[FL] Today, we begin a new module which is Population Ecology.

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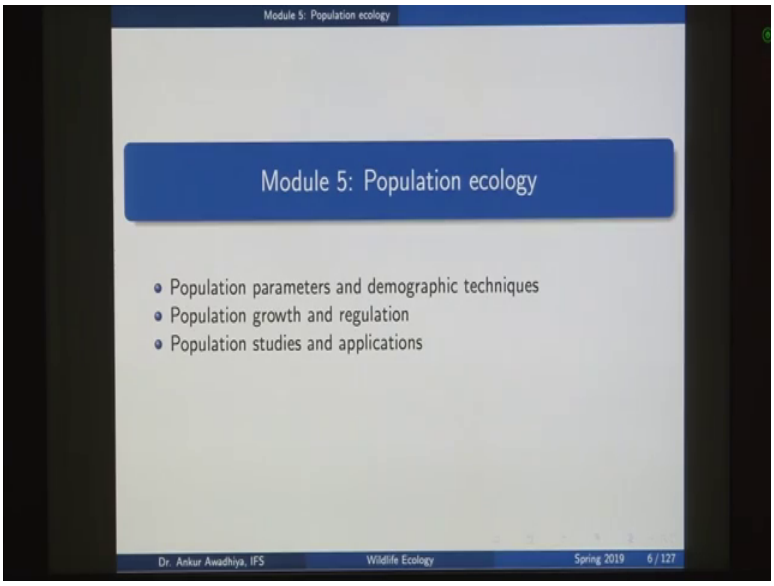

In this module we will have 3 lectures. The first one is population parameters and demographic techniques the second one is population growth and regulation and third one is population studies and applications of population studies.

So, let us begin with Population parameters and demographic techniques. So, here we want to understand what are the parameters through which we can describe a population. And then how do we measure those parameters, what are the demographic techniques that we have now demography demo means people, graphic means to write.

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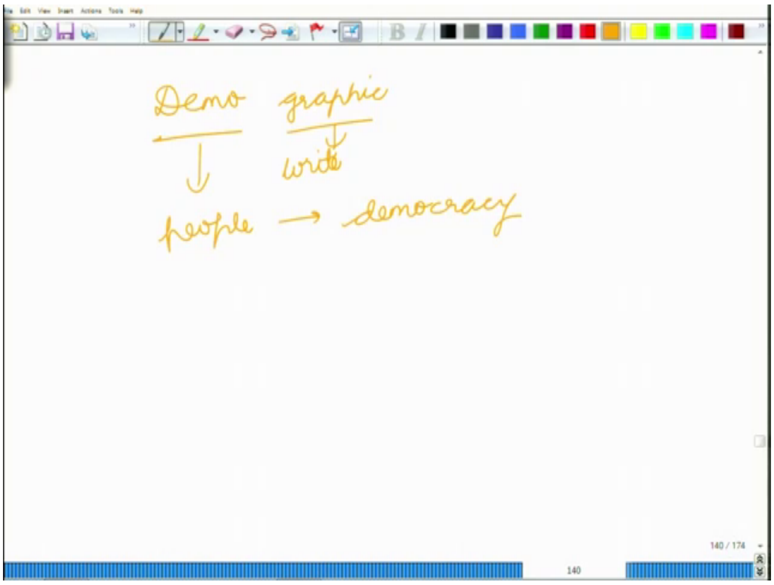

So, when we say demo graphic. So, demo is people as in the case of democracy which is the rule of people, graphic is to write. So, here we want to ask the question what are the methods through which we can write about the ;population; so, that is a demographic technique.

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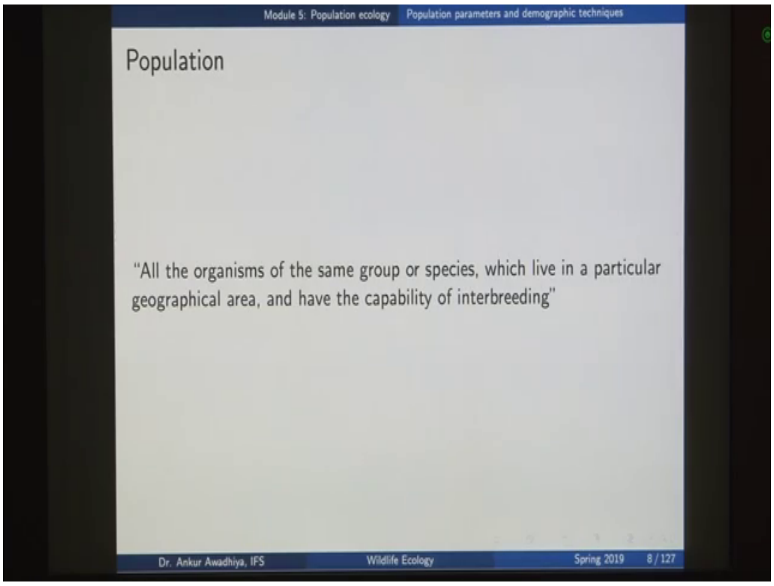

So, we begin with the definition of population as we had seen before all the organisms of the same group or species; which live in a particular geographical area and have the capability of interpreting. So, these are organisms of the same species, they are living together and they are able to interbreed.

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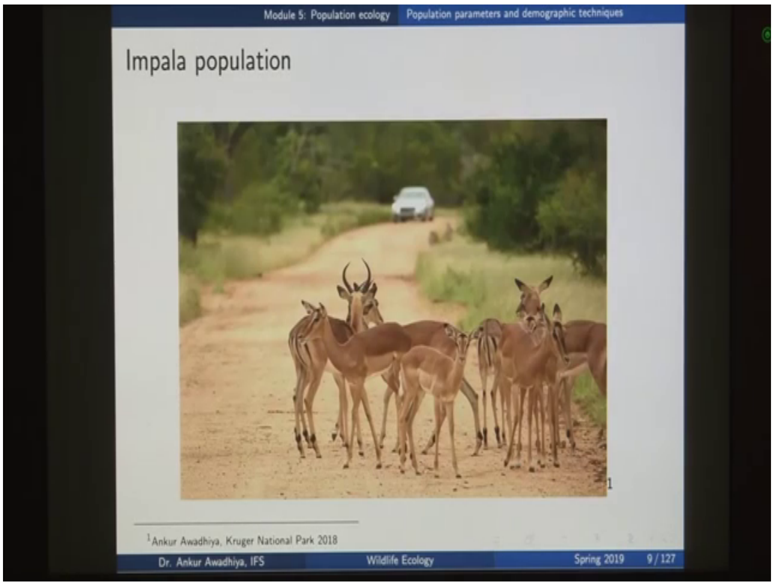

And a good example is this picture which is showing us a population of impala. So, here we have this deer which go by the name of impala these are found in Africa. So, here we have a population of impala and if we remember these are some cheetahs that we had seen before and so, this is also showing us a population of cheetahs that are living together.

Now why do we need to understand the population parameters? That is important because we want to regulate certain species and also because we want to understand more and more about certain phenomena that are happening in nature.

So, for instance if we need to increase the population of impalas in this ;area; now why would we want to increase the population of impalas? Well impala are a very important prey population and so if you have more number of prey you; you will also with time increase the population of the predators.

So, if for instance you are managing this area for cheetahs or you are managing this area for say lions; you would want to increase the impala population similarly in our case in India we want to increase the population of chitals and sambars so, that there is more food available for tigers.

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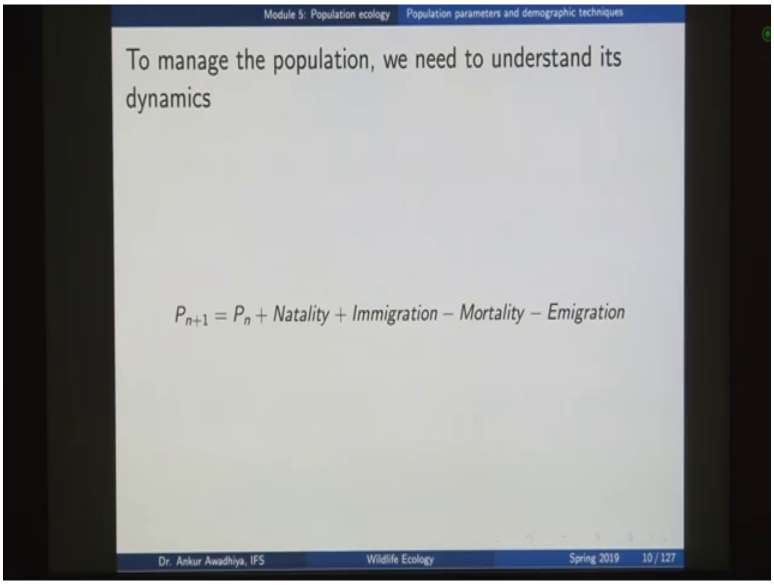

Now, if that is our aim we want to understand how this population will move with time. So, this is the equation that regulates the growth or decline of a population.

So, we have P n plus 1 which is the population at a time that is n plus 1 years is equal to P n that is the population at the nth year. So, here we are saying that this was the population in the nth year; what is the population in the next year that is P n plus 1. Now P n plus 1 is given by P n plus natality. Now natality is the birthrate; how many number of animals what increased because of birth in the existing population.

So, how many animals were added; now addition can be because of natality or it can be because of immigration. Now immigration is when you have animals that are coming from some other area into this area. Now if you look at the definition of population again ah; here we have which live in a particular geographical area.

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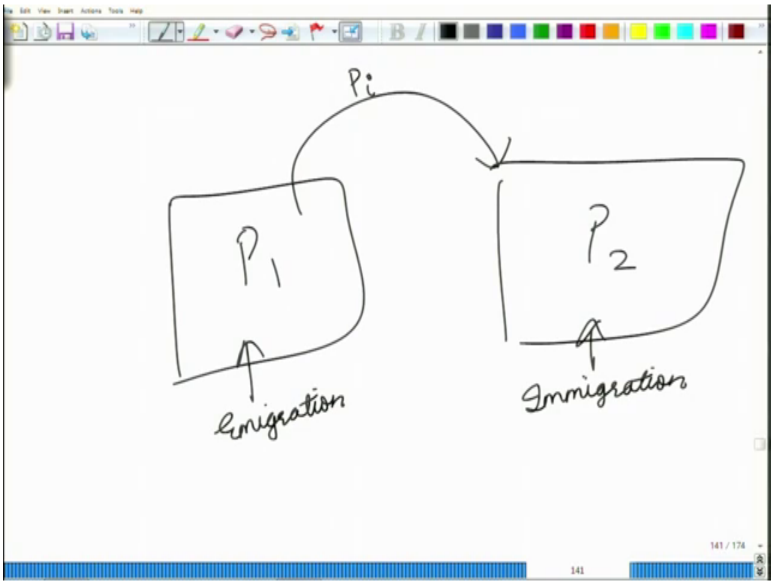

Now if we have see two populations; so here we have a population that is P 1; this population called P 2. And then there is some number of animals say P i that move from P 1 area to the P 2 area.

So, they are moving from the first population to the second population. So, for the first population we will see there that there is an emigration that is there are individuals that are leaving this population and going somewhere else. But in the case of P 2, we are observing immigration that is there are animals that are moving from some other place into this population.

So, in this equation what we see that P n plus 1 is given by P n plus the addition; addition is because of birth and because of immigration, minus the number of animals that are removed from this population. Now why do we have removals or how do we have removals? We have removals because some animals die off and then there are some animals that move away from this area.

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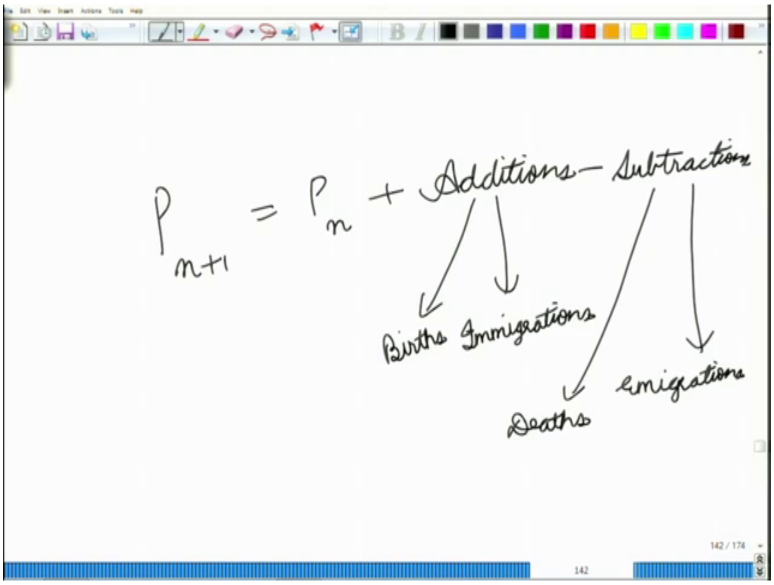

So, essentially what we are saying is that P n plus 1 is P n plus the number of additions minus the number of subtractions. So, you have some animals that are getting added addition can be because of births or they can be because of immigrations and subtractions similarly can be because of deaths.

So, some organisms are dying off or they can be because of emigrations. So, this is the basic equation through which we can understand how a population is moving. Now why do we need to make these assessments, why do we need to understand how much is the population, what are their parameters and how is it going to change?

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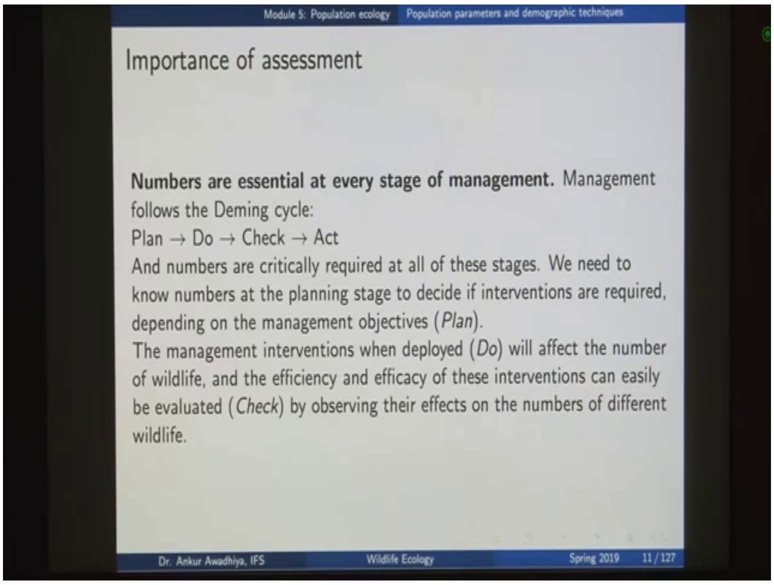

Well, it is important because numbers are essential at every stage of management. So, basically any management goes through these 4 stages which go by the name of the PDCA cycle.

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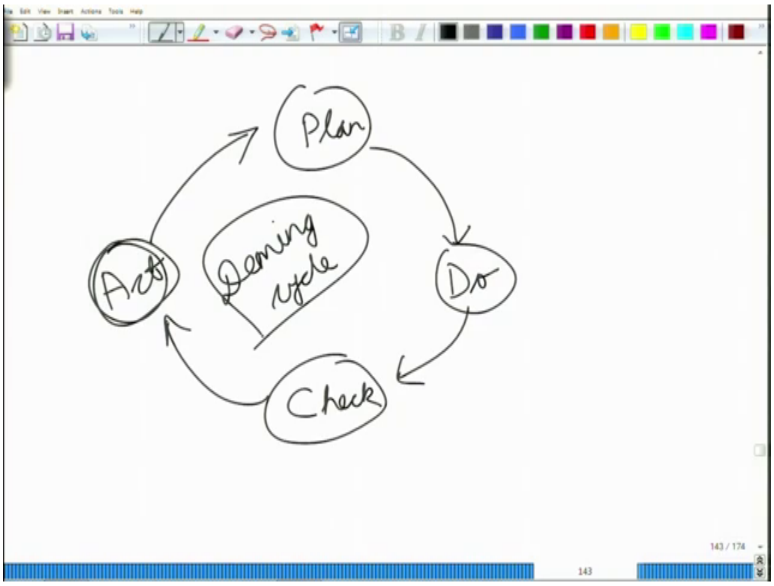

So, here we have P D C and A; so this is planning, so you plan something. So, essentially for instance we are planning that we want to have more number of tigers in our area. So, for that our plan would say for instance that you need more amount of protection, you need more amount of preys, you need to control diseases that are there in this population and so on.

So, once you have made this plan what are the things that you are going to do? Next you do those acts. So, from plan we move to the doing stage. So, in doing you actually implement those plans. So, doing is the stage of implementation once you have implemented something; next you want to check whether those implementations are having those impacts or not.

So, for instance you increase the population of chitals, but then the population of tigers did not increase; that could be a situation because tigers are getting posed up they are getting removed from this system because of hunters. So, after doing any doing stage you need to move to the next stage which is the checking stage. So, next you do a checking are your interventions having the desired impact or not and based on the results of your checking stage the next stage is acting.

So, acting is if suppose your tiger population is increasing do you further substantiate the number of chitals so that you further increase the number of tigers. Or if the number of tigers has increased to a level that you are satisfied with now should you stop increasing the number of chitals or for instance the number of tigers is still decreasing what do you do so that you are able to have a grasp on the situation. So, that is the acting stage and from that act we come up to the next stage of planning again.

So, for instance in this case suppose we figured out that you have a; you have tiger numbers that is reducing because of poaching. So, you will make another plan you will say that now we need these steps to reduce the poaching that is there in this population. So, this thing goes by the name of the deming cycle and at all of these stages planning, doing, checking, acting we require numbers.

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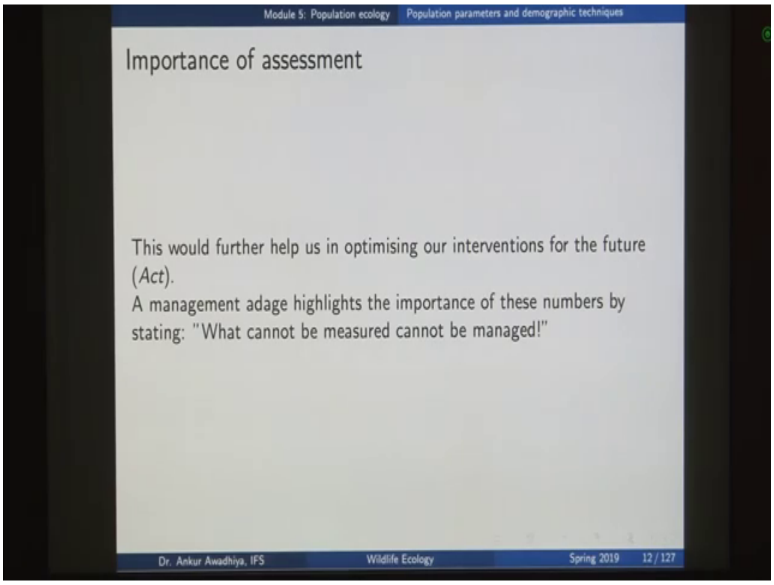

Why do we require numbers? Because if we do not have these numbers if we are not able to measure how much population do we have; how are we going to manage that population?

Because the first question that we are asking is we want to increase tiger numbers; if we want to increase tiger numbers the first thing that we should know is what is the current population of tigers and what is the population of tigers that we want. If we are doing something to the system we want to ask is this doing having an impact or not? So, at every stage you require numbers. So, which is by population assessment becomes extremely important.

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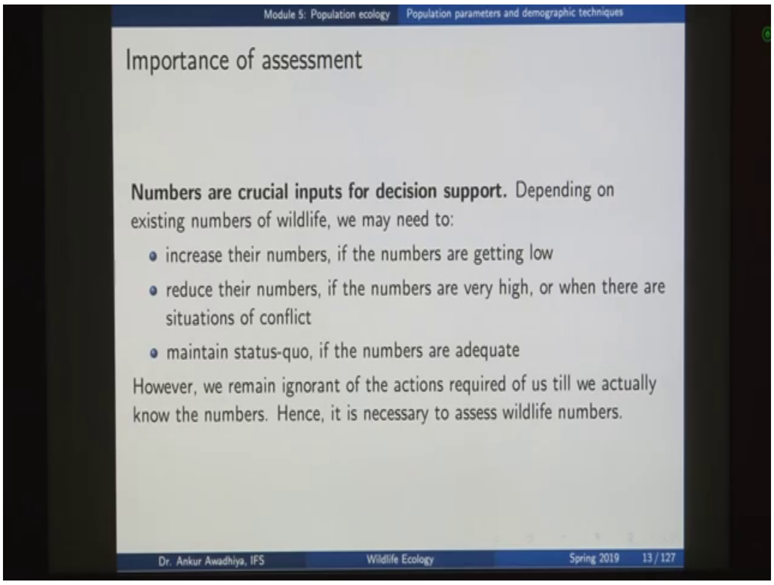

Now, probably in assessment is also important because numbers are crucial inputs for decision support. So, for instance we need to make these decisions; do we want to increase the number of tigers because the numbers are getting low or the numbers are already low or do we want to reduce the numbers because you have you have too many tigers and that are leading to conflicts or maybe your system is not able to support so many tigers.

So, do you want to reduce the number of tigers or do you want to maintain a status code; do you want to maintain the equilibrium state that yeah this many number of tigers is good for the system; so, we should have these same number of systems. However, we remain ignorant of the actions required of us till we actually know the numbers.

Do we want to increase, reduce or maintain status quo is something that we will only know, if we know the number of tigers that are existing and the number of tigers that we want. So, this makes assessment of the animal populations extremely important.

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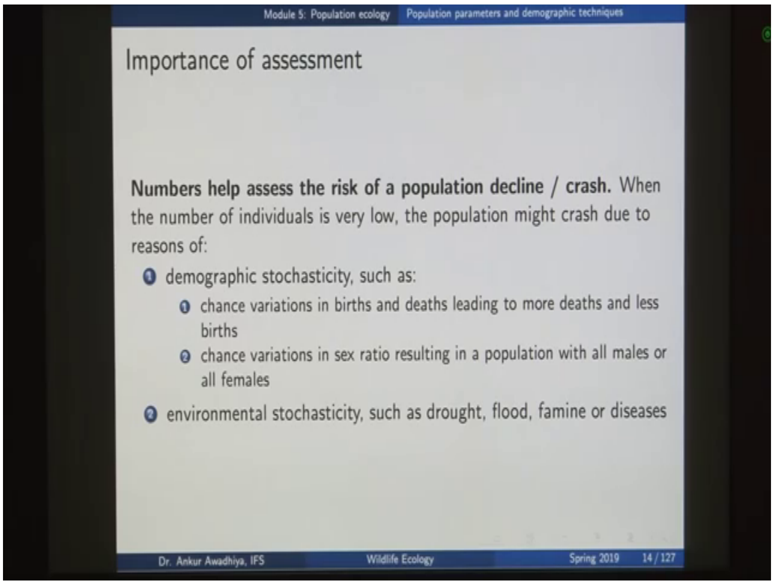

And we also require to assess the population status to assess the risk of a population decline or a crash. So, for instance if you have a very small population; you have say 4 tigers in any area and these 4 tigers turn out to be all males. So, if you have 4 males in an area the population is not going to increase any further. So, with the death of these 4 individuals the whole population or collapse down to 0.

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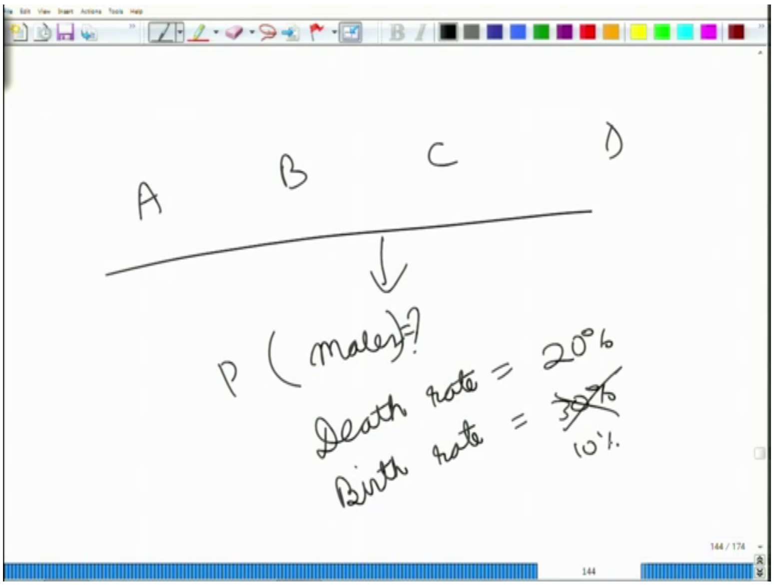

So, in such as to avoid such a scenario; you need to assess what are the probabilities that if you have alone female in your area or if you have very few number of individuals in your area what is the possibility that all the offsprings turn out to be males ?.

So, what is the probability that all the offsprings are males? So, you want to have an assessment of the probability of having such as of having such a scenario. Or for instance you want to understand if demographic stochasticity is going to have any impact. So, demographics stochasticity is one example what we have already seen; the second example is a chance variation in birth death.

So, for instance every population is suffering from some birth some deaths. Now what will happen is you have say a death rate of say 20 percent and a birth rate of 30 percent; if this is the scenario your population is going to increase.

But then by chance it is possible that this year in place of having 30 percent a birth rate; you only have a 10 percent birth rate and your population is going towards the collapse. So, you want to make an assessment of what is the probability that you might have such a situation or to understand; if there is a possibility of an environmental stochasticity.

Now environmentalists stochasticity means a chance event in the environment that may lead to a population crash. Such as you want to understand if any drought or any flood or a famine or a disease is going to have an extremely negatives impact on the population; now why is that important?

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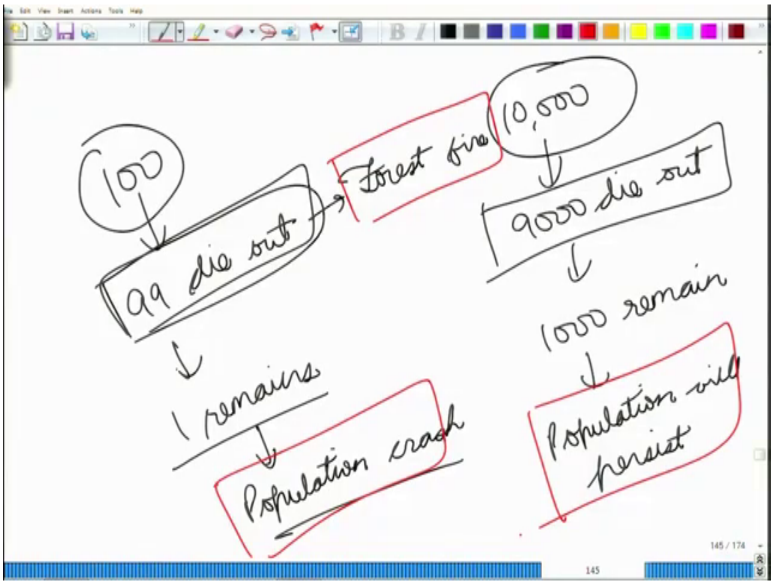

Suppose you have a population of say 100 individuals. Now, out of these 100 individuals say 99 die out and only 1 remains. Now you have these 99 that are dying out because of say a forest fire.

Now if you only have 1 individual that remains then you will have a population crash because you do not have any further births in this population. Now this happened because you already started with a very low population of only 100 individuals. Now in place of having 100 individuals say we have 10000 individuals; let us start with 10000 individuals and because of this forest fire which was an environmental stochasticity; you have a situation in which there is a massive number of tips and as many as 9 thousand individuals die out.

So, here we only had 99 individuals that were dying out here you have 9000 individuals that are dying out, but still you will have 1000 that will remain in the population and so the population will persist. Now to understand if you are we have the same scenario in both the situations; we have a forest fire that is clearing off a very large area of the forest. Now what is the impact of any of these environmental stochasticities can only be understood if we know the size of the original population.

So, with this we can make an assessment of the probability that you will have a population crash or a survival of the population.

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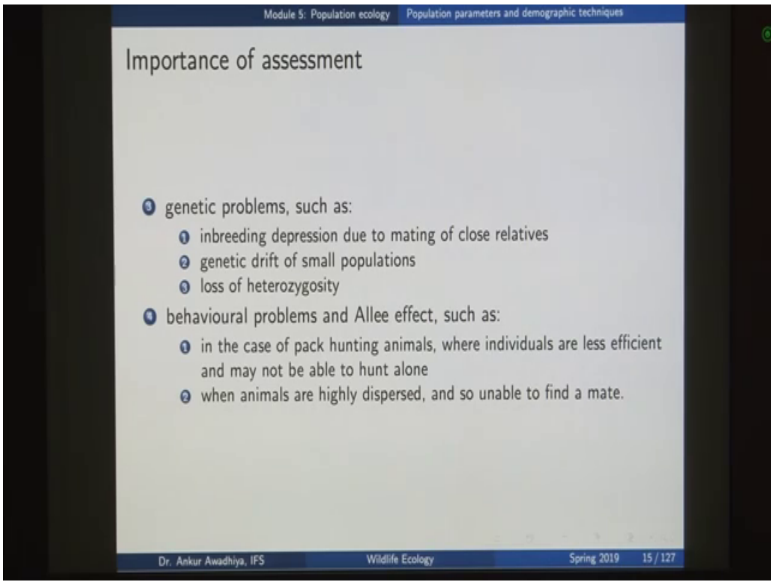

Or you can even try to understand what are the; what is the possibility that you will observe genetic problems in your population. So, if your population size is very less that you have a very high amount of homozygosity in this population; you might even see if situations of inbreeding depression or genetic drifts or loss of heterozygosity or then or if you have a very small population you can also start seeing behavioral problems behavioral problems and Allee affect.

For instance, in the case of pack hunting animals where individuals are less efficient and may not be able to hunt alone. A very good example is the case of the wild dogs; now in the case of wild dogs when the group goes out for hunting some animals remain back with the young ones, to protect the young ones.

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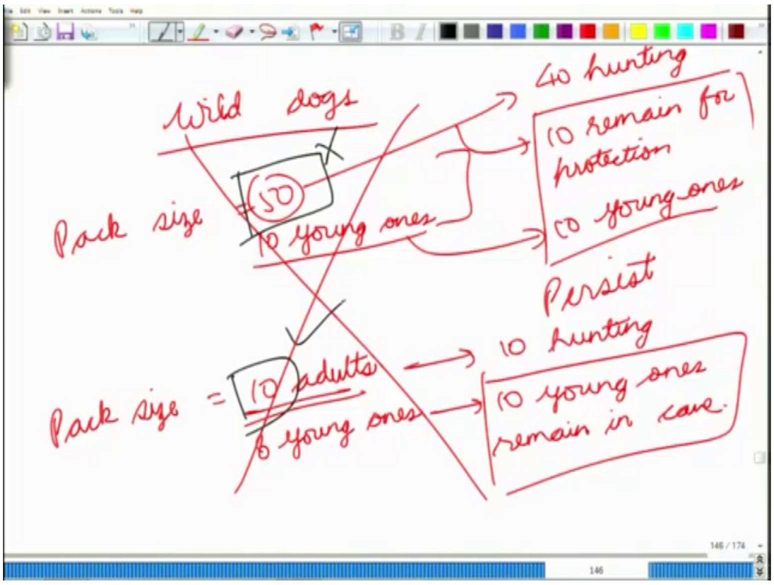

Now, for instance if you have a; we are considering the wild dogs and suppose you have a pack size of 50. Now, if you have 50 adults and say you have 10 young ones; now when these animals have to go out for hunting then out of these 40 you will a out of these 50 you will have 40 that go out for hunting; for instance then you will have 10 that remain for protection and you have these 10 young ones that also remain in the cave.

So, you have these 10 young ones that also remain in the cave. So because you are able to spare these 10 individuals to take care of the young ones; so you are able to; so this population is able to persist; so in this case the population is able to persist because the young ones are getting a protection. On the other hand if you have a very small size; so, you have a pack size which is say 10 individuals.

So, you have 10 adults and say you have 8 young ones. Now because these wild dogs hunt using a pack strategy; so all of these individuals they have been evolved in such a manner that when all of them go together and attack or they go together in a large number and attack a prey; then they are able to kill that prey. But then if you have only a single dog that might not be able to kill the prey. So, to have a possibility that you have some amount of food that you can bring back to the young ones all these 10 adults will have to go out.

So, all 10 go for hunting and you have all the 10 young ones that remain in the cave. Now in this case you do not have any amount of protection for these young ones. So, what happens is some other predators; so, things like leopards might come into this area and hunt these puppies. So, once that happens the whole population will is going to collapse. So, this is an impact that is known as the Allee effect; in which you have a very small number of organisms that are not able to perform their biological functions properly.

So, they are either not able to hunt properly or they are not able to find their mates properly and so on; so, we start seeing behavioral problems and Allee effects. Now these problems only occur when you have a very small population if you have these 15 individuals you would not have an Allee effect, but if you have these 10 individuals you will have an Allee effect; now to understand whether your; whether your population is at a scenario where it can suffer from these behavioral problems or Allee effects or genetic problems or so on; the first thing that you need to know is how many individuals are there in the population, which makes population assessment extremely crucial.

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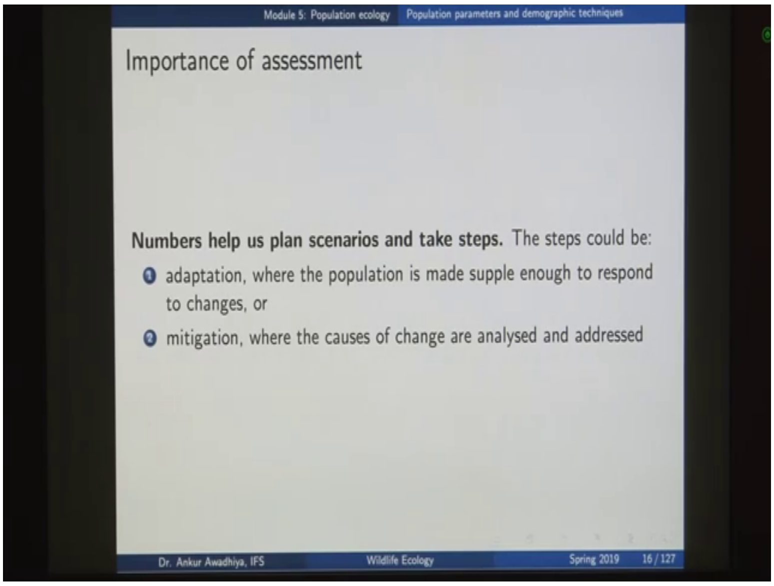

Now, population assessment also helps us to plan scenarios and take steps.

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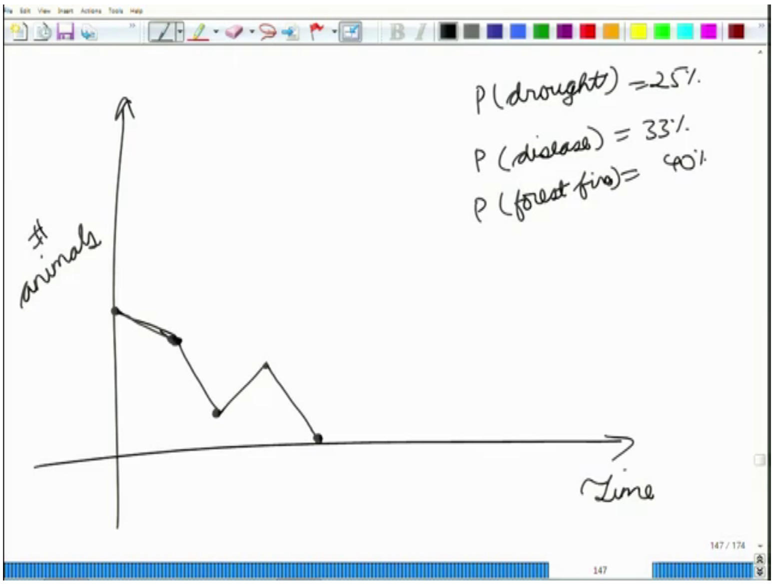

So, when we say planning of a scenario; what do we mean? We ask this question that suppose this is your number of animals of any species that you are interested in and this is time. And suppose we have this many number of individuals and you have a probability of say drought of say 25 percent.

So, once out of every 4 years you will see a drought probability of a disease is say 33 percent. So, one out of every 3 years you will see a disease probability of say a forest fire is say around 40 percent which means 4 out of 10 years you will see a disease. Now you can make scenarios you can ask; what is the possibility that this population is going to persist or not? So, for instance this is the first year and suppose the in the first year you suffered a drought; so, because of the drought the population collapsed.

Then the next year you got a situation where you had a drought as well as a forest fire. So, your population decreased even further maybe the next year was a good year. So, the population started to increase, but then you had another year in which you had a drought a disease and a forest fire and the population collapsed.

Now if you can if you and such a scenario is highly likely if you have a very small population size. So, you can make an assessment; you can make you can ask this question what is the scenario that is possible because you have these many probabilities of having a drought of flood or forest fire or disease and so on and in all of these scenarios what is going to be your action point.

So, for instance if we see that our population our starting population is so less that all of these impacts are going to crash this population; say 10 percent is the is our probability that this population is going to crash within 10 years; so, that is a very high possibility. So, in that case to overcome this possibility we might want to substantiate our population, we might want to put in more number of individuals or maybe we would want to protect our individuals from the common diseases; maybe we would want to vaccinate our animals or maybe we would want to avoid the avoid any situation of forest fire.

So, maybe we will go for a very intensive protection in that area, but that is only possible if we have the scenarios and scenarios is only possible, when we have the numbers. So, assessment of a population is extremely important and once we have these numbers when we once we have the scenarios we can go for adaptation or mitigation. Now in the case of adaptation you try to make your population supple enough to respond to changes.

So for instance you would if you have our disease you would want to give more amount of nutrition to the animals so that they are able to fend off these diseases or you or you would want to give them some amount of vaccinations. On the other hand you can you could you could even go for mitigation where the causes of the change are analyzed and addressed. So, in the case of disease you might want to kill off all the parasites or kill off all the vectors and so on. So, essentially an assessment of a population size or the numbers is extremely crucial.

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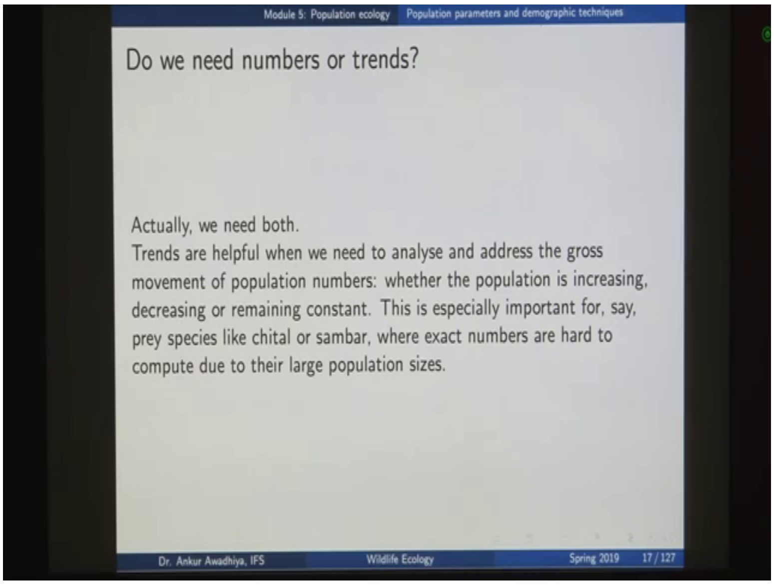

Now, when we are talking about a population assessment; the next question is do we want to see the numbers or do we want to see the trends?

So, numbers in trends means last year we had say 2500 tigers; so that is a number. And when we say trends we are saying that this year the number of tigers is greater than what it was in the last year. So, do we need number; so do we need trends? We will actually we need both of these trends are helpful when we need to analyze and address the gross movement of population numbers; whether the population is increasing decreasing or remaining constant. And this is especially important for prey species such as chital or sambar where exact numbers are hard to compute due to their large population sizes.

So, for instance in the case of prey species you do not want to know whether there are 10000 cheetahs in your area or whether there are 10000 10 chitals in your area. But as long as you know that the number of cheetahs is same or is increasing you are happy. So, in that case you do not have to go and may and count each and every chital.

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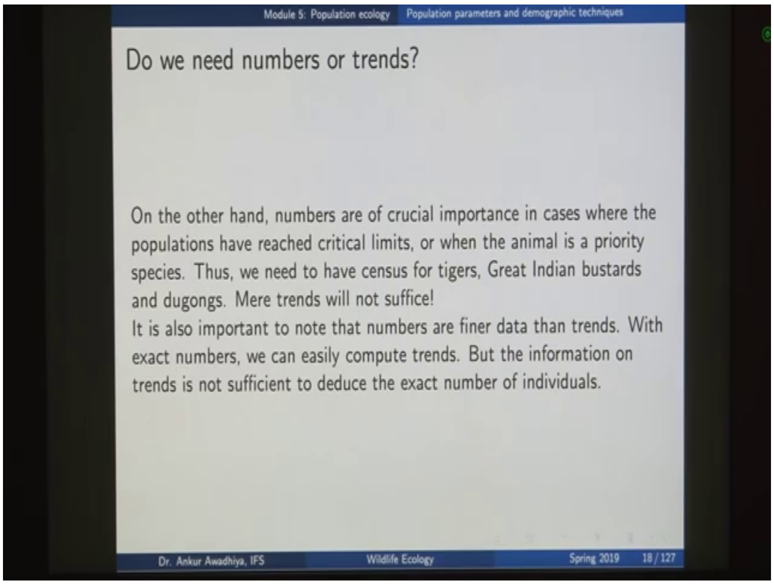

Whereas for some other organisms such as your critical species like tigers or dugongs you would want to know the exact numbers; now numbers give us finite data then trends. So, if you know the number of animals that was there this year last year and so on, you can compute trends from these numbers, but you cannot go the other way.

So, if we just know that this year the number of tigers is greater than that is greater than what we had last year and last year was greater than what we had previous to last year and that was less than what we had the year before. From that information you cannot figure out the number of tigers that we have today, but we have if we have the number of tigers we can very easily compute the trends.

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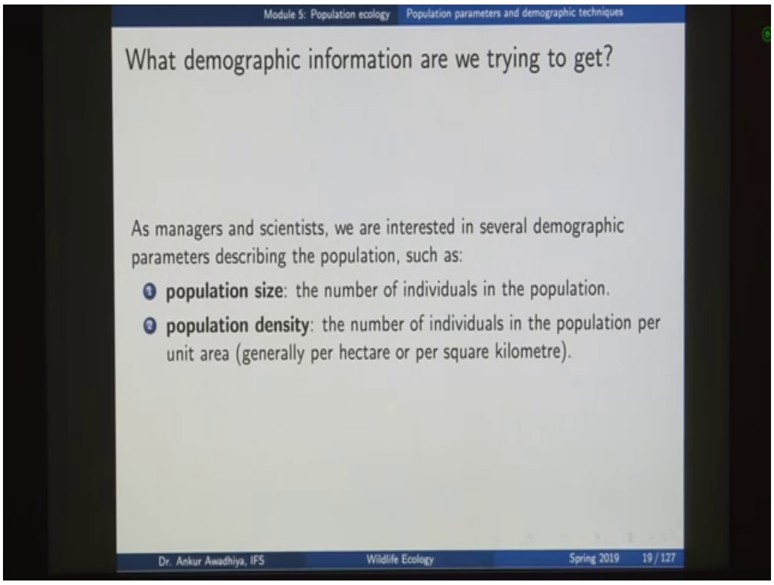

So, when we are talking about a population what are the population parameters what are the demographic information that we are trying to assist in this study.

So, we require a number of parameters the first one is the population size population size is the number of individuals in a population. So, when we say that Panna Tiger Reserve has say 35 number of tigers we what we are referring to is the population size that we have of tigers in the Panna tiger reserve. Now in place of population size we could go for the population density; population density is the number of individuals of the population per unit area. So, if say Panna tiger reserve has an area of 350 square kilometers.

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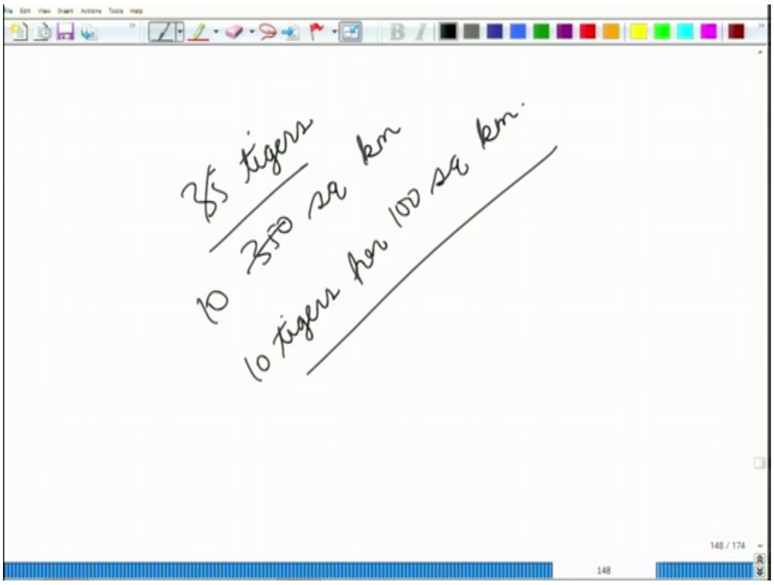

So, in that case we would say that we have 35 tigers in 350 square kilometers. So, that would mean 1 tiger every 10 square kilometers or 10 tigers per 100 square kilometers.

Now when we put the numbers in terms of per unit area per hectare or per square kilometer or per 100 square kilometer; what we are referring to is the population density. Now population density can vary a lot between different organisms.

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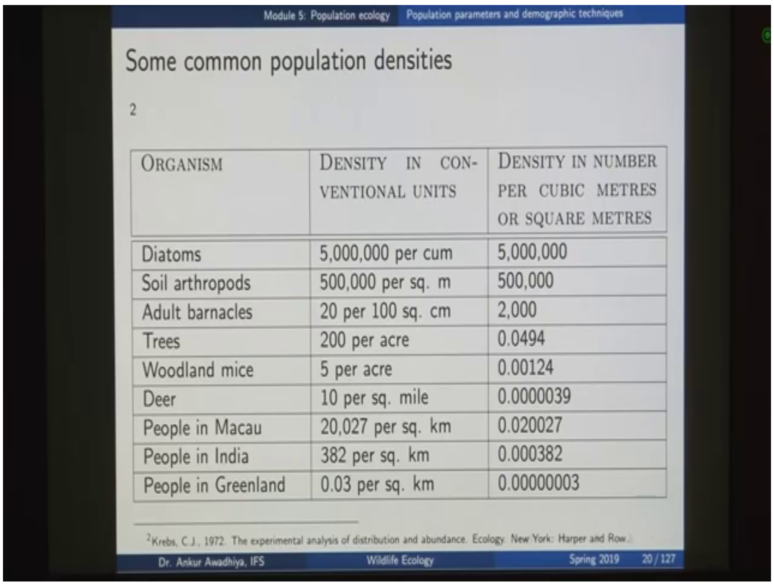

ORGANISM	DENSITY IN CONVENTIONAL UNITS	DENSITY IN NUMBER PER CUBIC METRES OR SQUARE METRES
Diatoms	5,000,000 per cum	5,000,000
Soil arthropods	500,000 per sq. m	500,000
Adult barnacles	20 per 100 sq. cm	2,000
Trees	200 per acre	0.0494
Woodland mice	5 per acre	0.00124
Deer	10 per sq. mile	0.0000039
People in Macau	20,027 per sq. km	0.020027
People in India	382 per sq. km	0.000382
People in Greenland	0.03 per sq. km	0.00000003

So, for instance if we look at density in say; numbers per cubic meters or per square meters; so things such as diatoms now diatoms are small animals that are found in the oceans and their numbers are represented in per cubic meter.

So, you have 5 million diatoms per cubic meter when you talk about soil arthropods; so you have this number of 500000 per square meter. But if we look at other organisms; so here we have these numbers of 500000 for arthropods. In the case of trees this goes down to something like 0.05; in the case of people it can go even down to something like 0.00000003 per square meter.

So, you have a very large diversity in these numbers; so for instance in the case of our tiger reserves the; the density of chital or the density of sambar is going to be much higher than the density of tigers. Now it is important to know this fact that you have a large variation so that you can discern the best technique that you will use to measure the population density.

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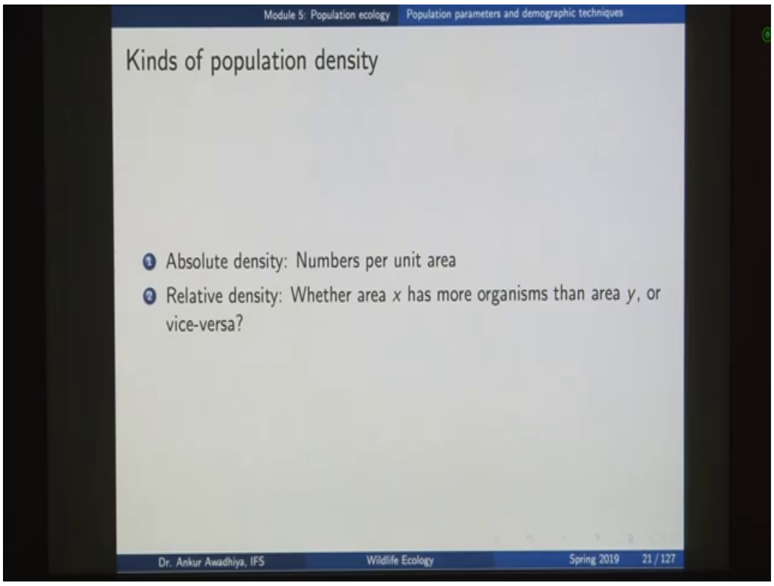

And when you talk about population density we can look at absolute density or relative density. Absolute density is the number of organisms per unit area and relative density is only asking the question whether in area x has more number of organisms then area y or thus area by have more number of organisms then area x.

So, in that case we are not interested in the actual numbers what we are interested in is only which area has more number of individuals; so, that is the relative density. Now we look at both of these population densities.

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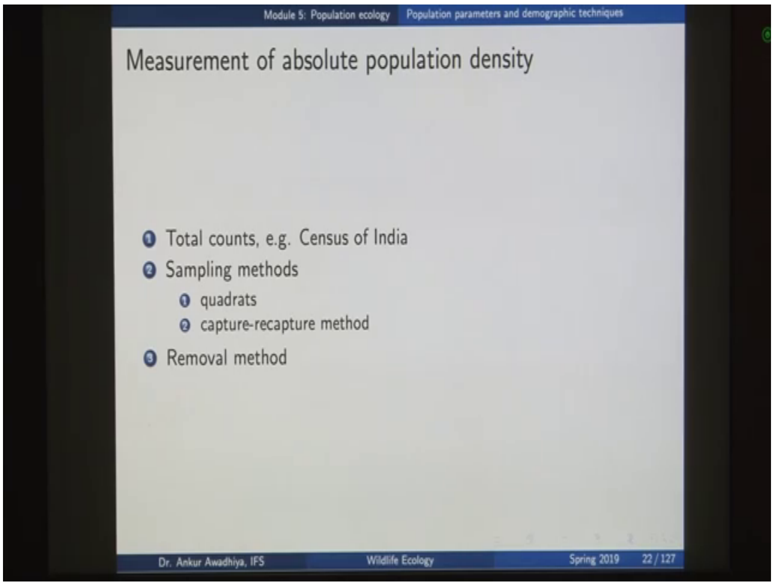

When we talk about the absolute densities; we can measure absolute densities in three methods. The first one is total count total count is you go and measure each and every organism. So, for instance census of India is the total count.

So, the census officials will go to every household and ask how many males are there how many females are there how many children are there and so on.

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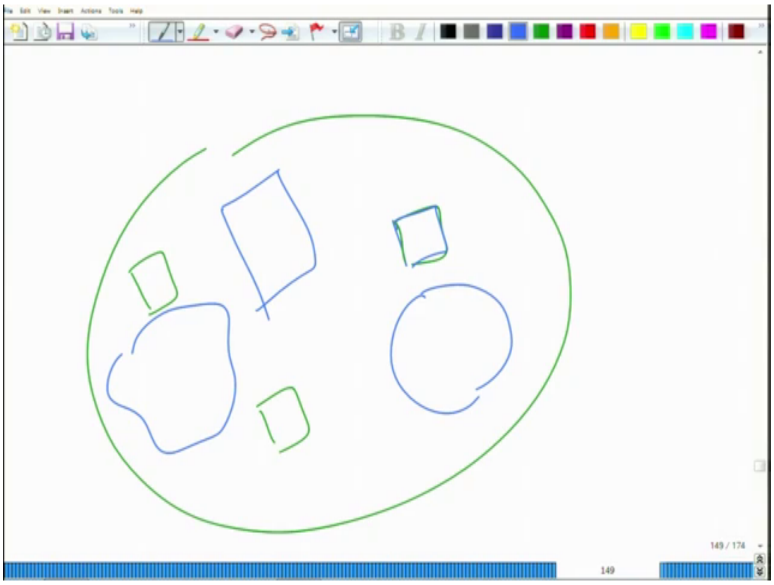

The second method is a sampling method now if you have a large area; so, you have this large area that is a forest and you cannot measure the animals everywhere. So, what you can do is you can take some samples out of this area, measure your animals, or count your animals get a density and then extrapolate that density to the whole of the area; so, that is the sampling method.

So, in place of doing our total count you are doing a sampling in some area and this sampling can be in the form of quadrats or in the form of capture recapture method and we will look at these in greater detail in a short file. And the third method is removal method; in the case of removal method you have put up traps you kill the animals and you look at the rate at which these animals are getting removed from the system.

So, this method says that if you have more number of animals; then more number of animals would die off and if you have less number of animals less number of animals would die off. So, with that you can make an estimate of the number of animals that are actually present in your area. Now this is not very useful in our Indian scenarios because we do not kill animals, but then this is also one method. So, we should know that this method exists.

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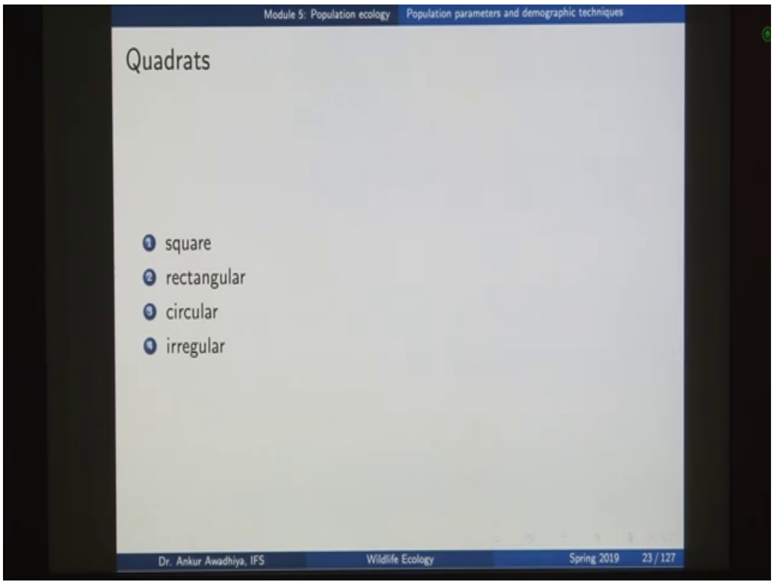

Now, when we talk about quadrats; so in the case of sampling we were talking about quadrats; in the case of quadrats you can have a square quadrats. So, these areas that we are using they can either be a square or they can be a rectangular area or they can be a circular area or we could even go for some irregular areas; so, all of these combinations are possible. But then when we are when you are using this quadrat method, the question is how many samples do we need where to set up these samples and so on.

So, for that it is important to know the process of sampling.

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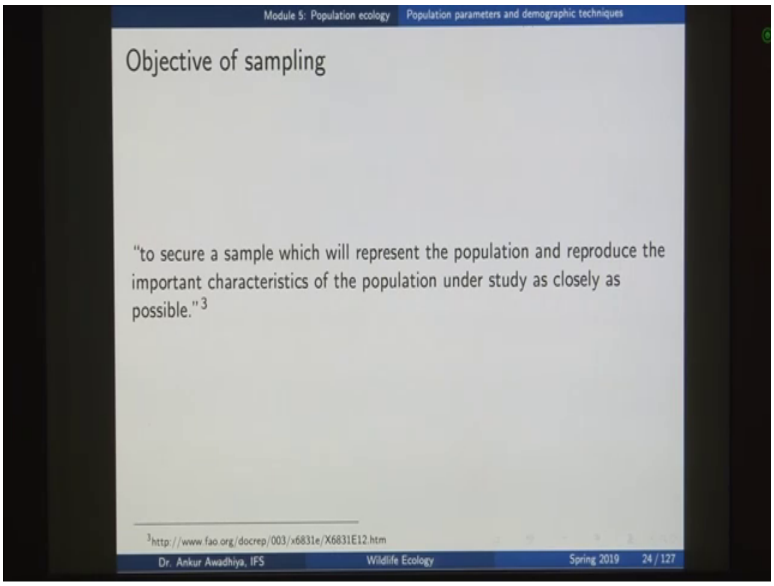

Now, sampling goes by the objective to secure a sample which will represent the population and reproduce the important characteristics such as the population under study as closely as possible.

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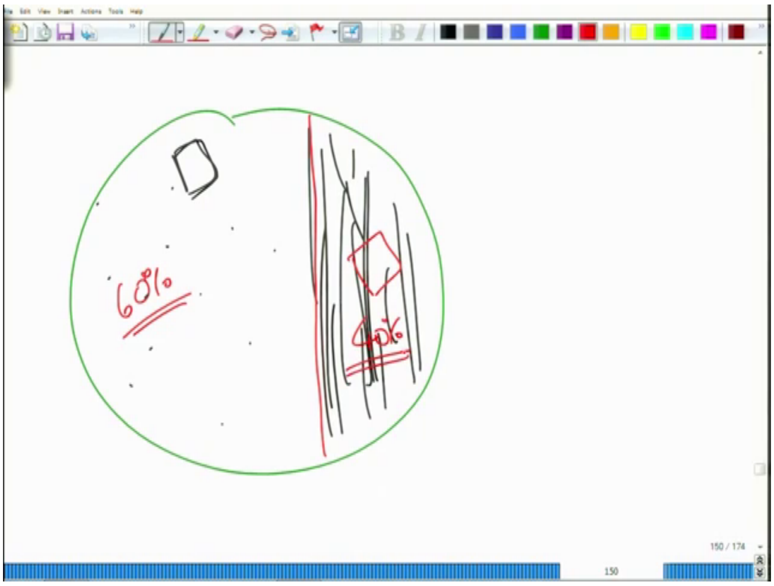

So, for instance if we have this area and in this area the right side has a much greater density of animals than the left side; so in this case when you are taking a sample you would want to have a sample that is representative of the whole area.

So, for instance if you take with just one sample here and you take this density and you extrapolate it to the whole of the forest; then your final estimate would be a very gross underestimation because you will say that here you have a very less density of animals. So, you are extrapolating and you are saying that the whole area has a very less density. On the other hand if you are taking quadrat only here then you might overestimate they overestimate the number or the density of animals.

So, the sample has to be chosen in such a way that it represents the population and reproduce the important characteristics. So, in this case what you should do; is you should if you have this information have been issue that this much area say 40 percent of the area is having a high population density. So, in that case you will take samples in a way that 60 percent of your samples fall in this area and 40 percent of your samples fall in this area; so, that it will becomes a representative of the whole population.

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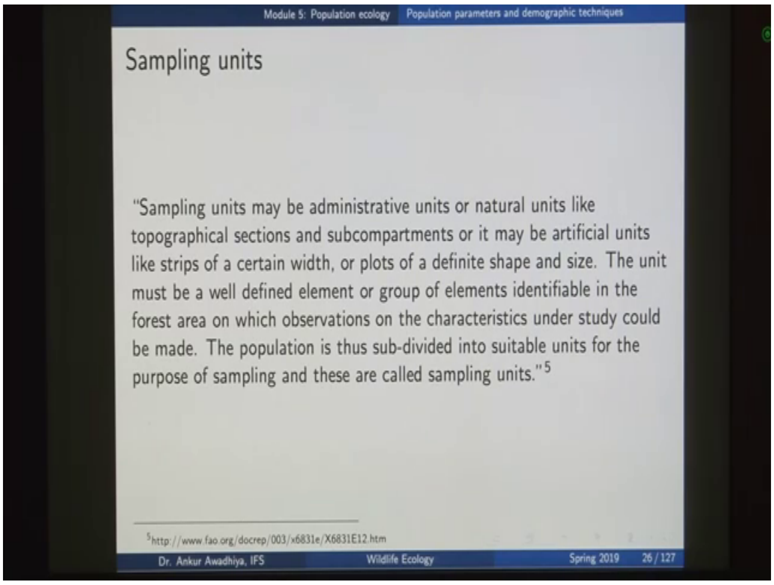

Next we have sampling units sampling units may be administrative units or natural units like topographical sections and sub compartments or it may be artificial units like strips of a certain width or plots of a diff of a definite shape in size.

The unit must be a well defined element or group of elements identifiable in the forest area on which observations on the characteristics under study could be made. The population is then subdivided into suitable units for the purpose of sampling and these are known as sampling units.

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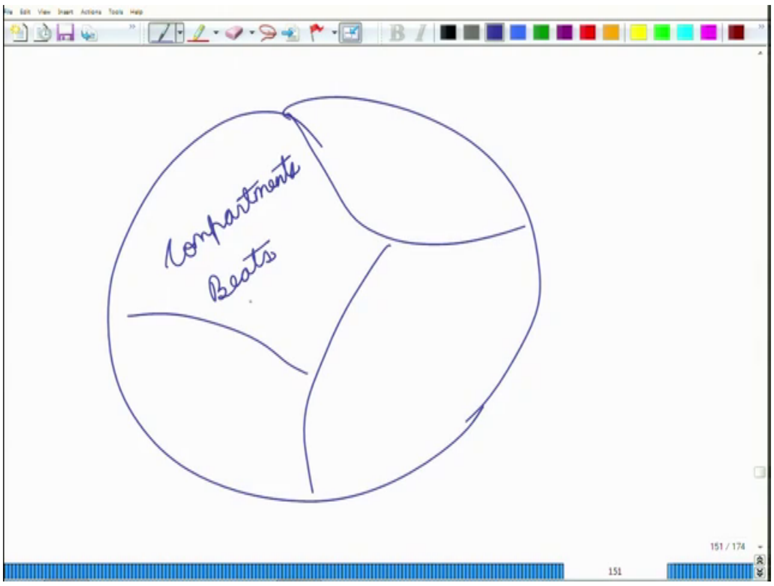

So, essentially if you have an area; you can make use of natural sub units or administrative sub units or artificial units. So, in the case of our forest we might go for see compartments; compartments are management units or we could go for beads which are administrative units. So, a bit is an area that is being that is being managed by a single forest guard or we could go for natural units.

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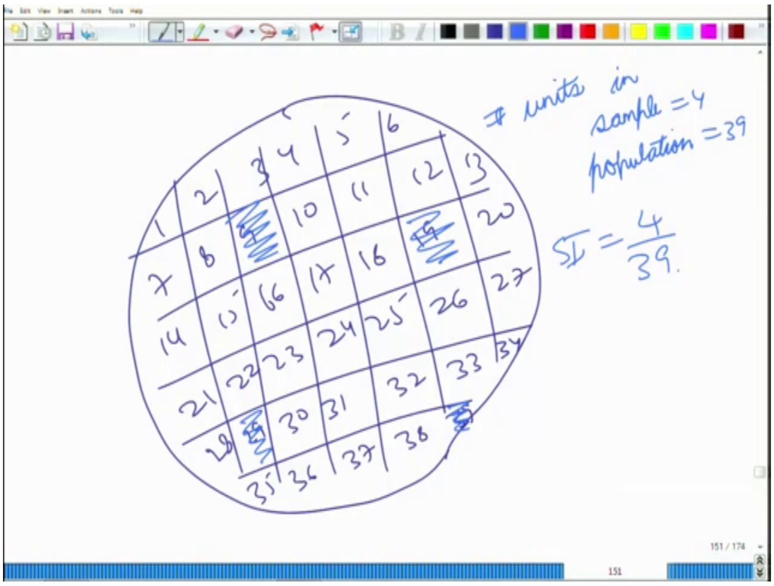

So, natural units for instance if this is the forest and then you have a river that is dividing it into two parts; so we can say that these are natural units or we would even go for artificial units in which case we can define certain in grits and we can say that these are what we have defined as our sampling units. Now next we defined a sampling frame.

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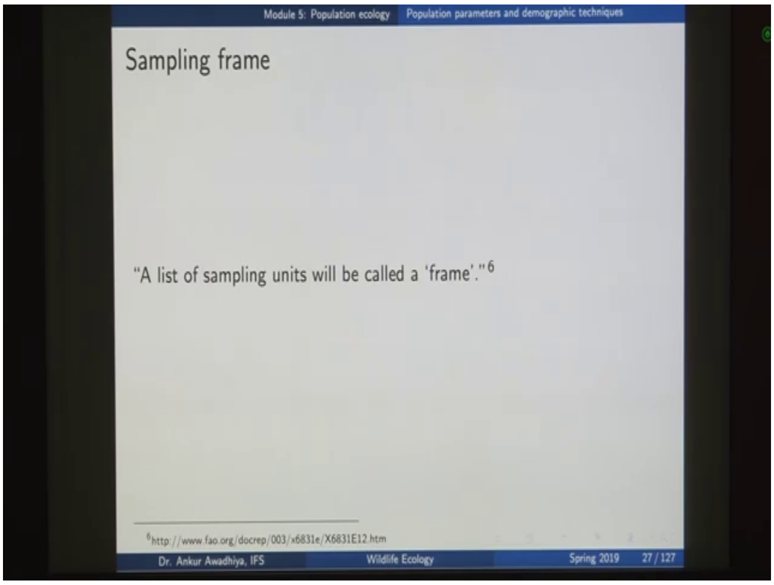

A list of the sampling units is called a frame. So, in this case if we say that we have all these grits 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 so on when we make a list of all of these then we call it as a sampling frame and from this sampling frame we pick up a sample.

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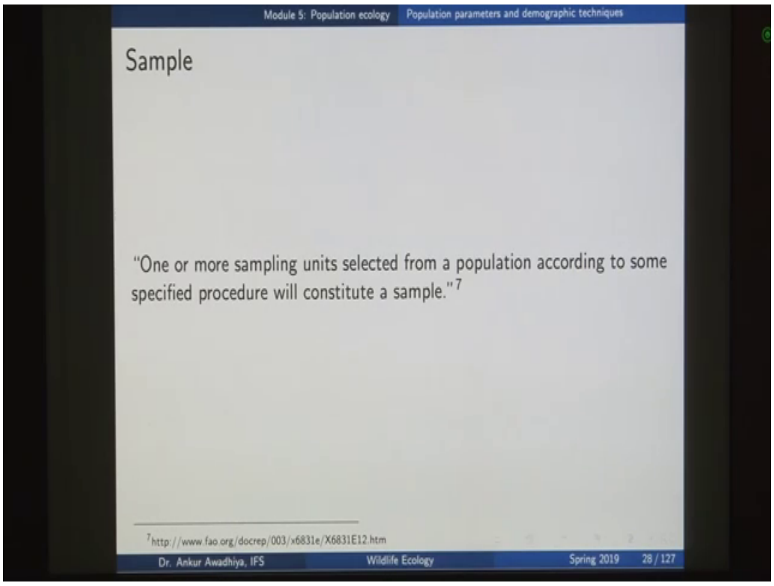

Now, a sample is one or more sampling units that is selected from a population according to some specific procedure to constitute a sample. So, for instance in this case we had 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, and 39; so, we have these 39 subunits and if we say that we are selecting this unit 9 and 19 and 29 and 39.

So we are just taking these 4 out of these 30 9; so these 4 will form a sample. So, these are one or more sampling units that are selected from our population according to some specified procedure and here our procedure was said any subunit that ends with a 9 as part of our sampling.

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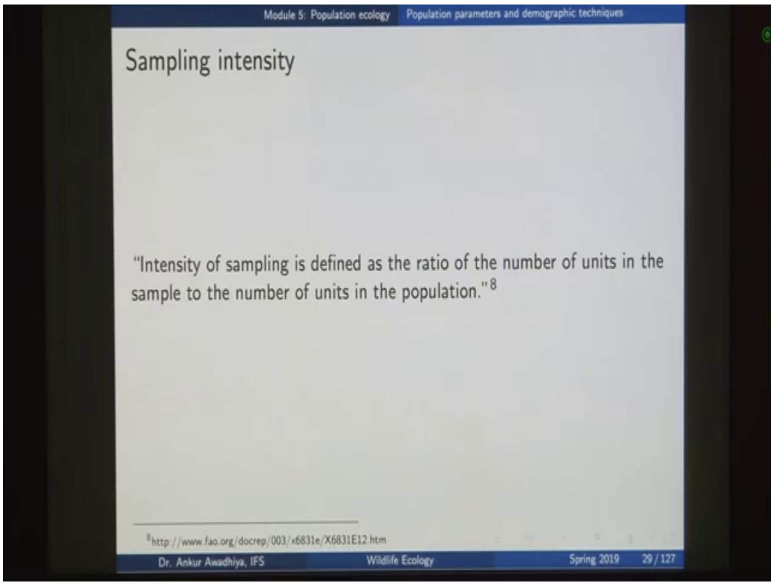

Next we have sampling intensity; sampling intensity or intensity of sampling is defined as the ratio of the number of units in the sample to the number of units in the population.

So, in this particular case our number of units in sample is 4 and the number of units in population is 39. So, in this case sampling intensity is given by 4 by 39. Now the more and more subunits that we take into our sample, the more is the sampling intensity and if we take all the subunits that are there in our sampling frame as part of the sample. Then you have a sampling intensity of 100 percent in which case your sample turns into a census.

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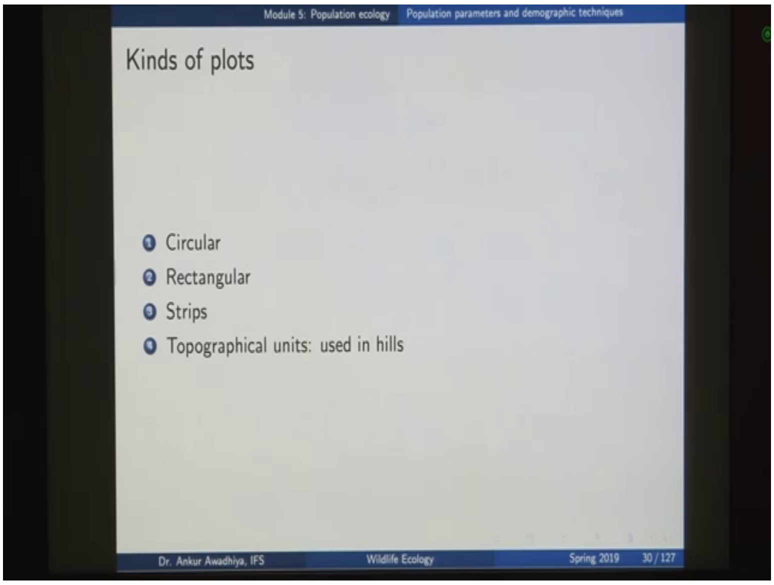

Now next we have the kinds of plots; so plots can be of any shape they can be circular, rectangular, strips or they could even be topographical units. So, when we see topographical units what we have is that you have a hill and then this hill you can see that you are dividing this hill into different area or different heights.

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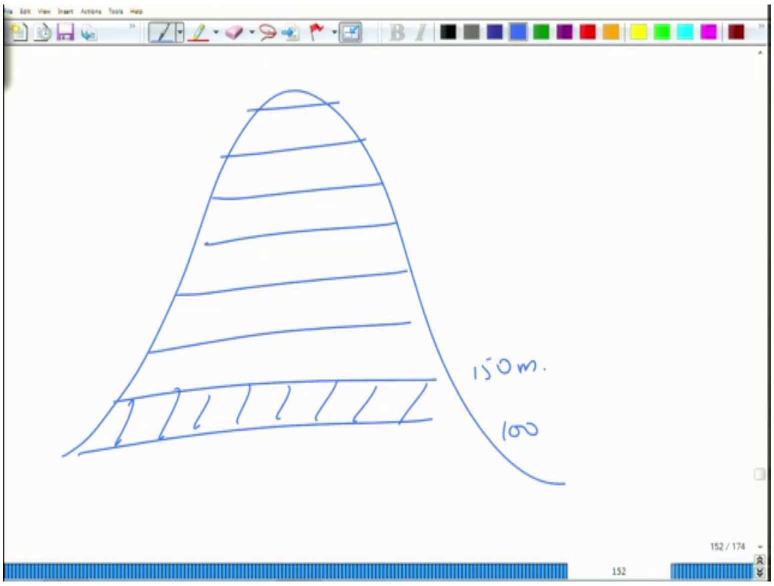

So, you say that this portion is one topographical unit because it is lying at a height of save between 100 and 150 meters. So, these kinds of topographical units are used as plots in the case of hills. Now the next question is once you have decided on the number of samples that you need to take; how do you decide which samples need to be taken?

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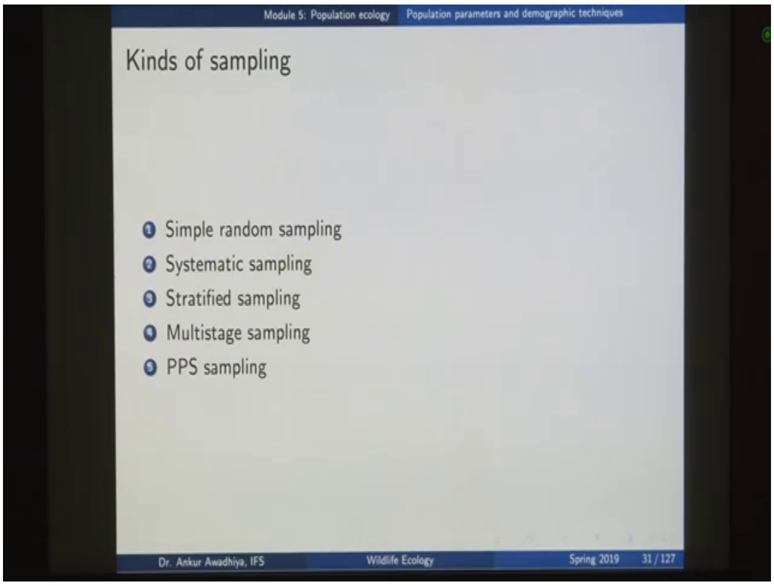

So, for that we defined different kinds of sampling. So, these are the most popular kinds of sampling; you have simple random sampling, systematic sampling, stratified sampling, multistage sampling and probability proportional to size sampling.

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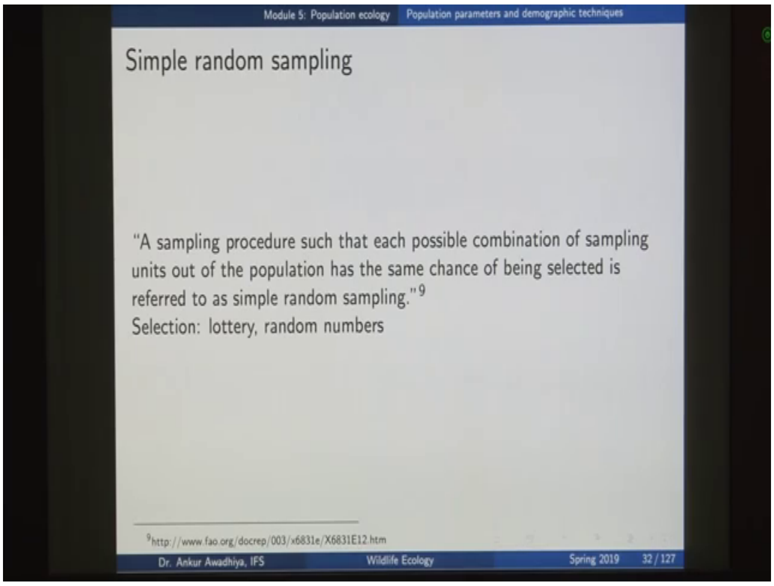

Now, we begin with the simple random sampling a sampling procedure such that each possible combination of sampling units; out of the population has the same chance of being selected is referred to as a simple random sampling example is lottery or random numbers.

So, in the case of simple random sampling what we are asking is we have to choose see 5 units out of the sample; so we remove these. So, in this case you have to select 5 subunits. So, what you can do is you can make chits or you can make 39 chits, you can write these numbers from 1 to 39 makes all of those chits and then pick up 5 different entities of out of those.

So, the 5 numbers that you would get they have been selected in a process in which all of these 39 units have an equal probability of being chosen; all of these have a 1 and 39 probability of being chosen. Now such a sampling goes by the name of a simple random sampling. So, that that can be through lottery or that can be used using random numbers.

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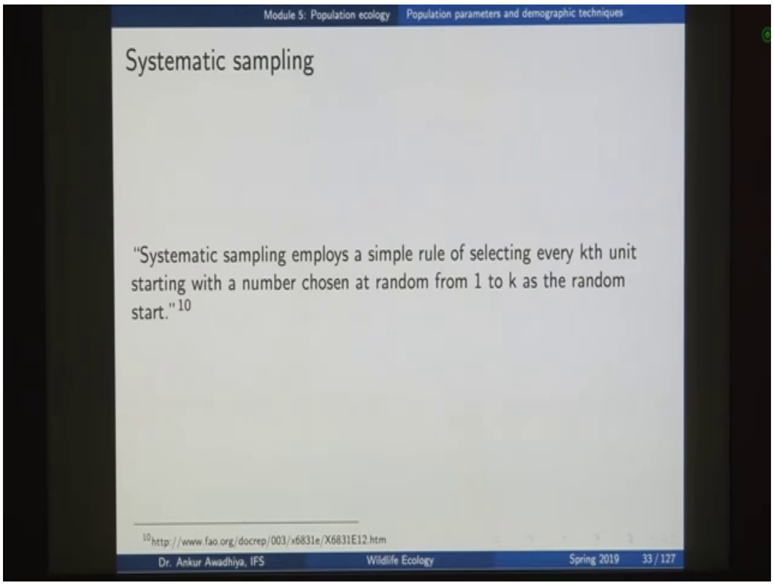

The second one where is a systematic sampling; systematic sampling employs a simple rule of selecting every kth unit starting with a number chosen at random from 1 to k as the random start. So, for instance in this case we can say that every 5th unit will form a part of the sample.

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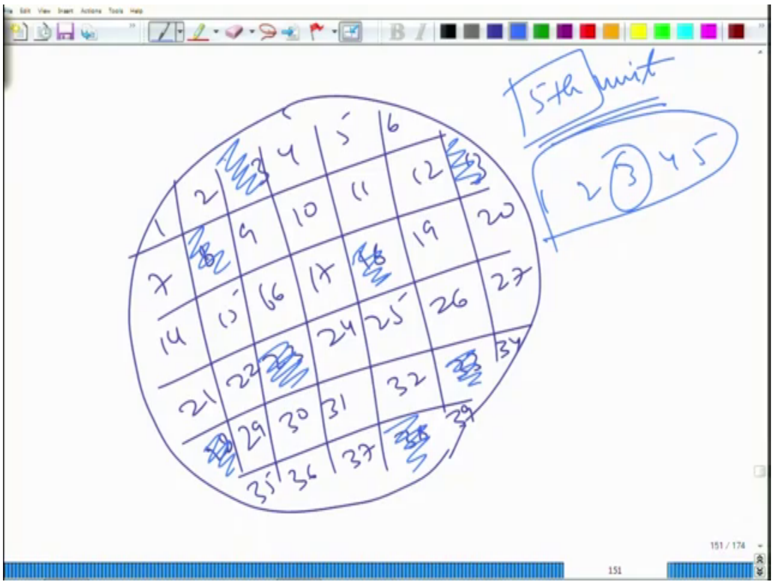

So, every 5th unit is a part of the sample and the first unit will be chosen at random. So, 1, 2, 3, 4, 5 you can choose any of these at random.

So, this can be through a lottery and suppose you have chosen the 3rd one. So, in this case we will say that the 3rd one is a part of the sample now the 5th one; 1, 2, 3, 4, 5; 8th one becomes the part of the sample. Next 1, 2, 3, 4, 5 the 13th one becomes a part of sample; then 18th becomes a part of samples, then 23rd becomes a part of sample, then 28th becomes a part of samples, 33 becomes a part of sample and a 38 becomes a part of sample.

So, this method in which you are selecting every kth unit; so, in this case every 5th unit is getting selected as part of a sample and the first one is being chosen at random from the first to the kth unit. So, in this case this kind of a sampling process goes by the name of a systematic sampling; A simple rule of selecting every kth unit starting with a number chosen at random from 1 to k as the random start.

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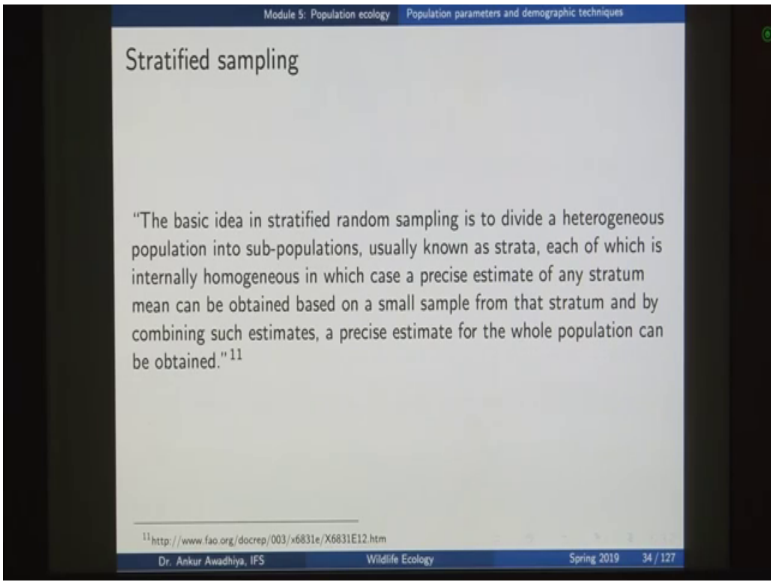

Next you have stratified sampling; now the basic idea in stratified random sampling is to divide a heterogeneous population into sub populations, usually known as strata each of which is internally homogeneous in which case a precise estimate of any stratum mean can be obtained based on a small sample from that stratum. And by combining such estimates a precise estimate for the whole population can be obtained.

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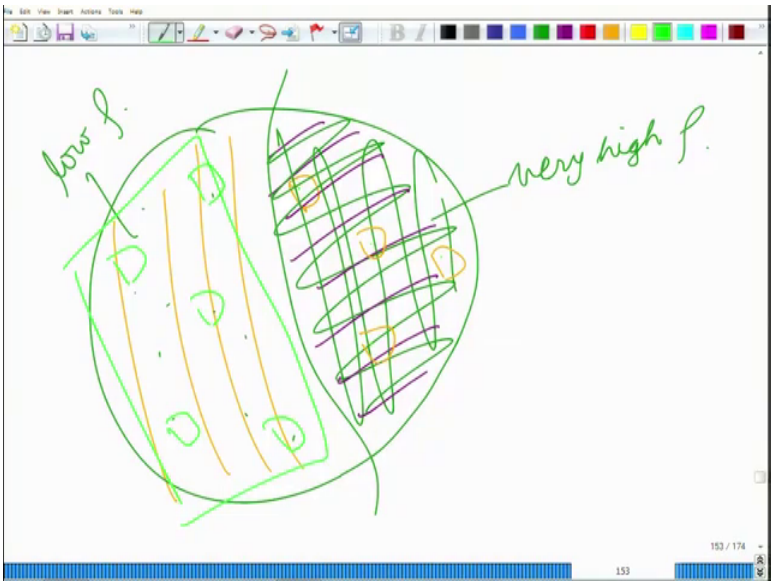

Now, in this case we are saying if this is our forest area and we know that this area has a very high population density; this area has a very high population density and this area has a low population density.

So, in this case the stratified sampling would say that in place of taking the samples randomly. So, earlier in the case of random sample we would have chosen; samples randomly anywhere. But in the case of your stratified sampling it says that because both of these areas are different from each other.

So, we cannot take single set of sampling, but we should divide this area into these two parts which are homogeneous in themselves. So, the first part this part is homogeneous and then this part is also homogeneous and then in both of these parts we take random samples.

So, here we take say 4 random samples, in this case we take 5 random samples. Now once that is done then these random samples will be we used to take out a mean that is representative of this part. And these 4 samples are used to take out a mean that is representative of the right half and in that way the number that we achieve through this computation will be a very close approximation of the total population; so, that is the stratified sampling.

So, you are dividing the heterogeneous population into sub populations. So, you divided your whole population into right half in the left half which are known as strata each of which is internally homogeneous. So, the right half is much more homogeneous the left part is much more homogeneous, but right and left together without heterogeneous populations.

And in which case a precise estimate of any stratum mean can be obtained based on a small sample from that stratum. And by combining such estimates a precise estimate for the whole population can be obtained.

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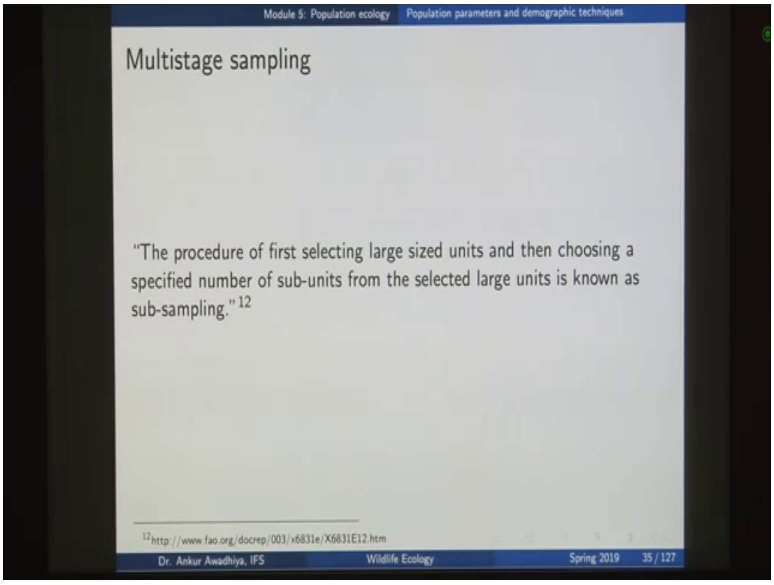

Next you have a multistage sampling; now a multistage sampling the procedure of first selecting large sized units and then choosing a specified number of subunits from a from the selected large units is known as sub sampling.

So, for instance if you wanted to know the population of chital in your area; you could say that the first level of sampling is states. So, you put all the states of India in a list 1, 2, 3, 4, 5, 6, and so on and then you selected say 5 states randomly; so, that is the first stage of choosing 5 states. And then out of those 5 states then you are doing a second stage of sampling in which you are selecting say 5 districts out of all of these 5 states; so, 5 districts from each states.

So, in this case you are first selecting large sized units which are states and then choosing a specific a specified number of sub units from the selected large units in the form of districts which become a part of the sub sample. So, this becomes known as the multistage sampling. So, you are first selecting last size samples and then selecting smaller sized samples from each of these large sized samples.

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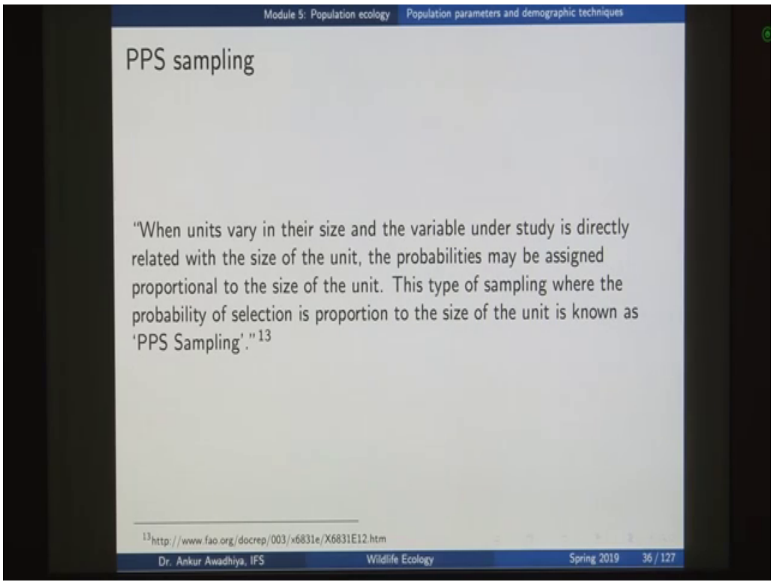

And the 5th one is a probability proportional to size sampling or PPS sampling; when units vary in their size and the variable under study is directly related with the size of the unit, the probabilities may be assigned proportional to the size of the unit. This type of sampling where the probability of selection is proportional to the size of the unit is known as PPS sampling.

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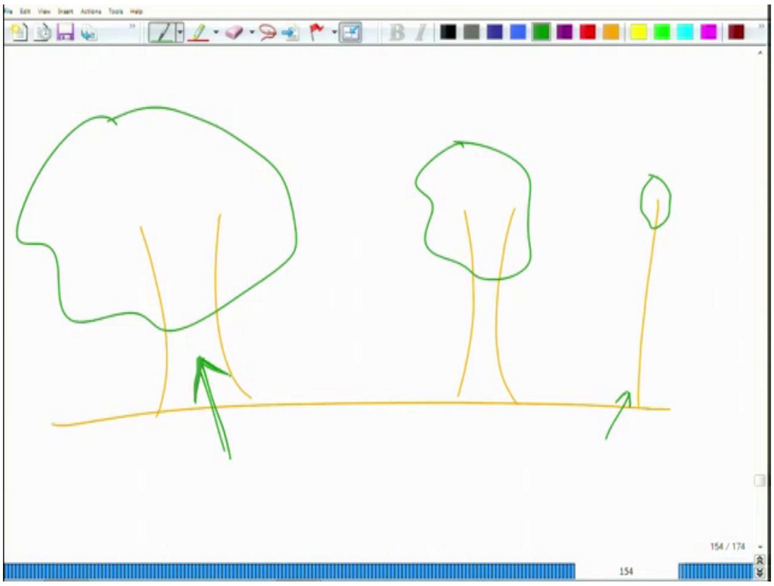

So, in this case suppose we are asking this question what is the amount of biomass that is available in a forest. So, you have large size trees you have medium size trees and you have some very thin trees.

So, you have this large size tree, you have this medium size tree and you have a very small size tree. Now if you in if you did not include the largest size tree; so, in that case your estimate would become very wrong. But if you say missed out this tree; then there estimate of the actual population parameter would not be very off.

So, in this case we need to ensure that the larger the tree the more should be its probability of getting incorporated as part of the sample; when you go for such a method it is known as a probability proportional to size; so the probability that that your unit becomes a part of the sample is proportional to the size of that unit; so that is PPS sampling.

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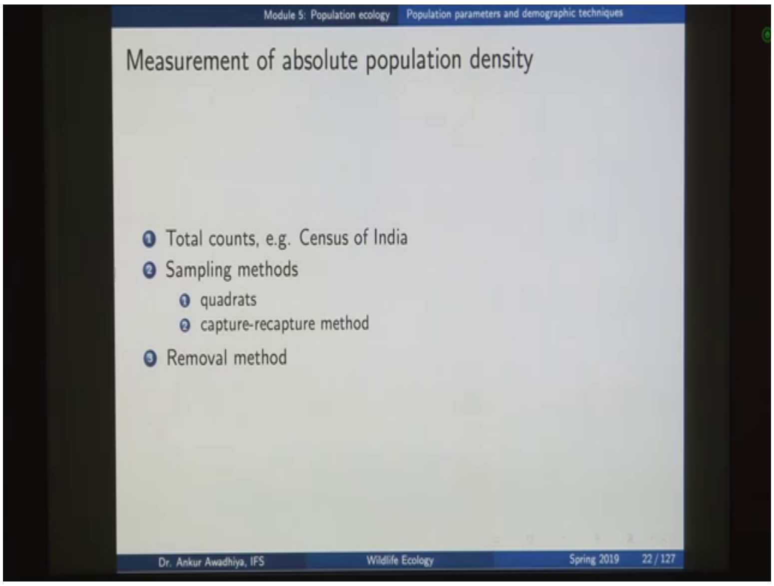

So, we were looking at the measurement of absolute population density the first one is count with the second one is sampling method where we just looked at quadrats. Another sampling method goes by the name of a captured recaptured method; now what is the capture recaptured method?

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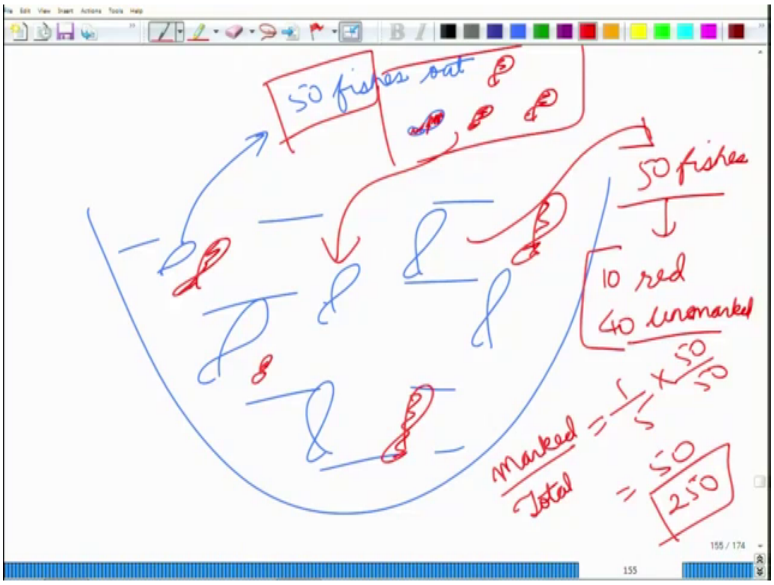

Suppose you want to make an estimate of the number of fish that are there in a pond; so here you have this pond then this pond has a number of fishes and you want to know; what is the number of fishes that is there in this pond?.

So, what you can do is you can first put up a net and you take some fishes out of this pond. So, suppose you were able to take say 50 fishes out. So, you are taking these 50 fishes out and then you are marking all of these fishes. So, how do you mark these fishes? Probably you take these fishes out and then you put them into a die that is coloring them red in color. So, now you have 50 fishes that are red in color.

So, this is the first stage and then once you have marked your samples; then you put all of these 50 fishes back into the pond; now all of mind you all of these are live fishes. So, once you put all of these back into the pond. So, they will then mix up with the other fishes. So, now, you will have a red fish here, you will have a red fish that is here, you have a red fish that is here. So, now they have mixed up with the population completely next you take another sample out of the pond.

So, again you are taking out 50 fishes; now out of these 50 fishes it turns out that 10 are marked that are red in color and then there are 40 that are unmarked. Now in this case we would say that because all of these fishes have completely mixed up in the population; so, we say that one out of every 4 fishes is marked.

So, the number of marked fishes; marked up on unmarked or marked up on total is the same. So, here we have 1 out of every 5 fishes is marked; now total number of marked fishes is 50. So, you multiply it by 50 by 50 and so you get that 50 out of 250 fishes are marked. So, by this way we can say that the total number of fishes in this pond is 250.

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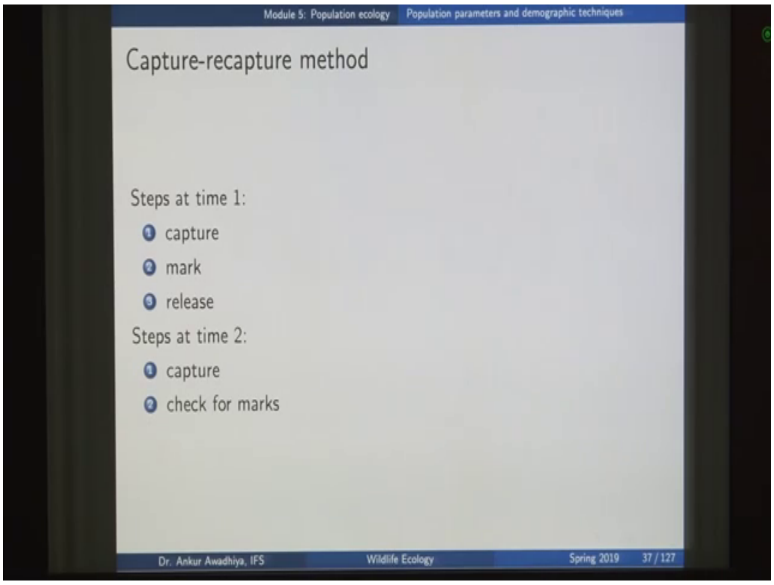

Now, to summarize the first stages at time t 1; you captured some fishes you marked those fishes in red in color and then you release them back. Then you wait for some time; so that all these fishes have mixed together and then at another time you captured these fishes and then you check for the marks again. So, this is the experiment that you are doing.

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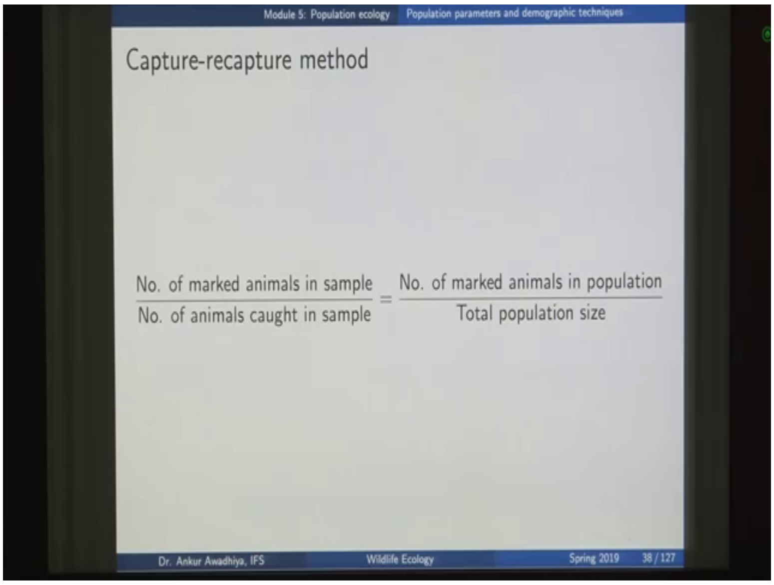

And then you come up with this formula number of marked animals in the sample divided by number of animals caught in the sample is the same as the number of marked animals in the population divided by the total population size. And by using this equation we can make an estimate of the number of animals that are there.

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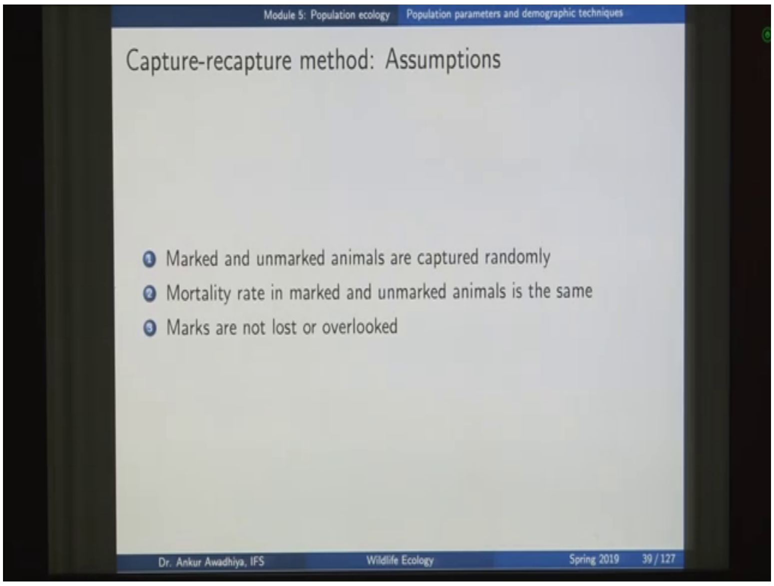

Now, this method makes use of some assumptions the marked and unmarked animals are captured randomly.

So, you should not use a method in which you are preferentially catching the unmarked fishes or preferentially catching the marked fishes; it has to be a random mix. Next mortality rate in the marked and unmarked animals is the same. So, if it so turns out that of the 50 fishes that you have marked input inside 40 fishes or say 49 fishes die out and out of the unmarked fishes there was no mortality.

So, in that case you would not be able to reach a correct estimation. So, there is this assumption that mortality rate and marked and unmarked animals is the same and then marks are not lost or overload.

So, it should not happen that you put your fishes you colored your fishes in a die that when you put it back then all of these dyes got mixed with water and the fishes lost their mark; so, because in that case you would not be able to make a correct estimate.

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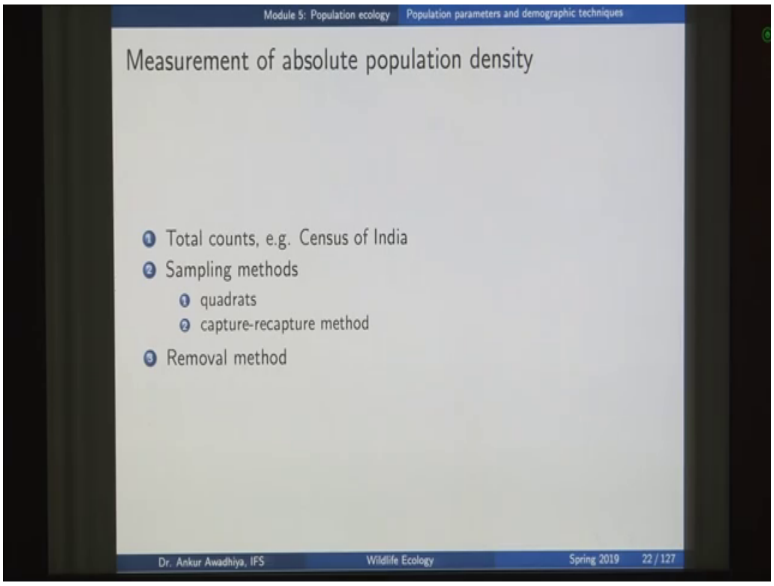

So, that was the second sampling method. So, we have these two sampling methods quadrats and capture recapture method.

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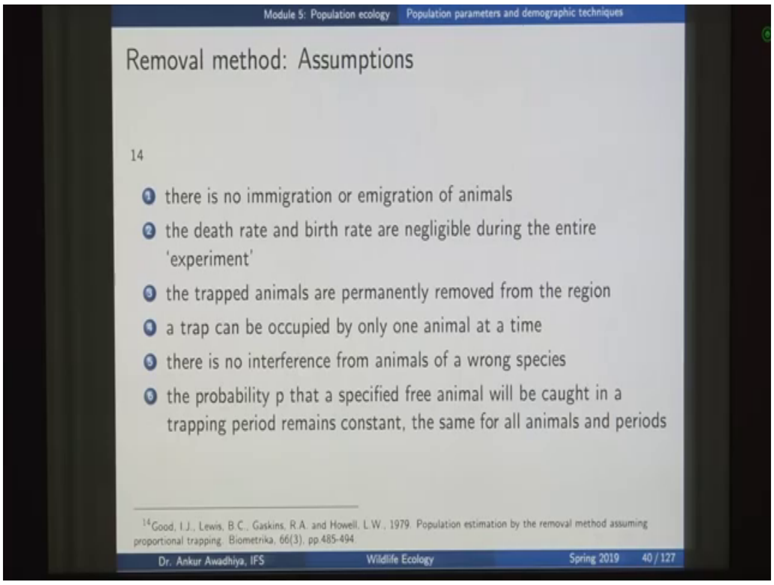

Now, the third method is the removal method in which you are killing or removing animals from the; from the total population. Now this method makes these assumptions there is no immigration or emigration of animals.

So, in the time where you are removing these animals; there is no influx, there is no out flux of animals then there is no birth or no death during this time. So, the death rate and the birth rate are negligible during the period of experiment during which you are removing the animals. The trapped animals are permanently removed from the region.

So, even if you are capturing these animals if even if you are not killing these animals; you should not release them back into the environment. A trap can be occupied by only one animal at a time there is no interference from animals of a wrong species.

So, essentially if you are say, if you are removing rats from a system it should not happen that you are also capturing mice together. The probability p that a specified free animal will be caught in a trapping period remains constant; the same for all animals in periods, so these are the assumptions.

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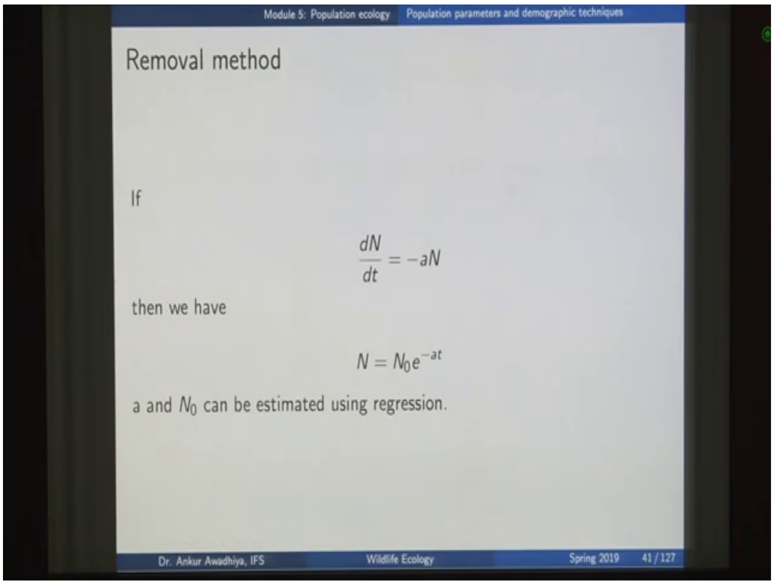

So, in this case what this matter sees is that the number of animals that are that you are removing per unit time or per unit effort is proportional to the number of animals that are present. So, suppose you are if suppose you had a removing 10 percent of animal set all times.

So, if you have 1000 animals; so you will be able to catch 100 animals with the same effort. Now if you only have 100 animals you will only be able to catch 10 animals. So, the rate at which the animals get removed from the system is proportional to the number of animals that you have in the system.

And from this we can integrate this equation to get N is equal to N naught into e to the power minus a t. So, here a is a constant, t is time, n is the number of animals and n naught is that is the number of animals at the beginning of the experiment. So, so if we go for a regression method we can compute the values of a and we can compute the values of N naught. And N naught is the number of animals that you have in the population before you started killing them off and removing them. So, these are the methods of estimating the absolute density of animals.

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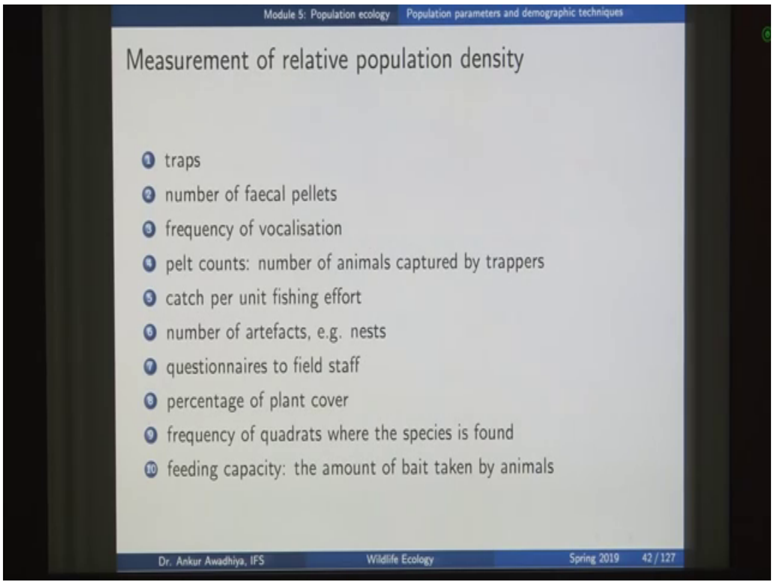

Next we look at some relative population density methods; now in the case of relative population density you should remember that we are interested in knowing which area has more number of animals whether its area x or area y.

So, we can say put up traps and see how many animals are captured in x; how many animals are captured in y. More number of animals more number of animals that are caught or we can look at the number of feacal pellets that are there in these two areas; if one area has got more number of feacal pellets more amount of done then it should have more number of animals. Or if you go to one area and use here say 10 sounds of tiger and in another area you go and you hear 1000 calls of tiger.

So, the area that has 1000 calls of tiger has probably many more number of tigers as compared to the area that has 10 calls of tigers. Or things such as pelt counts or the skin counts that are used by trappers or catch per unit fishing effort. So, you put a net in one pond and you are able to catch 10 fishes; you put the same net in another pond and in the same time period you are able to catch see 70 fishes. So, 70 fishes pond is having more number of fishes.

So, these are the ways in which we are able to estimate the relative population density. Number of artifacts how many nests do we have in an area or you can ask the field staff how many animals have you seen or you can go forth percentage of plant covered the more amount of curve that you have, the more number of animals you will have; a frequency of quadrats where the species is found or the feeding capacity. So, you put some amount of feed in these two areas in one area most of the field gets eaten up; so, that should be having more number of animals.

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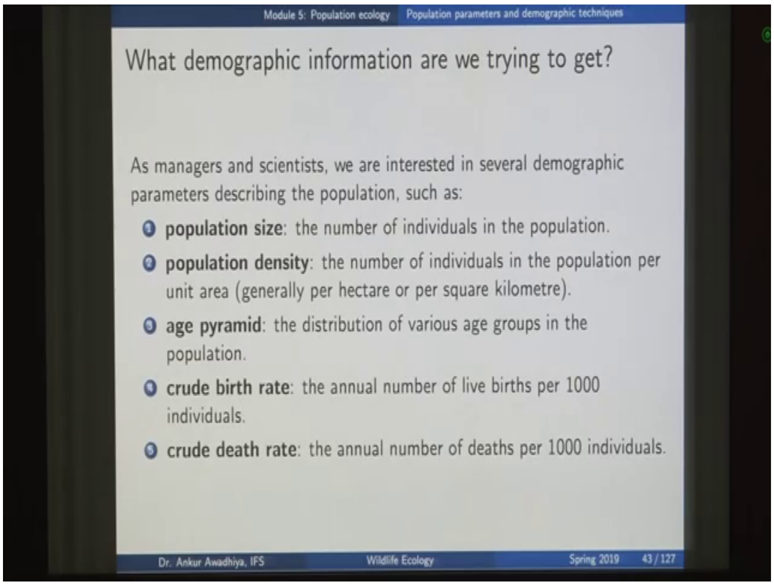

Now, apart from population size and density; we are also interested in knowing the age pyramid. Age pyramid is the distribution of various age groups in the population; is your population young is it and does it have more number of adult individuals; does it have more number of old individuals is what we are asking here.

Next is crude birth rate annual number of life births per 1000 individuals crude death rate number of deaths per 1000 individuals or things like general fertility rate; the annual number of live births per 1000 females of reproductive age.

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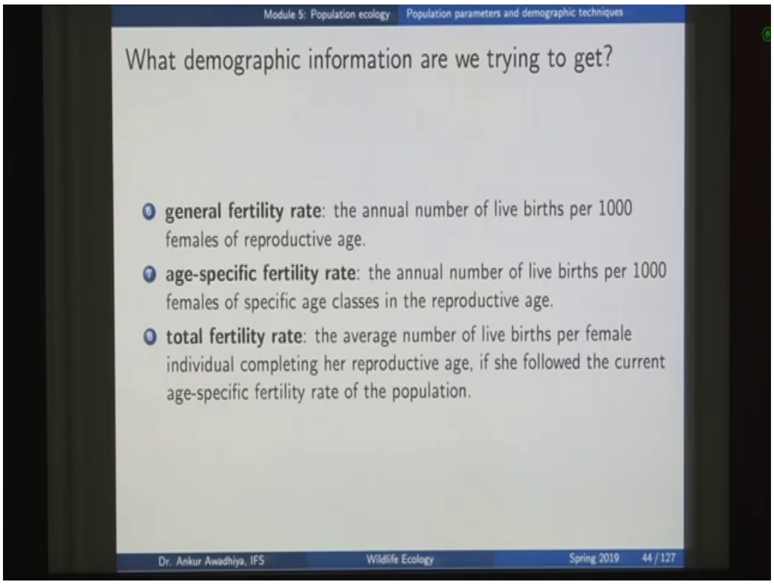

So, here we are talking about the females of reproductive age or the age specific fertility rate; the annual number of live births per 1000 females of a specific age class in a reproductive age. So, for instance in the case of tigers you are asking that if you have females of say 6 years of age; then in that case out of every 1000 females of 6 years of age how many number of annual litters ah; how many number of cups will they produce.

Or total fertility rate the average number of life births per female individual completing her reproductive age if you followed the current age specific fertility rate of population.

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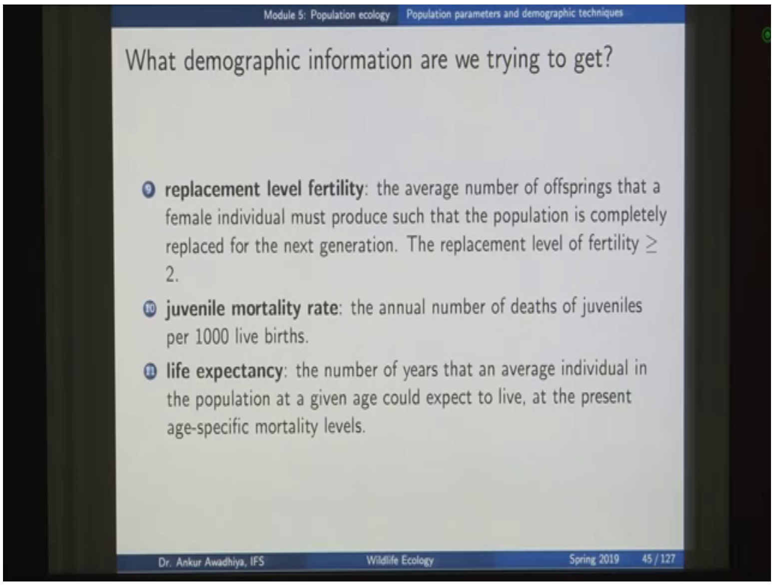

So, you are integrating the whole values or replacement level fertility. So, if you have two individuals one male and female how many children or how many offsprings are they producing to be able to replace themselves. So, if you have say a male and a female and if they are only producing one offspring so, in that case the population is going towards a decline if you have one male and one female they are producing 10 offsprings.

So, the population is increasing, but if they are producing around two individuals; so, there are two individuals in the parent generation and there are two individuals in the offspring generation. So, the population is able to replace itself. So, what is that replacement level fertility? Or juvenile mortality rate number of deaths of juveniles per 1000 live births or life expectancy the number of years that an average individual in the population at a given age could expect to live at the present age specific mortality levels. So, what is the life expectancy of your animal?

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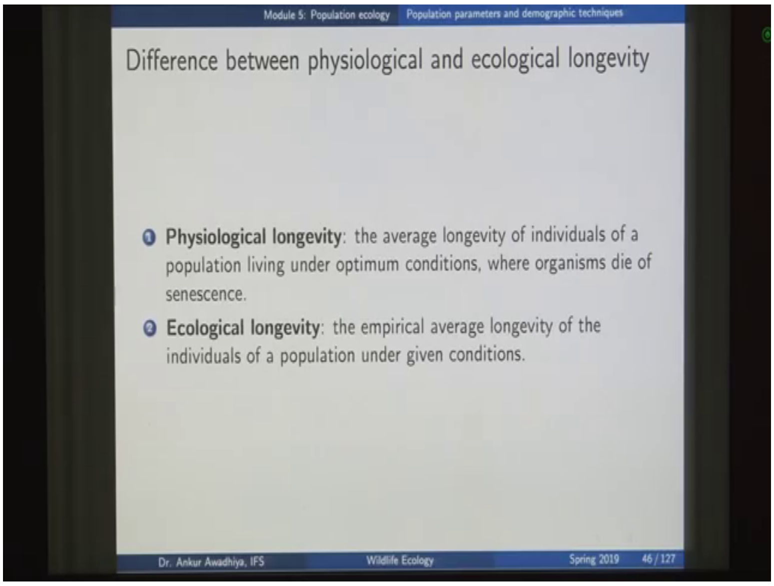

Now, when we talk about life expectancy there are two different variables; we can we could be talking about physiological longevity or ecological longevity. Now physiological longevity is the average longevity of individuals of a population under optimum conditions where organisms die out of an old age.

So, you are allowing all the animals to live till the end of their lives. But in the case of our ecological systems we are more interested in ecological longevity because when an animal goes becomes old; it might be preferentially preyed upon. So, it gets eaten up by the predator. So, what is the empirical average longevity of individuals of a population under given conditions under the conditions of diseases and other conditions of predators and so on.

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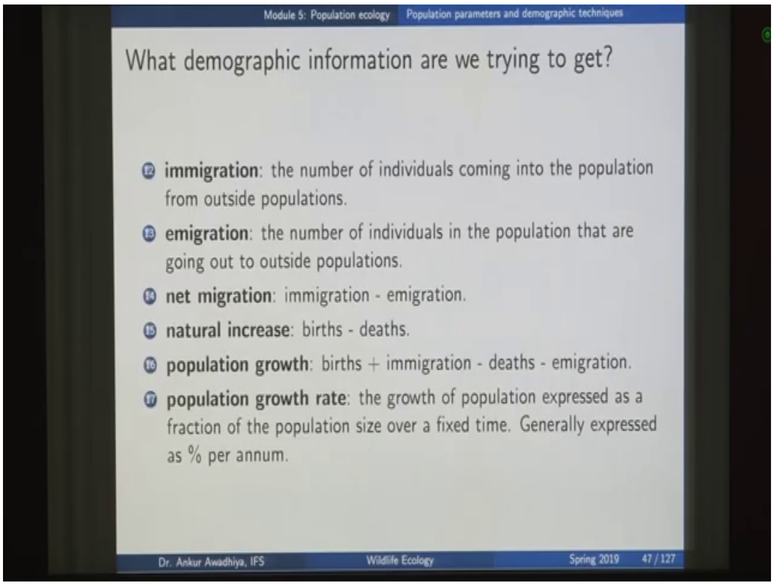

We could also be interested in immigration number of individuals that are coming into from outside or emigration; the number of individuals that are going out or the net migration which is immigration minus emigration.

Or say national increase in population which is the number of birth minus the number of death or we could be in be interested in the population growth that is birth plus immigration minus death minus emigration. Or the growth rate which is the population growth per unit time in terms of percentage per annum or in terms of numbers per annum.

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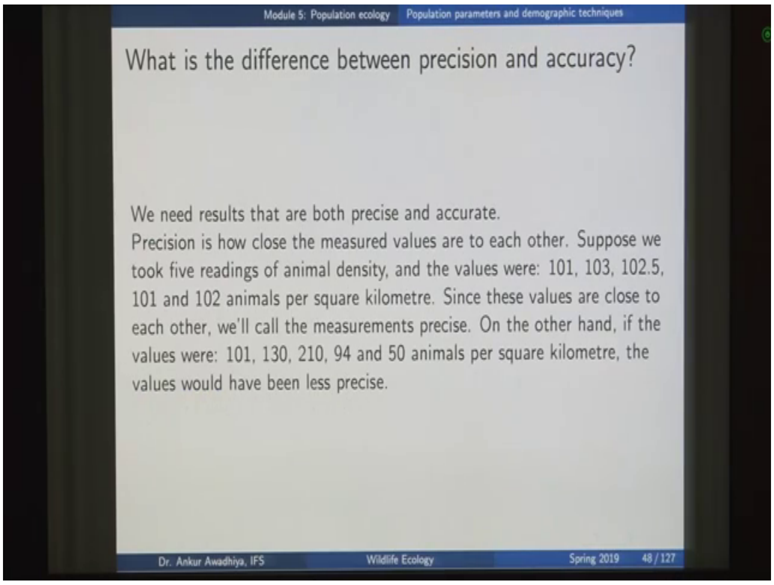

And when we are talking about any of these measurements; it is important to note that we are interested in data that are precise and that are accurate.

Now what is the difference between precise and accurate; suppose you do a measurement suppose you went forward and you measured the length of this pen. Now suppose those measurements were say 10 centimeters, 10.1 centimeters, 9.9 centimeters, 10.2 centimeters that is one set of measurements we have 10, 9.9, 10.1 and 10.2.

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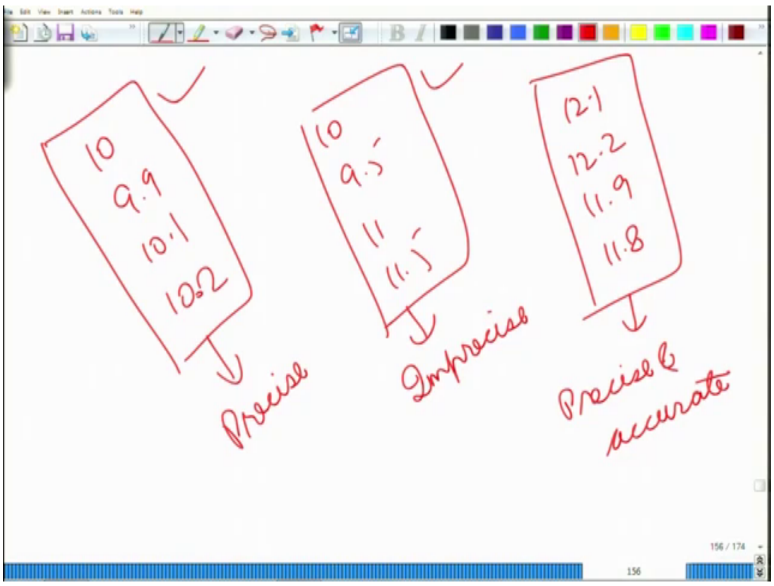

So, that is one set of measurements; there is another set of measurements. So, another person goes and she he or she measures this pen and he or she figures out that these lengths are say 10 centimeters, 9.5 centimeters, 11 centimeters and say 11.5 centimeters.

So, in the first case we see that all of these values are close together so, 10, 9.9; 0.1 difference 9.9, 10.1; 10.1, 10.2. So, there is a very little difference between all of these measurements; whereas, in this case the range is very large.

So, we say that these measurements are precise and these measurements are imprecise; how close are the values to each other? Now the second thing is what is the accuracy? Suppose it turns out that the length of this pen is say 12 centimeters. So, there is one person who is measuring it as this value; the second one who is measuring it like this and then there is a third one who is measuring it like; 12.1, 12.2, 11.9, 11.8.

So, in this case these values are precise and these values are also accurate. So, accurate is how close is your measurement to the actual value. So, when we are talking about population parameters what we are asking is how close is your value to the actual value that is out there in the field. Suppose there are 1000 individuals and suppose your measurement is giving you not 1000 individuals, but it is giving you only 500; individuals then we will say that the measurements are not accurate.

But if you are having 1000 individuals and you are able to say by your method that you have say 1005 individuals. So, your method is much more accurate than compared to the other method and when you repeat your observations how close are the observations to each other? Do you measure 1000, 1001, 998, 1002 and so on or do you measure 1000, 500, 1500, 2000 and so on. So, we need measures that are both precise and also accurate.

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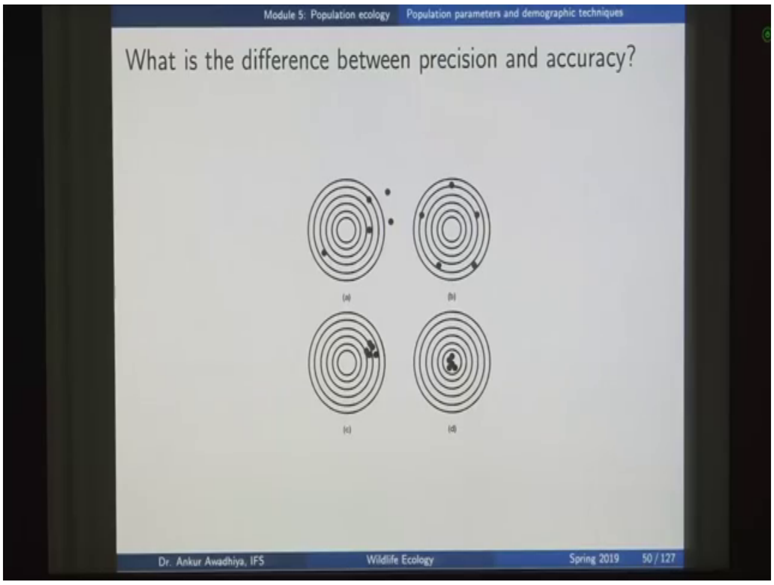

Now, in this case we can use this analogy; so this is a shooting board and then there is there are shooters that are shooting here. And here we see that in the case of this shooter all the shots are close together. So, we will see that this measure that this measurement is precise or this shooter is very precise; this one is also very precise, but both of these are not precise. However, this one is not accurate because he or she needs to go to the center, but it is at a distance; so, this one is not accurate.

This one again is not accurate; this one is accurate because it is close to the center. This one again can be called as accurate even though it is imprecise because the average would come to the center. So, by this way we can define accuracy and precision; how close are the values to each other and how close are the values to the correct value.

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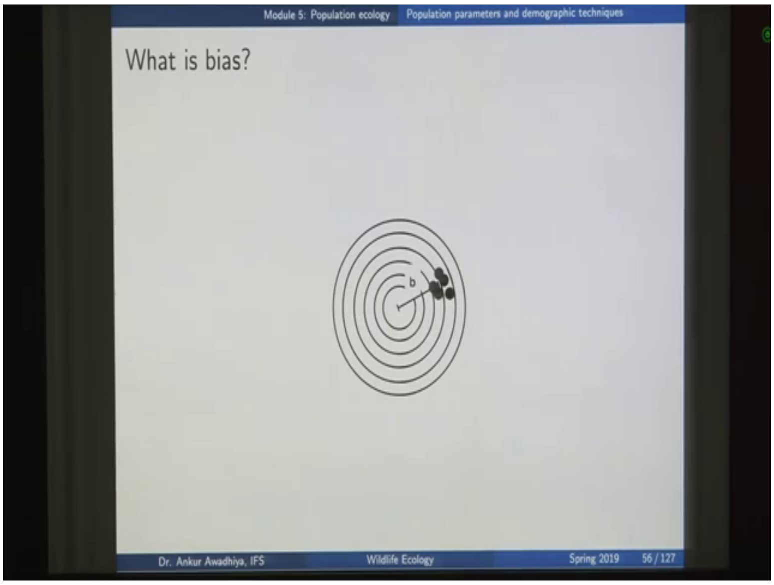

And if the values are close to each other, but they are not close to the correct value then we define this difference as the bias. So, bias is your values are very close to each other, but they are at a distance from the actual value.

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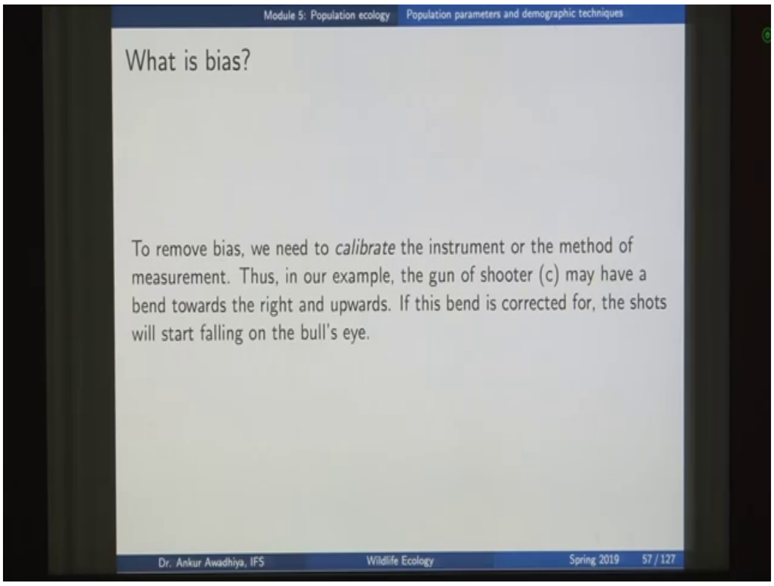

So, that value is bias and to correct for bias we go for calibration of the measurement. So, in place of say going for capturing capture method if that is giving us a large amount of bias; maybe we could go for a total census that would reduce the amount of bias that we have in the case of our measurements. So, in this lecture we looked at different population parameters, we looked at by measurement of a population is essential not only for ecology.

But also to understand how to manage all of these population; how to conserve these populations and then we looked at different techniques of measurement. We looked at sampling methods, we looked at different points of quadrats that are there, we looked at capturing capture method and so on.

So, all of these methods become extremely important to know the current status of the population and also to understand how that population is going to function in the future. And also to make this decision regarding whether or not do we want to put any interventions to manage these populations; so that is all for today.

Thank you for your attention [FL].