Wild Life Conservation
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Lecture – 04
Threats to Biodiversity

[FL]. Now that we know what biodiversity is, what its important is and how do we put a rupee or a dollar value to it. Let us now have a look at the Threats to Biodiversity. Now, before beginning, let us ask the question is our biodiversity actually under a threat or in other words, are we losing any number of species, if so can we put a numerical value to the number of species that we are losing every year. So, let us begin with a simple calculation.

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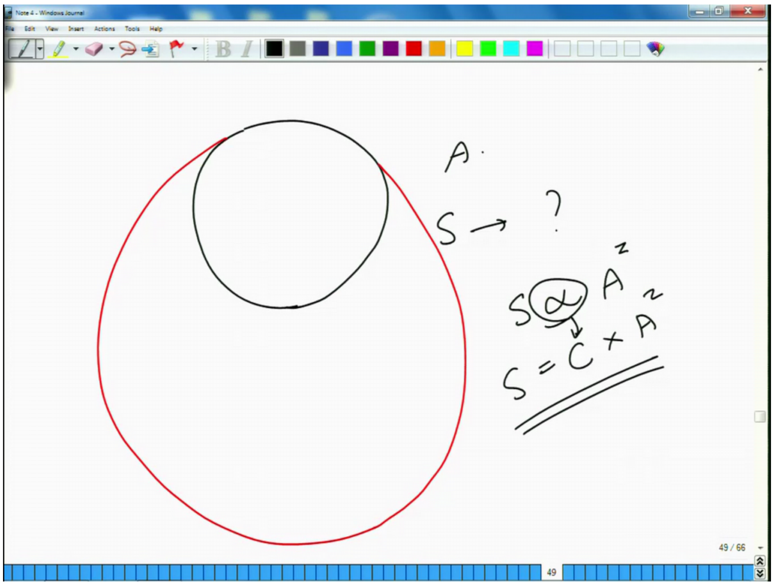

So, consider an island, so this an island; and this island has an area of A. And we want to know, the number species that are there in this island. So, this species number is question mark. So, we can intuitively think that if the island is of the size versus if we had a larger sized island, would be have more number of species in the smaller island or would we have more number of species in the larger island.

Now, it turns out that in the case of a smaller island, we will have lesser number of ecosystems; we will have lesser number of habitats and so lesser number of species. Whereas, in the case of a larger island, maybe we would be having some patches of woodlands, some patches of grasslands, some patches of water maybe, some patches of sand and so on. So, intuitively we can say that if the area of an island is larger, we would be having more number of species there.

So, we represent that by saying that the number of species is proportional to the area of the island, raised to some constant, because right now we do not know, whether it is directly proportional to the area of the island or say area of the island squared or may be the under root of the area of the island, so we just put this variable of z. So, z is something that would need to be computed. And here, we can also say that S is equal to C into A to the power z. So, we change this proportionality constant with C, so S is equal to C into A to the power of z.

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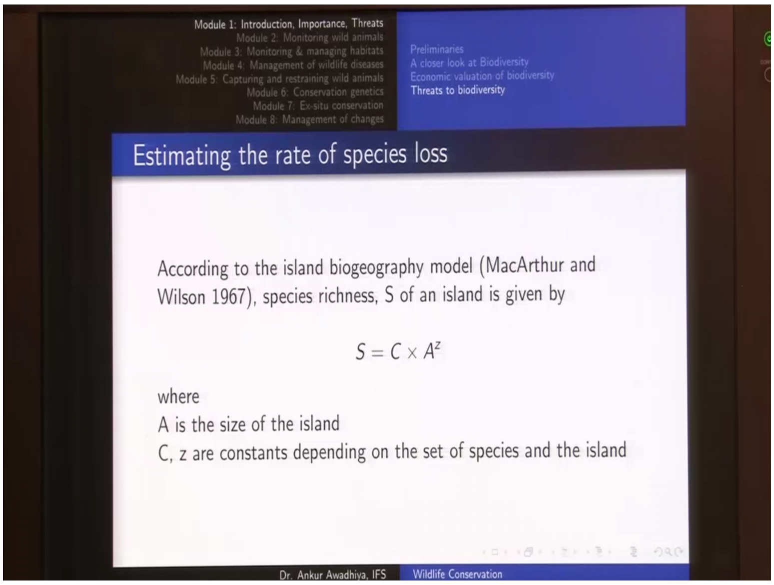

And this is what was first derived by these two people MacArthur and Wilson in 1967 when they gave us the island biogeography model. So, in this model the species richness, S of an island is given by S is equal to C into A to the power of z, where A is the size of the island, and C and z are constants depending on the set of species and the island.

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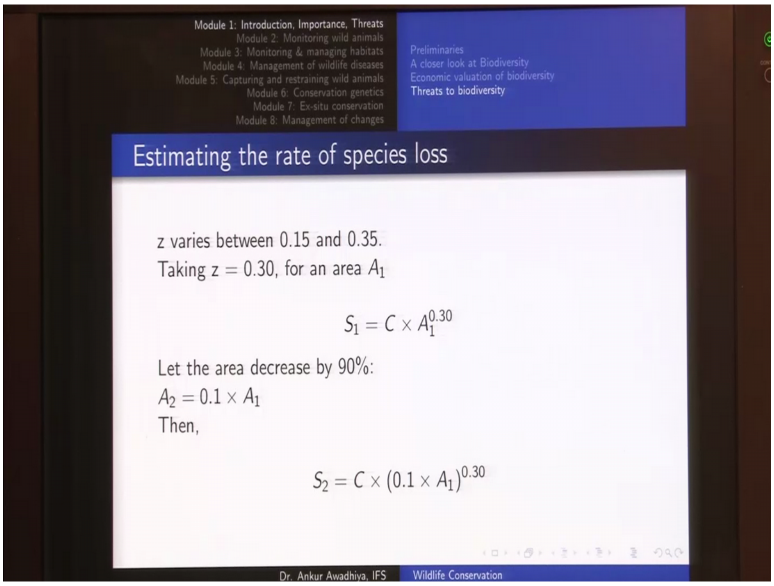

It has been figured out from a study of a number of islands. That the value of z varies between 0.15 and 0.35. So, let us take a middle value, let us say that the value of z is 0.3. So, for this value if the area of the island is A 1, we can write that S 1 is equal to C into A 1 to the power of 0.30, because that is 0.30. So, S is equal to C into A to the power of z; here A is A 1, and z is 0.3.

Now, let us reduce the area of this island by as much as 90 percent. So, the area of the island has been reduced and only 10 percent of the area is left. So, we can write it as A 2 is equal to 0.1 into A 1, only 10 percent of the area is left. And so, we can see that S 2 again using the same formula, it will be S is equal to C into the A to the power of z. Here A is equal to A 2 or 0.1 into A 1 and z is 0.30.

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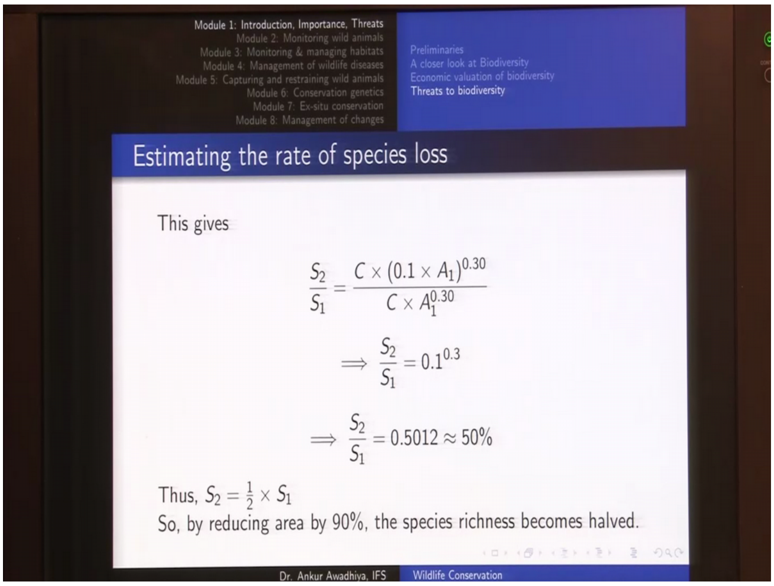

So, now let us have a look at the number of species that we would have lost. So, we take a ratio between both of these. So, S 2 divided by S 1 is given by C 1 into C into 0.1 into A 1 whole to the power 0.3, which is S 2; and S 1 is C into A 1 to the power 0.30. So, C and C cancel out, A 1 to the power of 0.3 also cancels out. So, we have S 2 divided by S 1 is 0.1 to the power of 0.3. And when we compute that, we get this value of 0.5012, which is close to 50 percent.

Thus, S 2 is half of that of S 1. So, by this simple calculation, we have found out that by reducing the area by as much as 90 percent, the species richness has only become halved.

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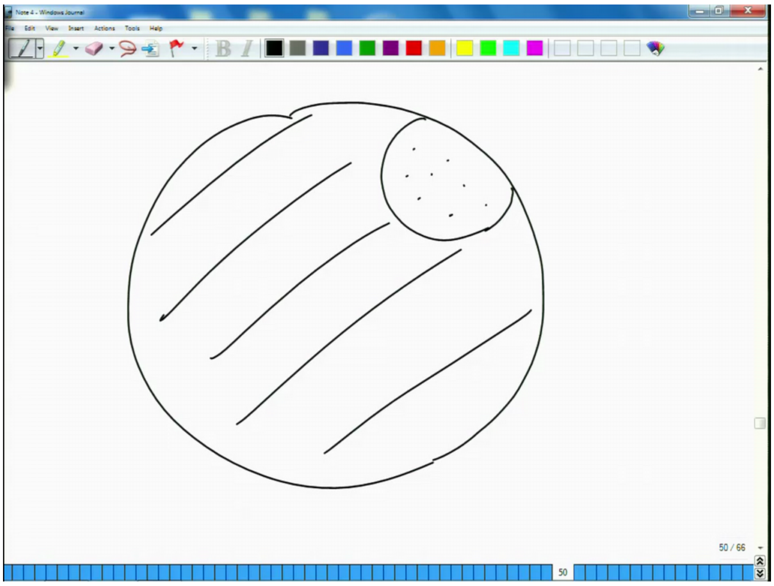

So for instance, coming back to the drawing board; if earlier we had this large area, and then all of this area is gone, only this much area is remaining. So, the number of species that are present in even in this small area will be as much as 50 percent of the number of species that were present in the larger area. So, now this was one simple computation. But then, how does this apply to the case of wildlife conservation.

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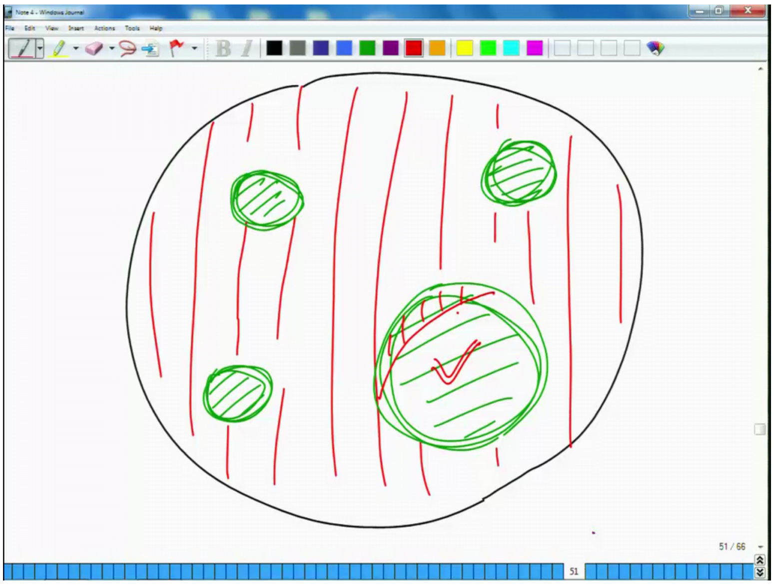

So, if we consider our forest so or let us say if we consider a large patch of land and this patch of land has say a forest here, a forest here, a slightly larger sized forest here, and may be a forest here, and rest of the area is covered by anthropogenic influences. So, we may have some habitations, we may have some farm lands, we may have some pasturelands, some industries, and so on.

So, even in this block of land, what we can see right now is that we have these smaller pieces fragments of forest that are separated from each other, and they are surrounded by a whole ocean of human influences or essentially, what we are observing here, are these small islands of forest that are left out in this whole vast area of human influences that has a very little amount of species biodiversity. Because, in the case of human habitations, we have converted all our forest into say farmlands. In the farmlands, we are only growing a few species of crops and we are thwarting off any other species of animal that gets inside.

So, essentially if there is any wildlife that tries to get into our farmlands, we push it back. If there are any birds that come into our area, we either shot them away or we kill them. So, the whole of this anthropogenic landscape has a very little species biodiversity. And these small patches of forest that are remaining are the only patches that now have biodiversity, so they have become islands in an anthropogenic landscape.

So, we can now use the same formula, we can use computations such as these to compute the rate at which we are losing our species. If for instance this patch of forest, this patch of forest was then even more encroach, so this portion if it were to be converted into another anthropogenic influence say a farmland, how many species would remain. So, how do we compute that?

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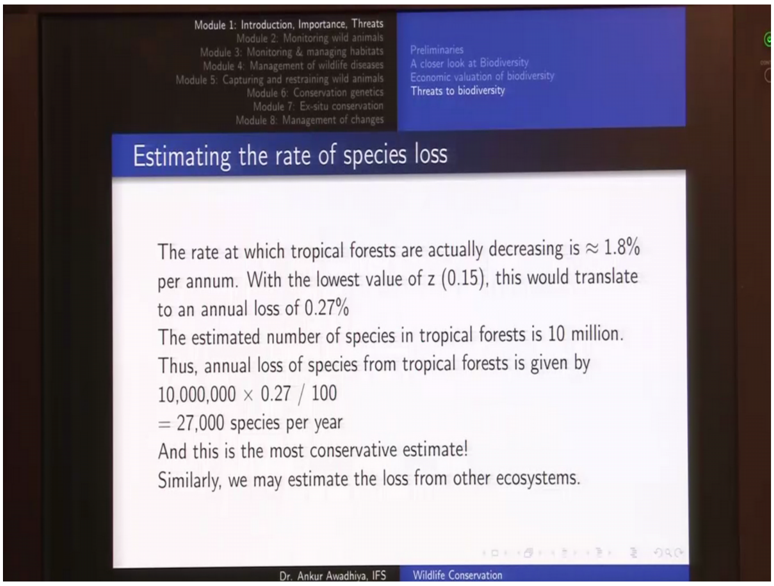

Now, let us take the case of our tropical forest, now the tropical forest are decreasing at the rate of 1.8 percent every year.

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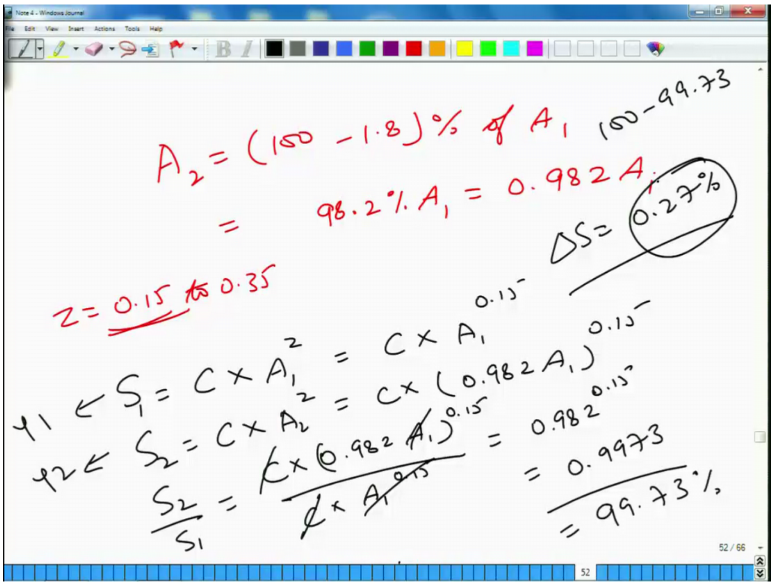

So, for instance if in 1 year, we have an area of A. In the next year, we will be having an area A 2, which will be given by 100 minus 1.8 percent of A, which is 98.2 percent of A, which we can also write it as 0.982 A or let us say A 1 so, it A 2 is equal to 0.982 into A 1.

Now, we had seen before that the value of z varies from 0.15 to 0.35 and we take the lowest value of z, because we are taking the most conservative estimate that is possible.

So, now let us compute the number of species. Now, S is equal to C into A to the power z so, we have S 1 is C into A to the power into A 1 to the power of z, which is C into A 1 to the power of 0.15. S 2 so, this is in the year 1; and this is in year 2 and here we have C into A 2 to the power z C into A 2 is given by 0.982 A 1 to the power of 0.15.

Now, let us find out S 2 by S 1 that will be given by C into 0.982 A 1 to the power of 0.15 divided by C into A 1 to the power of 0.15. C and C cancel out, A 1 to the power of 0.15 cancels out, is 0.982 to the power of 0.15, which is given as 0.9973. Now, what does this mean? It means that if we consider just one year, so from in this year, we have reduced our population from 100 percent to 99.73 percent. So, there is a loss of species that is given by 100 minus 99.73 was 0.27 percent.

So, just by reducing our area by 1.8 percent every year, we are reducing our number of species by 0.27 percent every year. Now, this 0.27 might look as a very small figure. Now, coming back to the slides; if we see the estimate of the number of species in tropical forest, we see that the number of species close to around 10 million. Now, if we take 0.27 percent of 10 million, we get 27,000 species that we are losing out per year.

So, when we looked at in our first lecture, we saw that there are a number of species that have not yet been evaluated. And when we talk about this species in the tropical forest, most of the species come under that category, because there are a number of frogs, there are a number of lizards, there are a number of annelids, a number of insects that are that are found in the tropical forest. We have not even cataloged those species, but we are losing them out at the rate of 27,000 species per year.

Now, why is this computation important? This is important, because if you ask any person about extinction, people would give you the example of say the dodo. And then, people would say that dodo is a bird that got extinct in the 1,600s. And then, if you talk about other species that got extinct, so people might come up with say a few names say such as the Yangtze dolphin. But, those species can just be counted on the finger tips, because most of the species that we are losing out, we do not even know what those species are. And this very conservative estimate, because we took the lowest value of z that was possible and we came up with this computation that just in our tropical forest, we are losing out species at the rate of 27,000 species per year.

Now, there are also other sorts of forest, we have temperate forests, we have grasslands that are also being diverted. So, we can say that we are losing, but many mores number of species than this figure of 27,000 species per year and so our biodiversities actually at a very great amount of threat, whether we know it or whether we do not know it.

Now, the next question arises. Given that we are losing this 27,000 species, are all the species that are found in the tropical forest, at in equal risk or they are at different risk.

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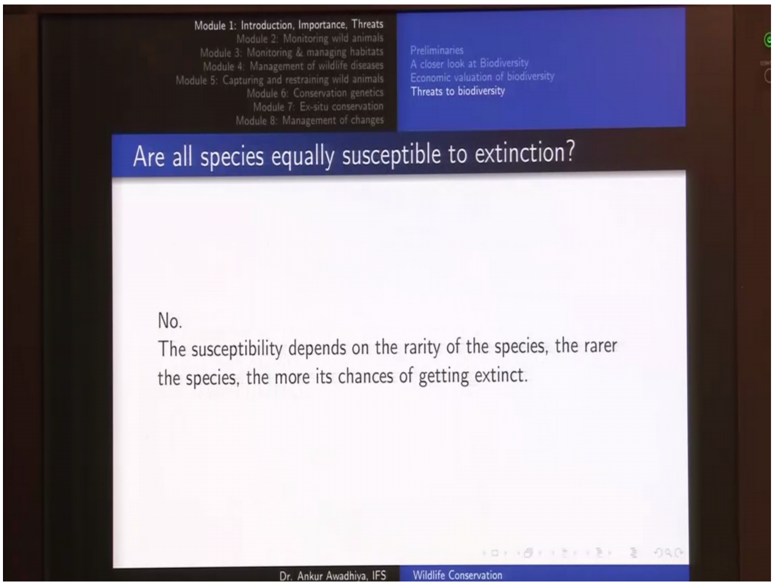

So, are all the species equally susceptible to extension? And the answer is no. The susceptibility depends on the rarity of the species, the rarer the species, the more is it is chance of getting extinct. Because, suppose there is a species that has say 10 million individuals, and even if we remove 9 million individuals, we will still be left with the million individuals that would be able to propagate this species. But then, if we have say 10 individuals, and if you remove 9 individuals, will be left with only 1 individuals and this individual will not be able to breed, because it does not have a mate. And so, it will be doomed to extinction, the species will be doomed to extinction.

So, the susceptibility depends on the rarity of the species. How many individuals are there at present that would determine whether a species is susceptible to extinction or not; now, if we know that susceptibility depends on the rarity of the species, the next question would come up; then why are some species rare, and why are some species abundant.

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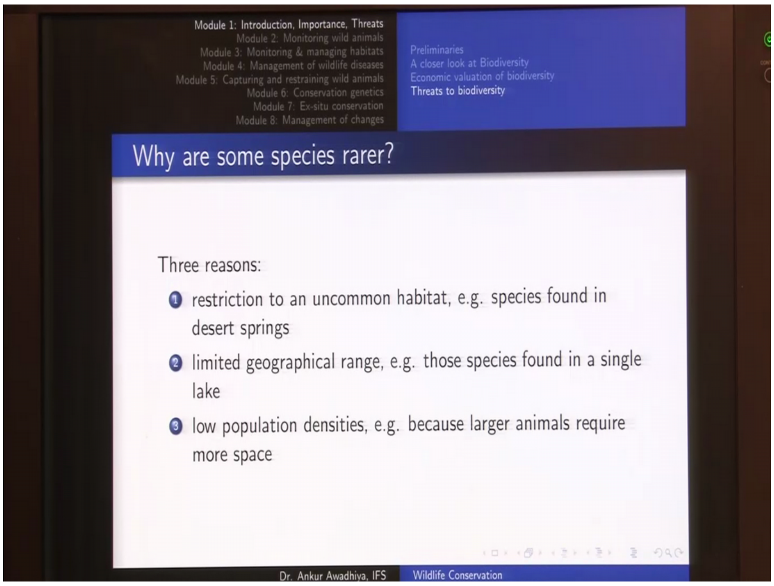

So, why are some species rarer? So, there are three reasons. One is that this species is restricted to an uncommon habitat. So, this habitat is not found anywhere, so an example is a desert spring. Now, deserts are areas that have very little amount of water, and these springs are found very haphazardly in very less numbers.

Now, if there is a species that requires a desert spring as its habitat, then just because these desert springs are not common; so this species will also not be common. The second reason is a limited geographical range so, examples include those species that are found in a single lake.

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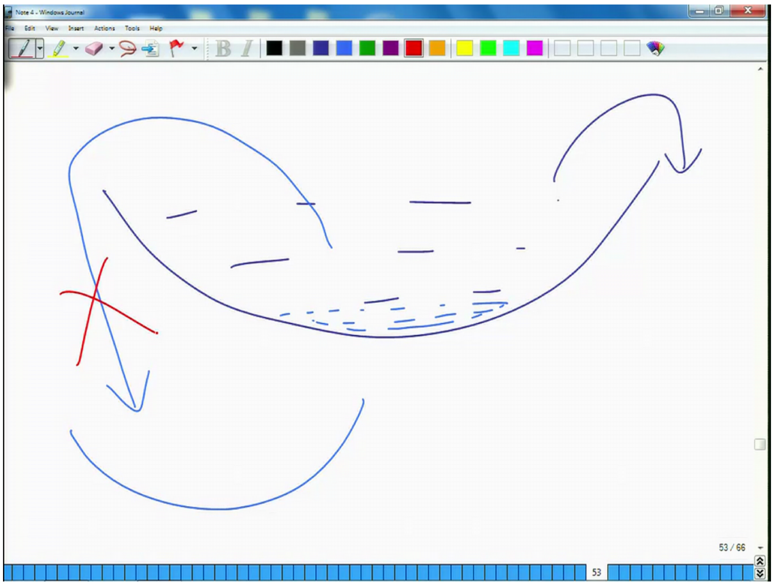

So, for instance, in the case of aquatic species, suppose there was a large size lake, and because this lake had a large size, so it had a number of species. Now, through division of water, we are taking water out and then, this lake is now left only to this much area.

Now, any of the species that were found in the earlier lake, are now bound to live in this smaller area so, a number of species will go extinct. But, even more important is that, because these species are found in water, they will not be able to shift to say another lake that is there in the vicinity, because these species cannot move over land or they cannot fly so, they will not be able to move to another lake, which limits the geographical range of those species. So, these species as are found in a single lake, they will be extremely rare. And we also call this species as endemic species, which are only found in certain areas, which are not found anywhere else.

And the third reason is those species that have low population densities especially, because they are larger animals that require more space. So, for example, an species such as the elephants; elephants require a huge amount of space.

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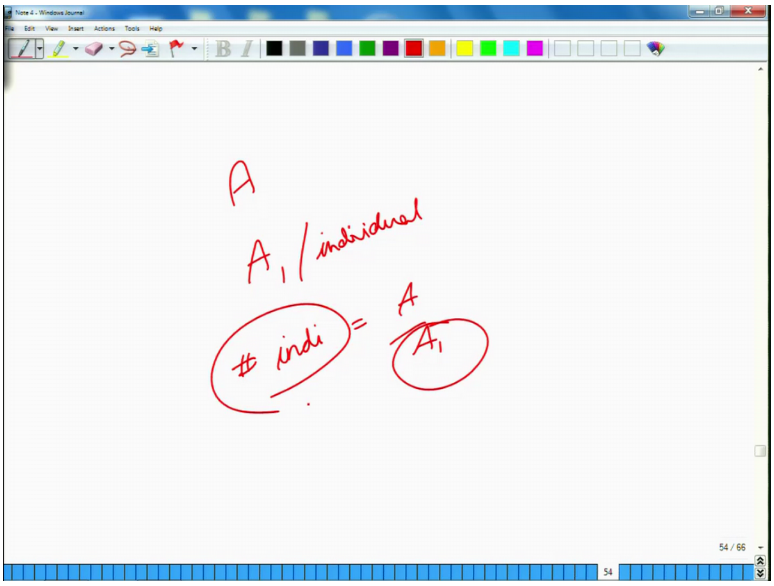

So, if suppose we have a total area of A and a species requires an area of A 1 per individual, so the number of individuals would be given by A divided by A 1. So, as A 1 increases, the number of individuals decreases. So, this is the third reason, why some species are rarer, because they are large animals, require more space. So, they are already present in very low population densities. So, these are three reasons, why a species is rare.

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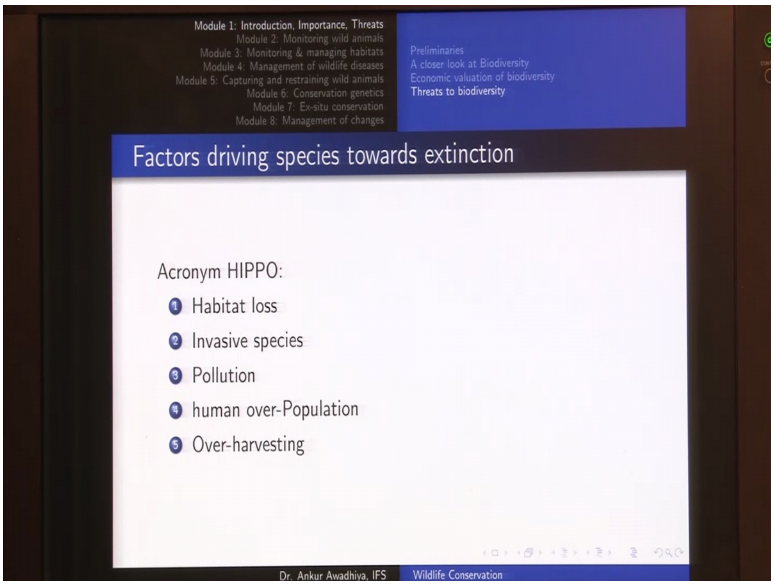

And then, what drives, these species towards extinction. So, there are these five factors that we can remember by the acronym of HIPPO. And HIPPO stands for, H is Habitat loss, I is Invasive species; now invasive species are those species that have come up into a habitat and I displacing all the other species that were native to that area.

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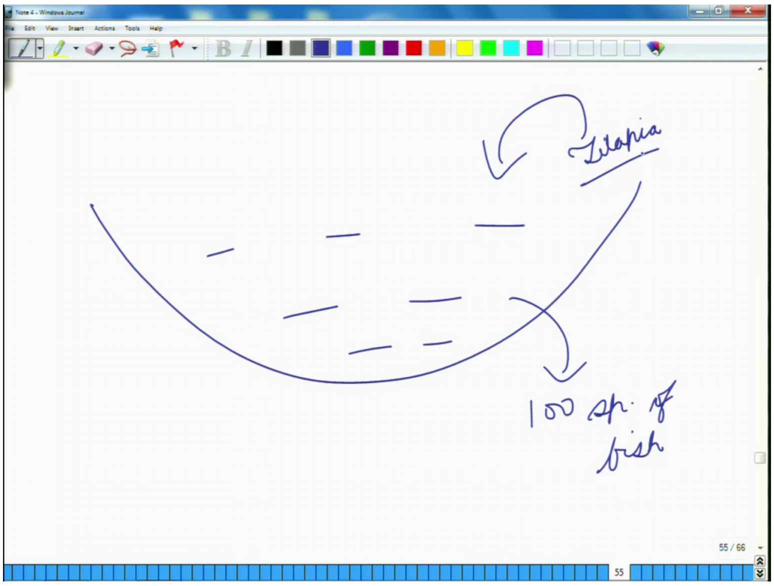

So, for instance in a lake, so in a lake there are suppose 100 species of fish, now for farming purposes, suppose we introduced 1 more species say that tilapia species. Now, tilapia is a species of catfish.

Now, catfish is a species that can eat all of the other varieties of fishes that are found in this lake. So, it would start by eating some species in the lake then, because it is getting enough amount of nutrition, it would reproduce. Once it has reproduced, now we have more number of tilapia. Now, more number of tilapia means that, they are eating more number of fishes.

And then, after a while, it would turn out that this lake that earlier had 100 species of fish, now is left with say only 10 species of fishes or may be at a later point of time, we have this lake in which only tilapia is found, nothing else is found. So, tilapia in this case would be referred to as an invasive species, it has invaded into this lake, and it has displaced or it has exterminated all the other species that are found in that area.

So, the I in HIPPO stands for the invasive species; P is Pollution, which leads to a degradation of the habitat; the other P stands for human over population, because these days human beings are the largest causes of species extinction. So, the more number of humans are there, the faster would be the rate of extinction. And O stands for Over harvesting.

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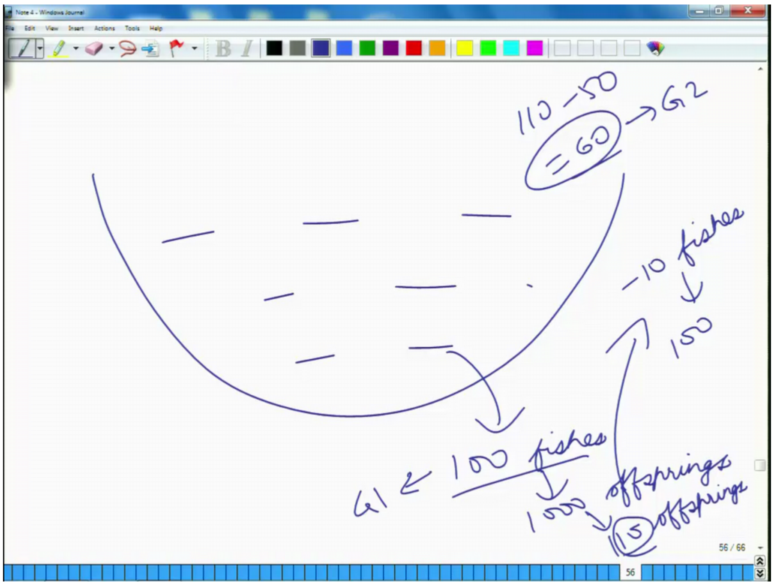

Now, over harvesting in this case means that if in a lake 100 fishes, now we are not talking about 100 species of fishes, we are talking about 100 number of fishes. Now, all of these fishes go through their natural cycles, so they are also reproducing.

Now, suppose these hundred fishes gave rise to say 1,000 offsprings, now these offsprings will then be eaten away by a number of other predators and suppose only say 110 offsprings are left for the next generation. Now, in this case, this lake would which will slowly start increasing in the population of the fishes. But then, we can keep it at constant pace by taking out these 10 individuals. So, if we harvested 10 individuals, so minus ten fishes, then the population would be 100 fishes for the next generation. And then, this would be a sustainable harvest.

But then, in pace of removing 10 individuals, suppose we removed 50 individuals. So, in the 1st generation, we had a hundred individuals; in the 2nd generation, we were left with 110 individuals of which we removed 50 individuals. So, how many individuals are left, 110 minus 50, which is 60 individuals in the 2nd generation

So, in the 1st generation, we had 100 fishes; in the 2nd generation, we have 60 fishes. Now, these 60 fishes will not be able to give rise to that number of offsprings. So, the number of off for the next generation will also reduce. And then, because we are harvesting at a rate that is faster, then this system can produce, so we will call at a AHO an over harvest.

So, over-harvesting is also another factor that is driving species towards extinction. And especially, in the case of those species that do not give rise to a number of off springs, such as the whales.

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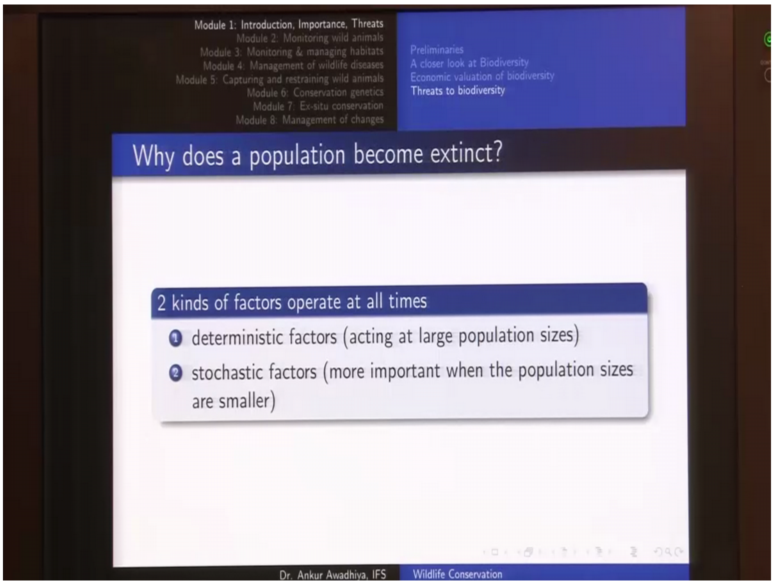

Now, for any population of a species to become extinct there are two kinds of factors; that are operating at all times. And these are two factors that lead a population to become extinct. The first factor is a deterministic factors, which acted larger population sizes. And the second are chance factors or stochastic factors, which are more important, when the population sizes are smaller so, let us look at these two factors.

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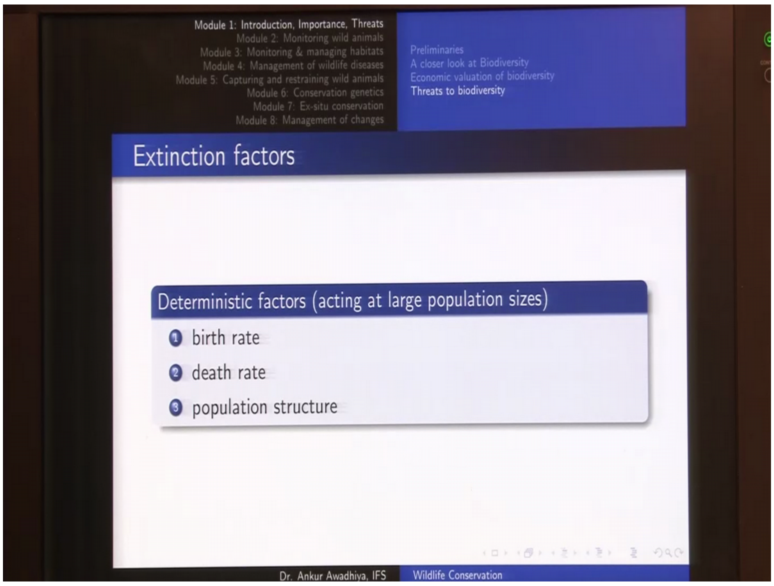

The first is the deterministic factors that act at large population sizes; what is the birthrate of the population, what is the death rate of the population, about what is the population structure of the population. So, for instance, when the birth rate is greater than the death rate, then the population is going to survive, but it in case, where the death rate is greater than birth rate. So, every year, this population has 10 new individuals that come in through birth, but 15 individuals die off because of old age. So, the population is slowly going towards a decline. So, this is a deterministic factor, because this factor will act even at larger population sizes.

So, even if we have say 1,000 individuals, and in these 1,000 individuals, whereas a birth of 100 individuals and 150 individuals are dying off so, even at this large population size is factors will act. And other the factor is the population structure, whether we have more number of adults in the population or whether we have more number of old and young individuals because, if there is a population that has more number of adults, then they would give rise to more number of offsprings. But, if there is a population that has more number of old individuals, then because the old individuals will not give rise to offsprings, so the population will go on declining. So, these are the deterministic factors.

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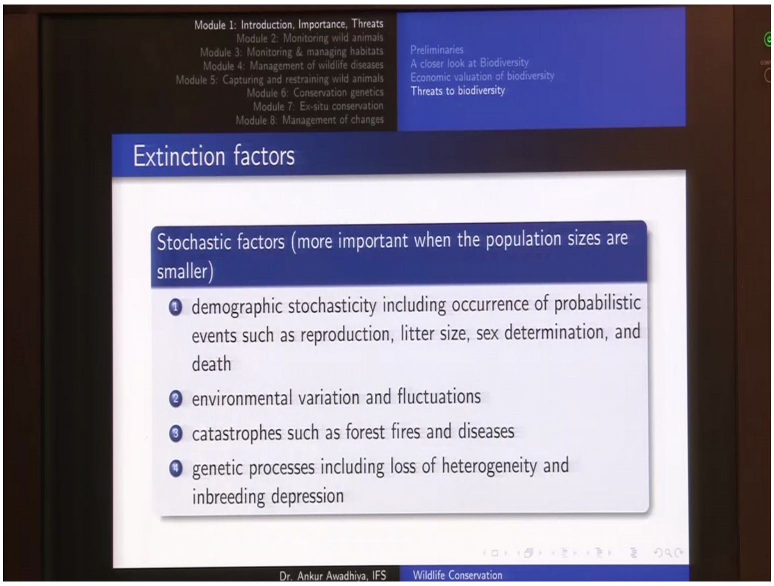

The next are chance factor or stochastic factors, which are more important, when the population sizes are smaller. Now, these include demographic stochasticity, such as the occurrence of probabilistic events such as reproduction, litter size, sex determination, and death. Now, coming back to the larger population size; if there are 100 individuals that are born in a population, then we can say that at a sex ratio of 1 male is to 1 female; roughly 50 individuals will be males, and roughly 50 individuals will be females.

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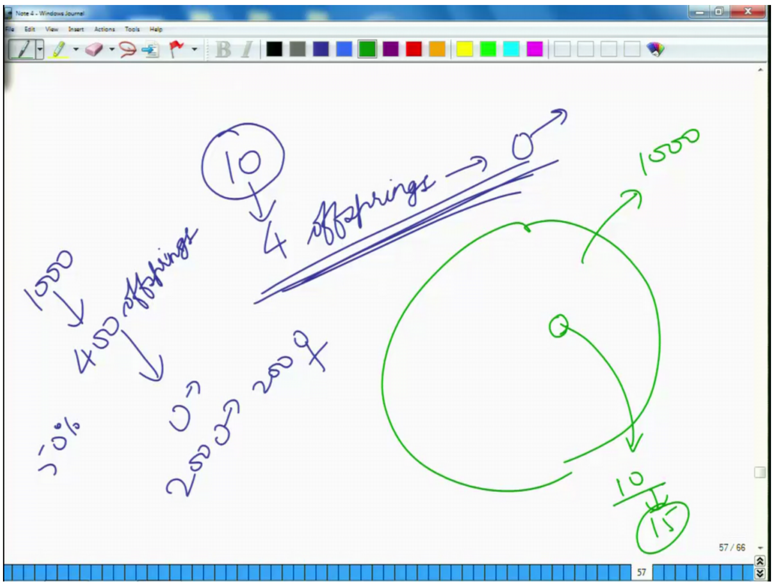

But then, look at a smaller population size, suppose we have a birth of only suppose you are left only 10 individuals, and these 10 individuals gave birth to 4 offsprings. Now, just by chance, it is possible that all of these 4 offsprings are males, there is no female born in this generation. Then what we will observe that when the females of the earlier generation die out, this new generation does not have any new females to replace the older female. So, this becomes a demographic stochasticity because of sex determination.

Now, such a scenario will not occur at larger population sizes, because suppose we have 1,000 individuals and then we have 400 offsprings, then it is very unlikely that all 400 of these will be males, because at a 50 percent sex ratio will be having roughly around 200 males and 200 females. But, at smaller population size is when we have only 4 of these it is possible just by chance that all 4 of these turn out to be males. Similarly, we have litter size. So, in case of a population that can gave a litter of 1 offspring to say 10 offsprings, it is possible that just by chance, it turns out that in one generation all the litters were of a small size, so that would lead to very fast rate of population decline also things such as environmental variations and fluctuations.

So, for instance, in the case of reptiles, such as turtles or crocodiles, so they have a temperature dependent sex determination. So, for instance, in the case of the crocodiles, we have males that are of a larger size, and at larger temperatures, we would see more number of males that have that have formed in that population.

Now, in those populations, it turns out that in if we have any environmental variation and fluctuations, such as we had year that had end that had a larger temperature overall. So, we will find more number of males that were found, and hardly any number of females, so that would also lead to an extinction, especially, at smaller population sizes.

Then catastrophes such as forest fires and diseases that remove a number of individuals from the population also things such as genetic processes including loss of it of a heterogeneity and inbreeding depression. Now, we will look at these in more details in the conservation genetics module.

But then, essentially what this is saying is that when you have a very small population size, then all the individuals that are there in the population are related to each other, so they may be say grandparents, parents, this generation with brothers and sisters. And then, when you do not have any other mate that is remaining in that population, because it is already a very small population, then there would be mating between very close relatives that leads to a number of recessive disorders that come up.

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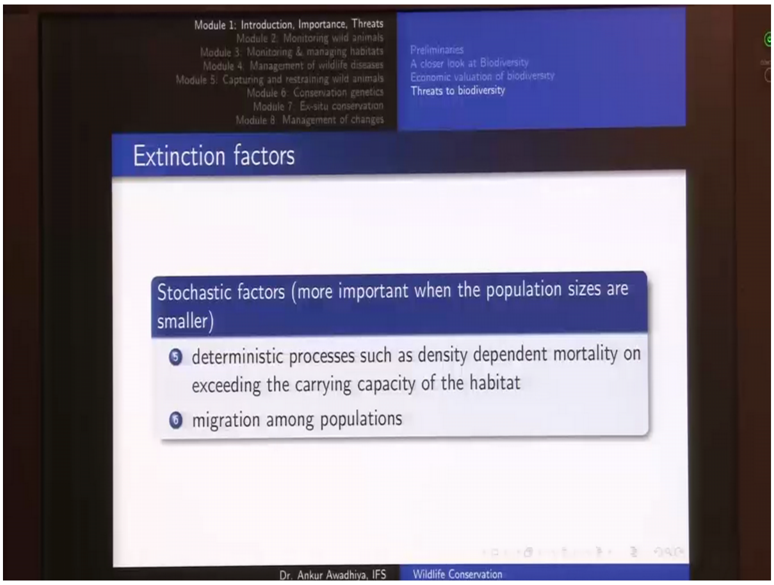

Next is deterministic processes; such as density dependent mortality on exceeding the carrying capacity of the habitat. So, basically what this is saying is that if you have a larger size habitat, and this habitat can support say 1,000 individuals. Now, this smaller population is confined to a very small habitat that can support say only 10 individuals.

Now, in this habitat we had say 10 individuals, and because of population change this rows to 15 individuals. So, in the case of these 15 individuals, the habitat will not be able to support them, and they will be a density dependent mortality. So, as soon as the as this population density increases, these individuals will start dying off. And the next thing is migration among population. So, it could also be situation in which most of the individuals migrate out of this population because of which the population declines.

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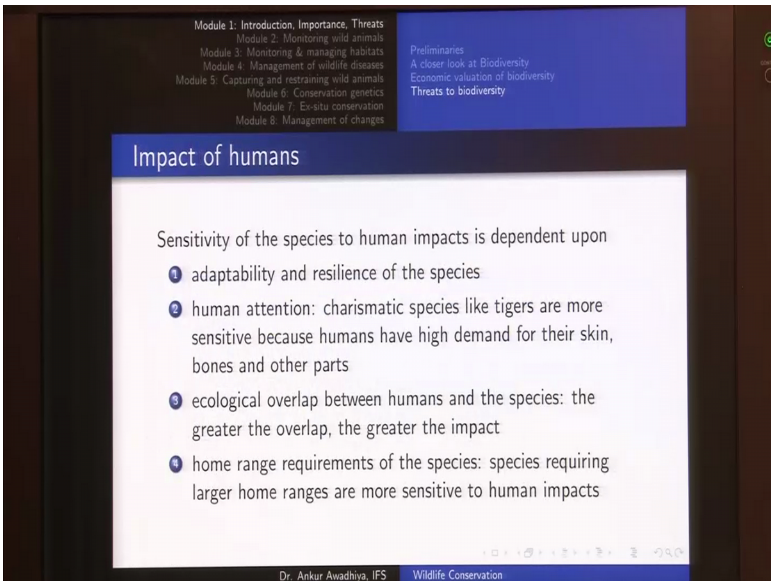

Now, the sensitivity of a species to human impacts, now because humans are the major reason of population extinctions. So, we also have to have a look at the impact of humans. So, the sensitivity of a species to human impacts is dependent upon a number of factors; one is the adaptability and resilience of the species. So, essentially it there is any human intervention in any area is the species able to adapt itself is it resilient to changes, or is it a species that has a very specific habitat requirement so, that if there is any small change in that habitat, the individual start dying off.

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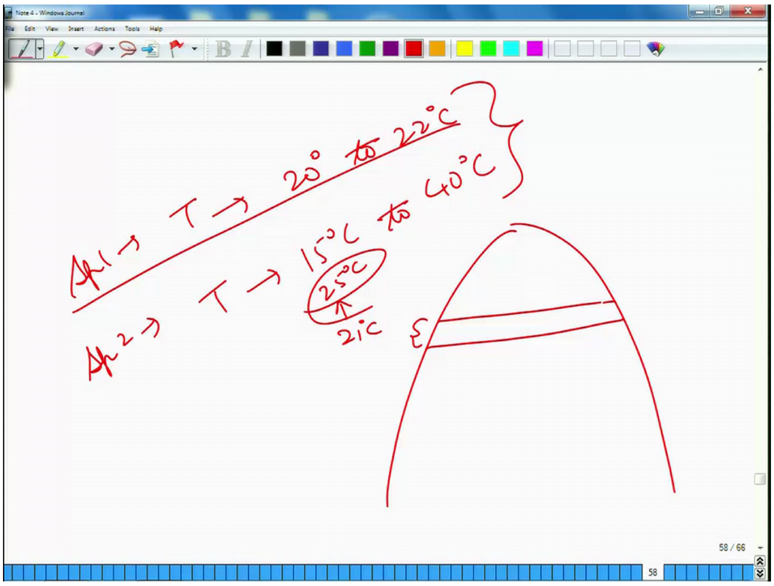

So, essentially we are talking about the level of tolerance that a species has. So, for instance, if we have a species that can tolerate temperatures of say 20 degrees to 22 degrees Celsius. And there is another species that tolerates a temperature of say 15 degree Celsius to say 40 degree Celsius. Now, both of these species are living in a mountain area in which we are having this is small zone, this small band that has a temperature of say 21 degree Celsius.

Now, because of human impacts because of global warming the temperature rises from 21 degrees to say 25 degree. So, this is species 1 and this is species 2. Now, in this case it would happen that is species one that has a very narrow range of tolerance to temperature would die off as soon as that temperature has increased to 25 degree Celsius because of the human impacts. Whereas as our second species will be more adaptable and will be able to resist these changes.

Next, we have human attention. So, charismatic species most of our flag ship species are charismatic species such as tigers or such as polar bears or animals such as say dolphins. And because they capture human attention, so they also become more sensitive because humans have a high demand for their skin bones and other parts.

So, a short while back we had a situation in which there was a very famous lion by the name of Cecil the lion in Africa and that lion was posed away for its trophy. So, its species such as lions, because they take human attention because they garner human attention, so they become more sensitive to them impacts of human beings.

Next is the ecological overlap between humans and the species, the greater the overlap the higher then impact. Now, here we are talking about the ecological overlap. So, let us consider some species that are found say in the Polar Regions. Now, because there are very less number of human beings that live in the polar regions, there is very little amount of ecological overlap. So, those species for instance would be safer from the impacts of human beings as compared to species that lived in say plane areas of India.

So, for instance, if we consider our indo gigantic flat planes that cover the northern areas of our country. So, we have observed quite a huge amount ecological overlap because earlier those areas where forested, but then human beings also wanted to live in those areas human beings also wanted to cultivate those areas. So, all those forest were cut down and all the species that were living in those areas suffered a massive decline in their populations.

Now, compared to that a species that lives in say the very high peaks of Kanchenjunga would be but safer because there are very less number of human beings that are going there and causing any impact there. So, if there is more ecological overlap then the impact of human beings is greater.

Another point is the home range requirements of this species. So, species that require larger home ranges are more sensitive to human impacts primarily because they require a larger area.

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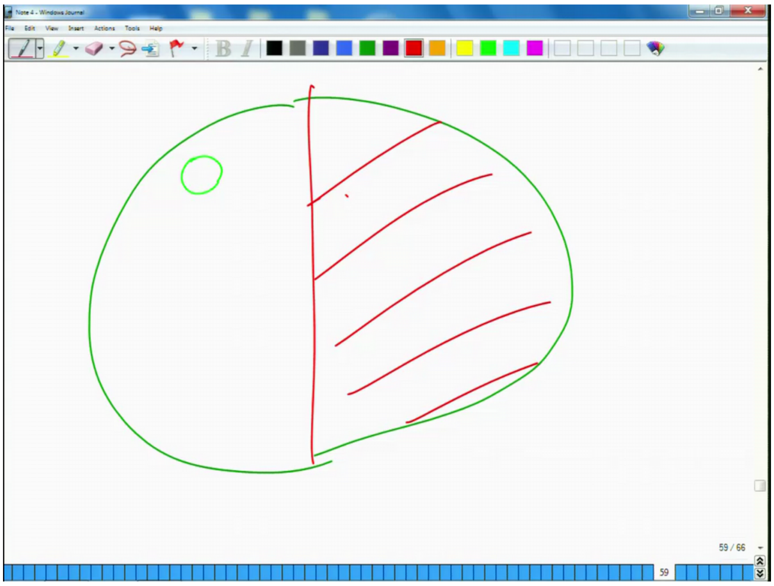

So, in this forest, if there is a species that requires the whole of this forest and if there is some other species that only requires this much patch of the forest. Now, if half of this forest is converted into grasslands, the first species that require the whole of the area would suffer much greater than the second species that was living in a very small area because this small pack is still left out.

Now, these are theoretical considerations, but then we can also quantify the impacts of humans and the impacts of other extinction factors by base of an analysis that goes by the name of population viability analysis.

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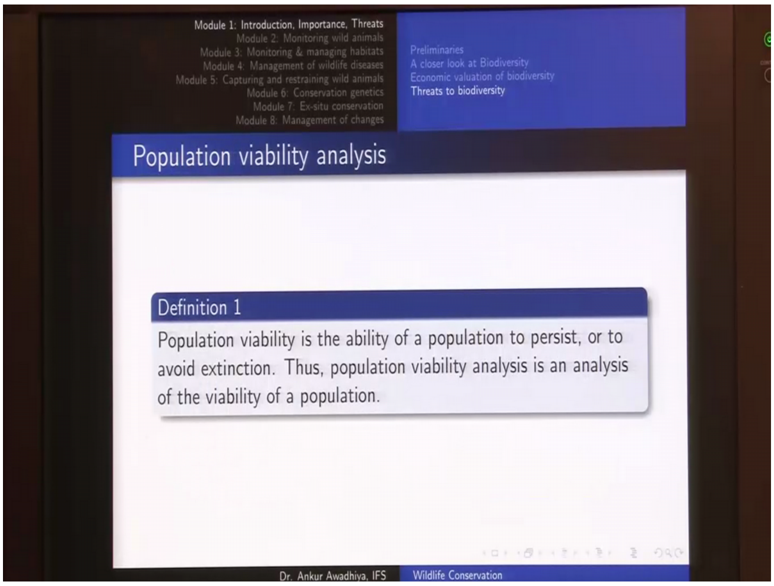

Now, population viability analysis, if the ability population viability is the ability of a population to persist or to avoid extinction. And population viability analysis is an analysis of the viability of a population. So, essentially in this technique that we are going to discussing in more detail in the conservation genetics module, so in this technique we will just touch over it here. So, this technique tries to find out whether a population is going to persist, or whether it will become extinct for n the next n years. So, for instance, we can compute that in the next 100 years will this populations survive or will this population become extinct.

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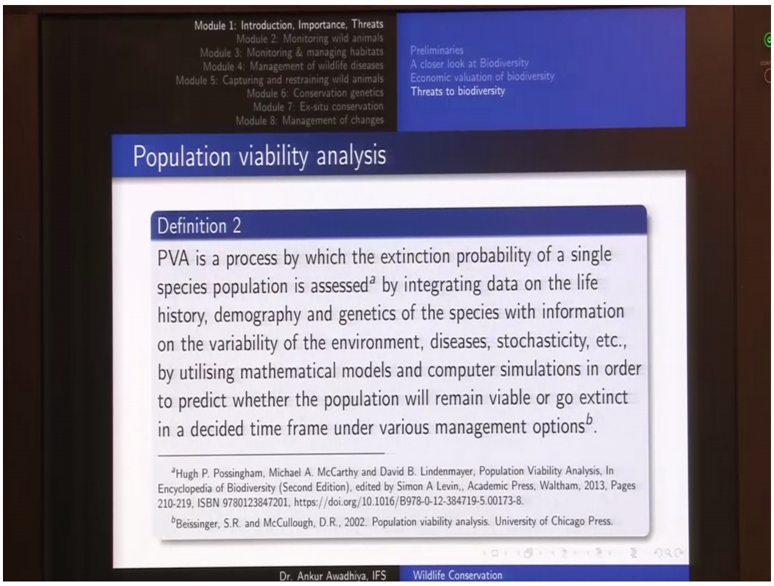

The second definition is that a population viability analysis is a process by which the extinction probability of a single species population is assessed by integrating data on the life history, demography and genetics of the species with information on the variability of the environment, diseases, stochasticity, etcetera, by utilizing mathematical models and computer simulations in order to predict whether the population will remain viable or go extinct in a decided time frame under various management options.

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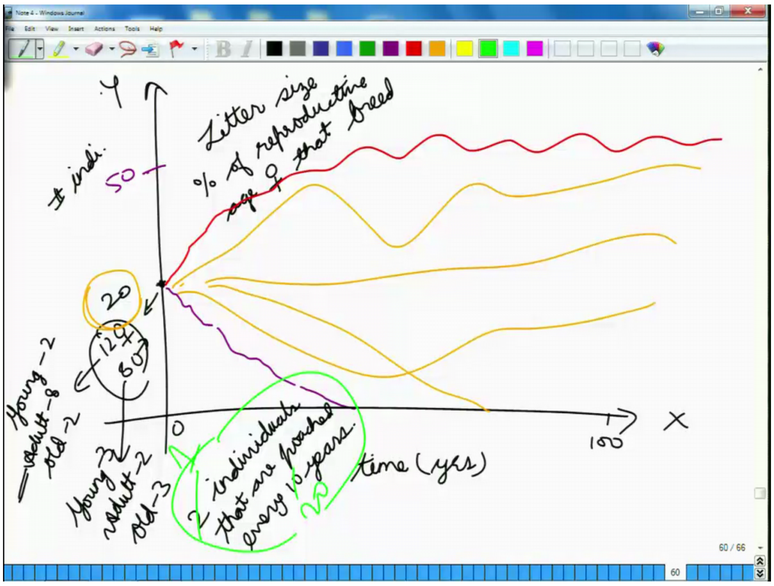

So, what it is saying is that let us consider a graph of the time period in years. So, this goes from year 0 to say 100 years. And suppose we started with the population of say 20 individuals so on the y-axis we have the number of individuals.

Now, if we have 20 individuals, and out of these 20 individuals, suppose we have 12 females, and we have 8 males. Now, if we know the life history of the organism, so we are using the life history, demography and genetics of this species. So, what we are asking is that if we have these many individuals and these females suppose we find out that from in the young females out of these are say 2 and then the adult females are say 8, and then the old females are say 2.

So, in this case, out of these 12 females, 8 females are adults so they are in the reproductive period. And out of these 8 males let us say we a that we have say 3 young males 2 adults male and 3 old males. Now, if we have such a operation structure and we know the demography of this population. So, when we say demography we are putting an data regarding the litter size. So, whenever there is any breeding then how many new cups are formed in the next generation.

Also we want to ask the question what is the percentage of reproductive age females that breed. Now, such kind of information can be had from the field data from field observations. So, for instance, we are looking at a tiger population and we are observing that out of say if we have I have 50 reproductive females and only 30 of them are breeding at any point of time. So, we would say that 30 out of 50 or 60 percent is the percentage of reproductive age females that would breed.

Now, if we put all of these information into our computer simulation and then we also put in the stochasticity variable such as variability of the environment, diseases stochasticity and so on. So, for instance, we can put into our model that say there are two individuals that are poached every 10 years, or say every 3rd year we have a forest fire that can that can impact say two individuals in the population or say 2 percent of the individuals of the population.

Now, when we put all of these data together in a simulation, what would come out is that because in the case of stochastic phenomena, they can occur in this year or they cannot occur in this year or may be two of the events can occur together. We can have a forest fire, we can also have a disease in the same year. So, our computer is going to used all of these information to create a number of scenarios.

Now, it is possible that in one scenario this population would start increasing and then it would maintain itself here. But then it is also possible that in another scenario we had this stochastic factors that occurred in the beginning. So, we had a diseases, we had a forest fire and we also had poaching in the first year; we have reduced these populations.

So, in that case it is possible that this population came down here and then after a short while it became extinct. So, the population size went from 20 to 0; whereas, in this case the population size went from 20 to 50. Now, these are just two scenarios. What our computer is going to do is that it will use n number of situations and n number of simulations to compute that out of every say 100 populations if we are considering how many of those populations will become extent in the next 100 years.

So, from that we will get a probability of extinction of a population of starting size 20 with these characteristics of the breeding population. Then we can also simulate the impacts of any management inputs. So, for instance, if we have better protections, so that in place of two individuals that are posed every 10 years, we have only one individual that is posed every 20 years so, then we can again simulate the whole thing.

So, all of these simulations would give us an indication of the extinction probability of a single species population. So, this goes by the name of population viability analysis. And we are going to look at it in much greater detail in our sixth module conservation genetics.

So, in today's module we had a look at different threats to biodiversity. We had an estimation of the number of species that we are losing out. We had a looked at various factors that lead a population towards extinction such as the factors of HIPPO the habitat loss invasive species, a human over population, pollution and the over harvesting of species.

We also had a looked at why some species become much more susceptible to extinction because there rarer or because human beings have a greater retention to them and so on. So, that is all for today and this is the end of today's module. And from tomorrow, we will begin a new module which goes by the name of monitoring of wild animals.

So, thank you for your attention. [FL]